Second Edition

Postgraduate Orthopaedics

SBAs FOR THE FRCS (Tr&Orth) EXAMINATION

A Companion to the Postgraduate Orthopaedics Candidate's Guide

EDITED BY
Paul A. Banaszkiewicz
and **Kiran K. Singisetti**

CAMBRIDGE Medicine

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Second Edition

Written by highly experienced clinicians and examiners, this thoroughly revised and expanded second edition is an essential text for orthopaedic trainees preparing for FRCS (Tr&Orth) examination. Highly illustrated and containing over 1,000 single best answer questions (SBAs), it is a high-quality, useful revision tool. Rather than promoting simple recall like most orthopaedic MCQ texts, SBAs encourage higher order thinking and judgement which will support more comprehensive revision and understanding for trainees.

This edition builds on key features from the first, containing new and updated exam questions that cover the spectrum of the orthopaedic syllabus. This includes difficult subject areas such as biomechanics, prosthetics/orthotics, anatomy and statistics. The text also contains two new chapters covering the impact of ethics and diseases on orthopaedic surgery. Crucially, this edition is tailored to post-pandemic examination and deals with the more difficult esoteric ambiguous types of SBA questions that often appear in the real test.

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Edited by

Paul A. Banaszkiewicz

Consultant Orthopaedic Surgeon, Queen Elizabeth Hospital, Gateshead NHS Foundation Trust

Visiting Professor, Northumbria University, Newcastle-upon-Tyne

Trustee Council Member, British Orthopaedic Association (BOA)

Editor, Journal of Trauma and Orthopaedics

Chair, Education and Careers Committee, BOA

Kiran Singisetti

Consultant Orthopaedic Surgeon, Queen Elizabeth Hospital, Gateshead Health NHS Foundation Trust

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Section 5 Applied Basic Sciences

Contributors

Muthana Abdelhalim MBBS MRCS
King Hussein Cancer Foundation and Center, Jordan

Ossama Al-Obaedi MBChB FRCS (Tr&Orth) PGCert Med Ed
The Royal London Hospital, London

Sattar Alshryda MBChB MRCP (UK) MRCS SICOT EBOT FRCS (Tr&Orth) MSc PhD
Al Jalila Children's Specialty Hospital, Dubai

Nayef Aslam-Pervez MBChB FRCS (Tr&Orth) Dip Med CAOS
Hull University Teaching Hospitals NHS Trust

Oliver Bailey MBChB BSc Hons MSc Sports Med FRCS (Tr&Orth)
NHS Lanarkshire - Trauma and Acute Knee Service

Paul A. Banaszkiewicz FRCS (Glas) FRCS (Ed) FRCS (Eng) FRCS (Tr&Orth) MClinEd FAcadMEd FHEA
Queen Elizabeth Hospital Gateshead; Faculty of Health and Life Sciences, Northumbria University

Sheba Basheer FRCS (Tr&Orth)
Sheffield Children's NHS Foundation Trust

Tim Brock MBChB BSc FRCS (Tr&Orth) MSc MRES
James Cook University Hospital, Middlesbrough

Matthew Brown FRCS (Tr&Orth) Dip Hand Surg (Br & Eur)
St John's Hospital, Livingston, Midlothian

Emerson Budhoo MBBS DM (Ortho) FRCS (Tr&Orth)
Caribbean Orthopaedic Foot and Ankle Institute, St Clair Medical Centre; Medical Associates St Joseph, Rampersad Medical Centre

Simon Chambers FRCS (Tr&Orth)
The Newcastle upon Tyne Hospitals NHS Foundation Trust

Rebecca Critchley FRCS (Tr&Orth)
Leeds General Infirmary

David Deehan MB ChB, MSc, MD FRCS (Tr&Orth)
The Newcastle upon Tyne Hospitals NHS Foundation Trust

Rishi Dhir MBChB BSc (Hons) FRCS (Tr&Orth)
Princess Alexandra Hospital, Harlow

Philip Dobson MBBS PhD FRCS (Tr&Orth)
The Newcastle upon Tyne Hospitals NHS Foundation Trust

Alexander Durst FRCS (Tr&Orth)
Welsh Centre for Spinal Surgery and Trauma, Cardiff

Niall Eames MD FRCS (Tr&Orth)
Royal Victoria Hospital, Belfast

Hussam Elamin-Ahmed MRCS
Queen Elizabeth Hospital, Gateshead

Walid A. Elnahal MD FRCS (Eng) FEBOT MSc
Royal National Orthopaedic Hospital Stanmore; Orthopaedics, Cairo University

Adam Farrier FRCS (Tr&Orth)
The Newcastle upon Tyne Hospitals NHS Foundation Trust

James Fernandes FRCS (Tr&Orth)
Sheffield Childrens Hospital

Craig H. Gerrand FRCSEd (Tr&Orth) MD
Royal National Orthopaedic Hospital, Stanmore

Christopher George Ghazala BSc Hons (Dunelm) MB BS MRes (N'cle) MSc (Edin) FRCS (Tr&Orth) FHEA
South Tyneside and Sunderland NHS Foundation Trust

James Gill MB BChir BSc FRCS (Tr&Orth)
West Suffolk Hospital, Bury St Edmunds

Daniel Hipps MBBS FRCS (Tr&Orth) PhD
The Newcastle upon Tyne Hospitals NHS Foundation Trust

Yusuf Omran Hasan MD FRCS (Tr&Orth)
Salmaniya Medical Complex, Kingdom of Bahrain; Royal National Orthopaedic Hospital, Stanmore

Heledd Havard MSc FRCS (Tr&Orth)
Royal National Orthopaedic Hospital, Stanmore

Gavin Heyes MBChB Msc FRCS (Tr&Orth)
Liverpool University Hospitals NHS Foundation Trust UK

Edward Holloway FRCS (Tr&Orth)
Chesterfield Royal Hospital

Munier Hossain MBBS PGCE MSc (Orth Eng) MSc (Oxon) FRCS (Glas) FRCS (Tr&Orth) FHEA
United Lincolnshire Hospitals NHS Trust

Richard Hutchinson MSc (Hons) FRCS (Tr&Orth)
The Newcastle upon Tyne Hospitals NHS Foundation Trust

Faizan Jabbar MBChB BSc MRCS
The Newcastle upon Tyne Hospitals NHS Foundation Trust

Edward Jeans BMedSci BMBS MRCS MSc
School of Engineering, Cardiff University; Wrightington, Wigan and Leigh Teaching Hospitals

Rajesh Kakwani MBBS MS (Orth) FRCS (Tr&Orth)
Northumbria Healthcare NHS Foundation Trust

Prasad Karpe MBBS MS (Orth) FRCS (Tr&Orth)
James Cook University Hospital, Middlesbrough

Jonny Kent FRCS (Tr&Orth) MB BS MD
North Cumbria Integrated Care NHS Trust

Maire-Clare Killen FRCS (Tr&Orth)
South Tyneside and Sunderland NHS Foundation Trust

Ling Hong Lee MD MCh PGCert Genomic Med
South Tyneside and Sunderland NHS Foundation Trust

Jonathan Lenihan BSc MBBS FRCS (Tr&Orth)
Addenbrooke's Hospital Cambridge

Lyndon Mason MB BCh FRCS (Tr&Orth)
Liverpool University Hospitals NHS Foundation Trust UK

Rory Morrison BMSc MBChb FRCS (Tr&Orth) PhD
Northumbria Healthcare NHS Foundation Trust

Andrea Nicolas FRCS (Tr&Orth)
The Newcastle upon Tyne Hospitals NHS Foundation Trust

Hussein Noureddine BSc CHM (Tr&Orth) FRCSEd (Tr&Orth)
University Hospitals of Leicester NHS Trust

Pradyumna Raval MBBS MCh(Orth) FEBOT FRCS (Tr&Orth)
East of England Deanery

Emma Reay MBBS FRCSEd (Tr&Orth)
James Cook University Hospital, Middlesbrough

Paul Rushton BMedSci BMBS MSc FRCS (Tr&Orth)
The Newcastle upon Tyne Hospitals NHS Foundation Trust

Shantanu Shahane Ms (Orth) Mch (Orth) FRCS (Tr&Orth)
Chesterfield Royal Hospital

Majeed Shakokani MBBS FRCS (Tr&Orth)
Cambridge University Hospitals NHS Foundation Trust

Kiran Singisetti MBBS MS Fellow EBOT FRCS Ed (Tr&Orth)
Queen Elizabeth Hospital, Gateshead

Razvan Taranu MSc FRCSEd (Tr&Orth)
Arcadia Hospital, Iasi, Romania

Nicholas Wei MBBS MRCS PGCert
Queen Elizabeth Hospital, Gateshead

David Yeoh MBBS Msc FRCS (Tr&Orth)
Norfolk and Norwich University Hospital, Norwich, Norfolk

Foreword

Any fool can know. The point is to understand.
Albert Einstein

The Postgraduate Orthopaedics team have significantly updated the content in the second edition for what is the foremost guide to the written section of the FRCS (Trauma and Orthopaedics) examination. The sections relating to understanding the purpose and standard setting of the SBA section give the readers clarity on why it is a proven method of testing higher-order thinking. For most orthopaedic trainees, the exam represents the pinnacle of their training and passing it is a validation that they are able to perform at a level expected of a day one consultant. The authors have captured the essence of the exam, which is to demonstrate a deep understanding of the art and science of our specialty and not simply to recite memorised knowledge.

The expanded sections include Ethics, Professional Behaviour and Leadership which are increasingly relevant in our clinical practice and therefore reflected in the exam. The questions are supported by up-to-date evidence and also identify areas of controversy. The book has been beautifully illustrated and the number of clinical photographs has been increased, which improves the reader's ability to retain information.

This edition not only is a guide for preparation for the exam but serves as a high-quality textbook of clinical knowledge for surgeons of all levels.

The Editor, Paul Banaskiewicz, is internationally recognised for his courses, books, publications and passion for training. He is a serving member of the Council of the British Orthopaedic Association and has been instrumental in improving the quality of education and training on behalf of the association. He has assembled and led an exceptional team of authors.

Hiro Tanaka
Consultant Orthopaedic Surgeon
Honorary Secretary of the British Orthopaedic Association

Preface

When the first edition of the SBA book was released there seemed to be a palpable sense of candidate disappointment with the book. This both surprised and disappointed us. We had been initially very excited as we thought the questions were the closest thing to the actual exam SBAs that candidates would come across. A lot of work had gone into the book. Good quality SBAs are difficult to write. It is much easier to slightly alter existing questions 'already out there on the market' or spend an evening producing some poor-quality questions without understanding the sophisticated nuances of SBA construction.

Reflecting on the genesis of the first edition there had been a number of difficulties and setbacks. One major problem had been formatting the SBA options to be alpha numeric. This is always the case for exam SBAs and we wanted our own SBAs to replicate the exam style. It seems a small detail but this was a major headache. We had also realised that in some of the basic science chapters the SBAs were probably more level 1 than level 2. It is extremely difficult to write level 2 basic science questions as a lot of the information tested relies on factual recall that is difficult to orientate clinically. Also, despite extensive proofreading some grammar errors had still crept into the book. The PGO logo had been missing from the front of the book. Despite these challenges by and large we had been satisfied with the overall content when we delivered it to Cambridge University Press. So where do we go from here? After reflection the most sensible thing was to dust yourself down, and plan for the second edition.

Most of us would want to get better at what we do and improve our performance. We took on board constructive criticism, tried not to dwell too much on discouraging negative criticism and evolved by embracing instructive criticism – adding on to what we already knew.

The plan for the second edition was simple – for each chapter replace five of the least effective or outdated SBAs with ten new ones, add a few more illustrations and references. We set our time scale for 3 months. So 18 months later with the initial plan completely out of the window we have improved the book as far as possible and are pleased with the end result. We could have gone on for another year writing to improve the book but have adopted a pragmatic approach.

We hope the book realises its aim of moving the material up a level and that it will guide you better in your exam preparation. Again, like all books of the Postgraduate Orthopaedics book series we make no claim to the originality of the material. We are distilling orthopaedic knowledge from the wider orthopaedic community specifically for exam-related subjects. We have attempted to acknowledge our sources wherever possible and our sincere apologies if we have inadvertently missed anyone out.

We hope you enjoy the book and it makes a difference to your Part 1 preparation. Even in a very small way – an extra mark shouldn't but may make the difference between passing and failing the exam.

Paul Banaszkiewicz

The website to accompany the books

www.postgraduateorthopaedics.co.uk

This website accompanies the textbook series: Postgraduate Orthopaedics. It includes:

- Postgraduate Orthopaedics: The Candidate's Guide to the FRCS (Tr&Orth) Examination, third edition
- Postgraduate Orthopaedics: Viva Guide for the FRCS (Tr&Orth) Examination, second edition
- Postgraduate Paediatric Orthopaedics

The aim is to provide additional information and resources in order to maximise the learning potential of each book.

Additional areas of the website provide supplementary orthopaedic material, updates and web links.

It is very important our readership gives us feedback. Please email us if you have found any errors in the text that we can correct. Let us know if we haven't included an area of orthopaedics that you feel we should cover. Likewise, any constructive suggestions for improvement would be most welcome.

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As ever, thanks to Jo McStea who keeps the whole PGO setup rolling along.

Chapter 1

Candidate Guidance for the Section 1 Written SBA Paper

Hussein Noureddine and Matthew Brown

The FRCS (Tr&Orth) examination comprises two parts (termed Sections), and transition to the Section 2 clinical and viva voce examination is dependent upon candidates passing the Section 1 written component.

The Exam Format

Section 1 is the written component of the Intercollegiate Examination in Trauma and Orthopaedic Surgery.

Section 1 examinations are currently held at Pearson VUE Test Centres at multiple locations throughout the United Kingdom and Ireland. Candidates can choose their preferred centre during registration. These test centres often host unrelated tests (e.g. driving theory, USMLE) that take place alongside the Section 1 examination. Computer stations are separated by dividers to help minimise visual distraction. Be prepared to focus so as not to be distracted by the movements of others. Some candidates may choose to travel further to utilise quieter test centres.

Candidates should bring photographic identification on the day of the exam. This is checked at registration and again before entry into the examination room. Exam conditions are strict. Bags and all but essential items will be stored in the lockers provided at most centres. Unsurprisingly, no mobile devices are permitted in the examination room. Video surveillance of candidates is common. Depending on the location, it is recommended to bring lunch, as some centres do not have local facilities to purchase food. Paper and a pencil are provided for making notes.

The computer-based questions include multimedia images such as radiographs and clinical photographs. Candidates are not permitted to read ahead but will be able to flag difficult or ambiguous questions for later review.

Overview

At the time of publication, the Section 1 examination consists of two papers as follows:

Paper 1 Single best answer (SBA) – 120 questions (2 hours 15 minutes)

Paper 2 Single best answer (SBA) – 120 questions (2 hours 15 minutes)

Total 4 hours 30 minutes – 240 questions

Candidates will have a 7-year period to complete the examination process for Section 1 (written SBAs) and Section 2 (clinicals). Please check the JCIE website for up to date candidate information and guidance (www.jcie.org.uk).

Candidates will have a maximum of 4 attempts in total at each Section across both the Intercollegiate Specialty Examinations and the Joint Surgical Colleges Fellowship Examinations (i.e., the total of 4 attempts applies to the Intercollegiate Specialty Examinations and the Joint Surgical Colleges Fellowship Examinations alone or any combination of the two).

Candidates with proven dyslexia may be eligible for the Section 1 and Section 2 examination times to be extended and this should be highlighted in advance of the exam.

There is no negative marking; therefore, all questions should be attempted. Sample questions can be viewed on the JCIE website. Experienced examiners perform a formal process of standard setting to decide the final pass mark for each paper. The SBA questions are subject to quality assurance procedures, including feedback from both examiners and candidates. Difficulty level, content, discrimination index and internal consistency are analysed. Ambiguous questions or those deemed insufficient to differentiate between candidates are removed through this process.

The SBA questions consist of an introductory theme, a question stem and five possible responses (listed A–E), of which one is the most appropriate answer. SBA questions are exactly what the name suggests: candidates choose the best from five possible answers. It is important to note that this is not a 'single

correct answer' but a 'single best answer'. Moreover, all five possible answers could be considered correct, but candidates are asked which is best, or most appropriate, given the information provided. As questions are designed to test higher order thinking, this could mean that limited or irrelevant information is provided. Questions require a judgement based on interpretation of the available evidence. Questions that candidates later complain about, for example, 'there was more than one correct answer' or that a question was 'too ambiguous', can often prove the best performing questions. Although the standard is widely publicised to be set at the level of a day one consultant working in the generality of trauma and orthopaedics, candidates should appreciate that some questions will appear more niche and stretch them more than others.

At the time of publication, consideration is being made to reduce the total number of SBAs in Section 1 (perhaps reducing from 240 to 180 questions). We await to see future developments and candidates should review the JCIE website for any future changes.

Advantages of SBA questions:

- They can assess higher order learning and discriminate between candidates of differing ability.
- They can assess a broad sample of the curriculum within a relatively short period of time, which helps to improve reliability and validity.
- With all trainees assessed using the same highly standardised questions, they make for a fair assessment.
- Automated marking helps to remove examiner subjectivity and reduce costs.
- The pitfalls of other question formats (e.g. extended matching, true/false) make SBA questions a popular choice for high-stakes examinations such as the FRCS.

Disadvantages of SBA questions:

- A candidate's reasoning for selecting a particular answer cannot be assessed.
- Despite permitting a broad assessment of the curriculum, there is little opportunity to focus in-depth on a particular subject.
- They rarely reflect the real-life practices of surgical diagnosis and management, which are varied and nuanced.

The five example SBA questions provided on the JCIE website are shown opposite.

1. A 35-year-old man has a combined ACL rupture and posterolateral instability. There is a bony varus knee deformity with lateral thrust in the stance phase of gait.

   What is the most appropriate treatment for this patient?

   A. ACL reconstruction alone
   B. Distal femoral osteotomy
   C. Reconstruction of the posterolateral corner alone
   D. Simultaneous reconstruction of the ACL and the posterolateral corner
   E. Valgus osteotomy and ligament reconstruction simultaneously

2. A 4-year-old girl has had a swollen, painless left knee joint for eight weeks. In the last ten days her left ankle has become swollen. It is uncomfortable after she has been sitting for twenty minutes. Examination of her eyes shows an irregular pupil on the right side.

   What is the most appropriate first step in the management of this patient?

   A. A painful heel due to enthesiopathy is a common associated condition.
   B. Her pupillary abnormality is likely to be due to a dislocated lens
   C. Synovectomy leads to improved joint function over the short and medium term
   D. The HLA B27 gene is a strong marker for this condition
   E. This child is likely to be rheumatoid factor negative

3. A 25-year-old man had an acute dislocation of his shoulder, which was reduced. During the follow-up visit he was found to have wasting of the deltoid and the infraspinatus muscles.

   Injury to which one of the following neural structure accounts for this finding?

   A. Axillary nerve
   B. Lateral cord of the brachial plexus
   C. Posterior cord of the brachial plexus
   D. Suprascapular nerve
   E. Upper trunk of the brachial plexus

4. A 20-year-old woman has had low back pain for the last six months. She has no fever or constitutional symptoms. Radiographs of her thoracic

spine show coarse striations of the vertical trabeculae of the 12th thoracic vertebra. Her ESR is normal.

What is the most likely diagnosis?

A. Bone cyst
B. Fibrous dysplasia
C. Haemangioma
D. Non-ossifying fibroma
E. Osteoblastoma

5. **Considering Hawkins type 3 talar neck fractures, which of the following statements is correct?**
   A. Medial malleolar osteotomy should be avoided because of danger to the blood supply
   B. Talar osteoporosis after three months indicates satisfactory fracture healing
   C. The rate of talar avascular necrosis is related to the rapidity of reduction
   D. The risk of avascular necrosis is 90%
   E. The sub-talar joint is not involved

What is the Relevance of the FRCS (Tr&Orth) Examination?

The FRCS (Tr&Orth) examination helps to reassure patients, the GMC and employers that a candidate has reached the necessary standard required for independent practice as a consultant surgeon. The reference level is that of a day one consultant working in a district general hospital in the generality of trauma and orthopaedic surgery. It is important for the public to have confidence in the process. The exam assesses knowledge and judgement, clinical acumen, management and treatment planning, in addition to communication skills.

Bloom's Level 1, 2 and 3 Questions

The Section 1 examination is designed to test knowledge from across the Trauma and Orthopaedics (T&O) curriculum by using questions that require higher order thinking. Bloom's Taxonomy defines six cognitive categories: knowledge, comprehension, application, analysis, synthesis and evaluation. The taxonomy presents a cumulative hierarchy, with categories ordered from simple to complex and concrete to abstract. The five categories that follow knowledge cover skills and abilities, with mastery of simpler levels considered a prerequisite for mastery of the next more complex level. Rather than assessing factual recall (level 1 questions), the FRCS (Tr&Orth) examination aims to assess each candidate's ability to apply their knowledge to solve a clinical scenario or problem (level 2 and 3 questions). Higher order questions make up most of the question bank, and the aim is to increase the proportion further.

The difference between level 1 and level 2 questions is best illustrated with an example. For a tibial shaft fracture:

> Level 1: How do you classify (knowledge), how are you going to manage the fracture and what is your operative technique?
>
> Level 2: What will be your treatment plan for the patient?

Higher order thinking is being replaced with the term 'higher order judgement'. The difference is best illustrated with an example. For a tibial plateau fracture, higher order thinking may test why the fracture is classified as a Schatzker type III rather than type II. With higher order judgement the patient is presented as a 46-year-old man with a tibial plateau fracture that has 4 mm of articular depression. This fracture would normally require operative fixation with grafting and elevation of the articular surface. However, the scenario is expanded to include the patient's medical history, which includes diabetes, peripheral vascular disease and chronic alcohol abuse. Candidates are expected to make a judgement based on clinical experience. How one manages this patient in reality may differ significantly from what is outlined in the textbooks! The examination is designed to assess real-life decision-making.

Multilogical thinking is a new and evolving concept in exam theory that pertains to questions requiring knowledge of more than one fact to logically and systematically apply concepts to solve a problem or clinical scenario. Such questions present multiple viable answers and are highly valued for their capacity to differentiate between candidates.

Shifting Challenges of the Section 1 and Section 2 Examination

During the Covid pandemic, patients were removed from the Section 2 examination and replaced with clinical photographs and images. This unsettling period required new clinical VIVA questions to be written for the new exam format. Candidate

unfamiliarity with the new format created anxiety, and patients returned to the Section 2 intermediate cases in November 2022. At the time of publication, the short cases continue without patient involvement and the long-term plan for patient involvement remains unconfirmed. Many of the short case clinical pictures are to be replaced with short video clips.

For the International FRCS (Tr&Orth) examination it is likely that patients will not be reintroduced and that the Covid format will continue indefinitely.

Due to reduced patient involvement in Section 2, it is felt that candidates will need to be more robustly tested on clinical examination scenarios in the Section 1 examination. Traditionally, Section 1 had high pass rates and was considered as passable for most candidates to progress to the more difficult Section 2 examination. Following the Covid-era format changes, there has been a move to ensure Section 1 provides a more rigorous assessment of candidate knowledge and clinical understanding. This has proven a shock to many candidates expecting to sail through their Section 1 examination with minimum of effort. In addition, SBAs are now more clinically focused, with each requiring higher order thinking to work out the 'most correct' answer rather than the learning of facts from traditional orthopaedic revision textbooks that had proven sufficient when preparing for previous Section 1 examinations.

General Advice

The Section 1 examination seeks to test background knowledge and judgement that will have developed during daily clinical work, rather than abstract facts from a book. The exam, and the preceding revision period, will be stressful and exhausting. Plan upcoming clinical rotations to ensure that they will permit the necessary time for revision and cover gaps in clinical knowledge and experience. Such placements should also allow for the clustering of annual and study leave for revision and courses in the weeks leading up to both parts of the examination. It is generally recommended to start revising at least 6 months before the Section 1 examination. Candidates who report preparing for just a few months are either superbly talented, incredibly lucky or inappropriately misleading. Avoid accepting unrelated projects, such as research or audits, in the months ahead of your revision.

Candidates should ensure that they are physically and mentally prepared. Eating a well-balanced diet, keeping hydrated, minimising alcohol intake and taking regular revision breaks are all advised. Engaging with regular physical activity and hobbies will also help to improve concentration and well-being. It will prove helpful to allocate an evening or afternoon per week to spend with family and friends. Concentrate on sleep hygiene in the weeks and months preceding the examination. Remember that caffeine has a half-life of 4–6 hours, meaning that it will take up to 24 hours for it to be cleared. Additionally, maintain a clear distinction between revision and relaxation by avoiding bedroom-based revision if possible.

After completing a bank of questions, it is important to allocate sufficient time to review the answers, which can take far longer than expected. With this in mind, consider supplementing evening revision with early morning revision. Every candidate will have different home circumstances and revision preferences, so it is important to create a personal schedule that suits. Identify areas of knowledge that are lacking early in your revision journey and tackle these subjects head-on (i.e. do not delay congenital hand, stress-strain theory or brachial plexus revision until the weeks before Section 1!). Avoid wasting time by reading around answers for questions that were answered correctly and with relative certainty. There is insufficient time for this feel-good approach given the breadth of the T&O curriculum. It is a valuable revision strategy to review correctly answered questions that were based on a lucky or best guess. Reviewing these questions will help consolidate your knowledge. Many candidates soon realise that practising questions must be prioritised over reading or making detailed notes.

The following advice may be useful:

- Troublesome questions are made more difficult if candidates are underprepared. Understand the breadth of the T&O curriculum and practice the SBA question format to develop the required exam technique.
- Confront difficult areas of the curriculum early and avoid burying topics for the few weeks preceding the examination, as this consolidation stage is associated with its own stresses.
- One mark can make the difference between a pass and a fail. Practice questions at the correct knowledge level and under timed conditions. Some websites permit the setting of a time limit for each question. At the start of your revision,

consider allocating 70–80 seconds per question and reduce this to 50–60 seconds as your knowledge and familiarity improve.
- Efficient time management during the Section 1 examination is important. Go fast. Candidates have only one minute to read and interpret each question, consider the options and indicate an answer. Some questions will present cases with a longer stem.
- Each question carries a 1 in 5 chance of being correct, so be sure to provide an answer for every question. There is no negative marking.
- If an answer is not immediately clear, flag the question, mark a best guess (preferred to leaving it unanswered) and move on promptly with the foresight that returning later may not be possible. Flagging a question electronically will help expedite later review. Marking a best guess will avoid the common error of running out of time and throwing away marks.
- Read questions carefully and understand fully what the question stem is asking. All of the options presented may not be ideal, but one must be selected from the options available. Additionally, the answer to questions requesting the 'most appropriate management' may differ from those asking the 'next most appropriate step in management'.
- Candidate feedback suggests that around 20% of questions are straightforward. These test standard textbook knowledge, with answers easily narrowed down to perhaps two options (level 1). The remaining questions are less obvious, with detailed or ambiguous stems and similar answers requiring a more considered judgement (levels 2 and 3).
- Do not assume that ambiguous questions will be removed during the final quality assurance process, as very few questions are actually removed.
- In recent examinations there has been a greater emphasis on higher order anatomy questions. Consider reading an anatomy textbook and practice anatomy questions.

The Build-Up to the Examination

Much of the knowledge and judgement required for the FRCS (Tr&Orth) examination will have been acquired during training; however, the T&O syllabus is extensive, and the examination requires a lot of preparation. Applications are made through the JCIE website, where guidance notes, eligibility criteria and future dates for Sections 1 and 2 can be reviewed. Candidates should plan their preferred date or 'diet' for Section 1 after considering their likely personal and professional circumstances. For UK trainees with a National Training Number (NTN), the date of their ST6 ARCP review is an important waypoint. NTN trainees must achieve an Outcome 1 at their ST6 ARCP before they are eligible to apply. Those not in training are required to demonstrate a level of competence and knowledge equivalent to that achieved by NTN trainees at the end of ST6.

Be sure to read the JCIE 'Guidance Notes for Applicants' document far in advance of making an application.

The Section 1 examination is usually timed a few months ahead of the next Section 2 (clinical and viva voce) examination. The preferred exam dates for both parts are requested at the time of initial application; however, the date for Section 2 will only be confirmed after Section 1 is passed. First-time applicants must submit their application with full payment for both Sections ahead of the published deadlines, which are set approximately 10–12 weeks ahead of each Section 1 examination. The number of candidates permitted to complete Section 2 at each diet is capped and it is widely understood that candidates who apply far in advance of the application deadline are more likely to secure their preferred Section 2 date if successful at Section 1.

The following must be satisfied when completing the online application:

- Payment in full (covering Sections 1 and 2)
- Three completed Structured Reference forms
- Curriculum vitae
- Summary of operative experience
- Photographic identification

NTN trainees should submit three Structured Reference forms, including one completed by their Training Programme Director (TPD) and two by other consultants. Applicants not in training should provide structured references from the head of department (clinical lead) and two other consultants. To avoid unnecessary delays, candidates should contact potential referees far in advance of their planned application date.

Fee penalties apply to candidates who withdraw from the exam after the closing date, so choose the

preferred date carefully after considering all the aforementioned circumstances. It should be noted that candidates who withdraw during an examination will be deemed to have failed and will forfeit one of their four attempts.

Preparation and Revision Resources

Approaching the examination as a single assessment consisting of two parts (as opposed to two separate entities) is the preferred revision strategy. The common denominator for Sections 1 and 2 is for candidates to develop knowledge that is of sufficient breadth and depth. Those who begin by revising topics using textbooks and online resources before proceeding to SBA question practice often succeed in passing both parts in successive diets (e.g. February Section 1 followed by April Section 2). In contrast, those who approach Section 1 by concentrating heavily on questions may require a longer interval to convert the SBA 'best of 5' skill to that of being able to coherently elaborate and expand on topics during the Section 2 viva voce examination. A combination of both strategies is perhaps the best compromise. Whatever strategy is adopted, be sure to dedicate sufficient time to practice the SBA question format, aiming to complete a few thousand questions as a minimum. Questions will not only reinforce and test knowledge, but also help to gauge the time constraints of the actual exam.

Although fundamental to preparing for the Section 2 examination (clinical and viva voce), some candidates find an informal study group helpful during Section 1. Peer-to-peer teaching and discussion is a powerful learning tool. Although group learning can take various forms, verbalising knowledge according to a structured revision timetable can prove useful, especially ahead of the Section 2 examination. Revision groups should be limited to a small number of individuals who share similar knowledge levels, plan to sit the exam on the same date and are fully committed to the process. Moreover, it is important to recognise when revision methods are proving ineffectual as evidenced by poor progression or revision group distraction or fatigue. Candidates should be honest with their study partners if this becomes the reality and refocus or redesign their revision strategy at the earliest opportunity. Finally, consistency and continuity are imperative, and candidates should avoid prolonged gaps in their revision.

The following revision resources are commonly used by candidates for the Section 1 examination:

- **Postgraduate Orthopaedics – The Candidate's Guide (3rd edition)**
  This comprehensive textbook helps to prepare candidates for the clinical and viva voce aspects of the Section 2 examination. It utilises concise prose, graphics, illustrations and case-based examples to consolidate knowledge gained during preparation for Section 1. Cases are designed to reflect those in the examination. Insights from recent candidates help to demonstrate good and bad practice during the viva voce examination. Although this textbook is oriented towards Section 2, the core topic sections will provide a useful revision aid for the questions found in Section 1.
- **Postgraduate Paediatric Orthopaedics**
  Although oriented towards the Section 2 examination, this textbook is packed with diagnostic and surgical tips that will aid success in both parts. The dysplasias section offers a structured methodology when approaching any skeletal dysplasia, and the cerebral palsy section touches on gait analysis with clear graphs of the types that could be asked in both parts of the exam.
- **Miller's Review of Orthopaedics (7th edition)**
  This comprehensive textbook presents the breadth of T&O surgical practice in one volume, including anatomy and the basic sciences. The book is aligned with the American Board of Orthopaedic Surgery examination but remains very popular for FRCS (Tr&Orth) revision, especially when preparing for Section 1. Recent editions are easier to read and include colour illustrations, clinical photographs and tables. Candidates may choose to focus on specific sections or chapters, read it in its entirety or use it as a reference alongside other resources.
- **Basic Orthopaedic Sciences (2nd edition)**
  This popular textbook for both parts of the exam aims to cover the basic sciences that underpin T&O surgical practice. Topics include biomechanics, biomaterials, immunology, pharmacology, imaging techniques and statistics. Some chapters read more clearly and accurately than others.
- **Orthopaedic Basic Science for the Postgraduate Examination: Practice MCQs and EMQs**[1]
  Included here are more than 500 multiple choice and extended matching questions related to

orthopaedic basic science. Detailed and insightful explanations are included for each question. The level of knowledge required is perhaps above that expected for the FRCS (Tr&Orth) examination but it is good to assess areas of the curriculum that are often neglected in everyday practice.

- **Postgraduate Orthopaedics: MCQs and EMQs for the FRCS (1st edition)**
  The predecessor to this SBA textbook was published in 2012. It contains an additional bank of quality SBA and EMQ questions that remain relevant to the FRCS (Tr&Orth) examination. Answer explanations are short but adequate for rapid revision. Candidates may consider using this older textbook later in their revision when they are better able to identify information that may be outdated.
- **AAOS Comprehensive Orthopaedic Review (2nd edition)**[2]
  This comprehensive and well-presented three-volume text is designed for the American Board examination. The final volume is dedicated to multiple choice question practice. An excellent but expensive resource.
- **Succeeding in the FRCS T&O Part 1 Exam**[3]
  This book has received mixed reviews, with the majority proving highly critical. Questions concentrate on factual recall and explanations can be confusing, unfocused and contradictory. It is perhaps a book to consider borrowing rather than buying and should not form a significant part of one's Section 1 preparation.
- **Practice Questions in Trauma and Orthopaedics for the FRCS**[4]
  The questions in this outdated book more closely reflect the standard of the MRCS examination and are far removed from that of the FRCS (Tr&Orth) Section 1 examination. Poor online reviews reflect the low level of knowledge examined.
- **First Aid for the Orthopaedic Boards (2nd Edition)**[5]
  This book is written for the in-service examinations (Orthopaedic In-Training Exam [OITE]) of the American Board. It receives mixed reviews, with the question style and depth differing from that observed in the FRCS (Tr&Orth) Section 1 examination. Although it is easy to read and may help you score a few extra points, it is expensive for what it provides.
- **Review Questions in Orthopaedics**[6]
  Originally written for orthopaedic residents preparing for the in-training (OITE) examinations of the American Board, this book (often termed the 'black book' by UK candidates) has remained a favourite supplementary question bank for the FRCS (Tr&Orth) Section 1 examination. Despite having been published in 2001, the comprehensive SBA questions and accompanying high-quality explanations have helped maintain its popularity. However, it may be time to re-evaluate, with recent candidates suggesting that the questions are outdated, difficult and esoteric when compared with the Section 1 examination.
- **1000 EMQs in Trauma and Orthopaedic Surgery**[7]
  This book does not reliably recreate the questions found in today's Section 1 examination and is of limited use. Some trainees have found the questions confusing and overly complicated. Perhaps doubly obsolete when considering that the EMQ format has been phased out.
- **FRCS (Tr&Orth): MCQ and Clinical Cases**[8]
  This book includes around 60 SBA questions and a similar number of worked viva voce cases taken from the *Bone & Joint Journal* (*BJJ*). Although most SBAs rely on factual recall (level 1), the book's primary merit lies with the good-quality explanations. Online reviews are mixed, with many preferring to use the book when preparing for the Section 2 examination.

Other Sources

- **Orthobullets**
  This website is an essential tool for the Section 1 examination. The generous question bank provides detailed explanations that link to the subject areas or chapters on the website. Candidates can revise topics and then construct sets of questions relevant to the area of focus (i.e. paediatric orthopaedics or arthroplasty). The website resembles a virtual textbook with topics generally covered in sufficient detail to guide revision. Topics appear to be loosely based on *Miller's Review of Orthopaedics*; however, bullet points largely replace the textbook prose, with a focus on American practice and the Board examination.

  The primary advantage of Orthobullets is the functionality that permits candidates to create bespoke SBA test papers. Candidates can set the

number and focus of the questions tested (i.e. random or subject-specific) and the time allocated per question. The site also maintains a record of performance, with scores presented according to test date and subject area. The primary disadvantage is that the free questions (more than 2,000) rely heavily on factual recall (level 1) and are generally of a standard below that required for the FRCS (Tr&Orth) examination. The paid-for premium content provides a higher standard but they still more closely resemble the style of the American Board examination.

- **UKITE**
  The United Kingdom In-Training Examination (UKITE) was established by the British Orthopaedic Association (BOA) in 2007 as a curriculum-based self-assessment tool for the FRCS (Tr&Orth) examination. It has evolved to emulate the Section 1 examination more closely. Although the breadth of the T&O curriculum is sampled, the UKITE assessment relies more heavily on questions testing factual recall. Completing the annual UKITE assessment during orthopaedic training is a useful formative assessment tool for monitoring progression and understanding the breadth of the T&O curriculum.
- **Postgraduate Orthopaedics**
  The newly revamped website includes SBA questions and case-based discussions that complement core revision material to help reinforce difficult key concepts and develop higher order thinking skills.

The Week of the Examination

As the Section 1 examination approaches, consider reducing exam day anxiety by travelling to the test centre in advance. Candidates should consider familiarising themselves with the venue, its surroundings and the available services (i.e. transport, parking, refreshments). For Section 2, consider arriving a day or more in advance of the exam for the reasons outlined above. Get into 'exam mode' by minimising distractions and arranging to meet other candidates for face-to-face practice.

Finally, good luck when revising for both parts of the FRCS (Tr&Orth) examination. It is a fair exam that represents the pinnacle of T&O surgical assessment and practice worldwide.

Notes

1 Dawson-Bowling SJ et al. *Orthopaedic Basic Science for the Postgraduate Examination: Practice MCQs and EMQs*. Gloucester: Orthopaedic Research UK Publishing; 2012.

2 Lieberman JR, ed. *AAOS Comprehensive Orthopaedic Review*. Rosemont, IL: American Academy of Orthopaedic Surgeons; 2009.

3 Gulam Attar F, Ibrahim T. *Succeeding in the FRCS T&O. Part 1: Exam*. London: BPP Learning Media; 2011.

4 Sharma P. *Practice Questions in Trauma and Orthopaedics for the FRCS (Master Pass Series)*. Milton Keynes: Radcliffe Publishing Ltd; 2007.

5 Mallinzak RA, Albritton MJ, Pickering TR. *First Aid for the Orthopaedic Boards*. 2nd ed. Bronson, TX: McGraw-Hill Medical; 2009.

6 Wright JM, Millett PJ, Crockett HC, Craig EV. *Review Questions in Orthopaedics*. Rosemont, IL: American Academy of Orthopaedic Surgeons; 2001.

7 Sharma H. *1000 EMQs in Trauma and Orthopaedic Surgery*. Glasgow: FRCS Orth Exam Education; 2008.

8 Khanduja V. *FRCS (Tr&Orth): MCQs and Clinical Cases*. London: JP Medical Ltd; 2014.

Chapter 1

Candidate Guidance for the Section 1 Written SBA Paper

Hussein Noureddine and Matthew Brown

The FRCS (Tr&Orth) examination comprises two parts (termed Sections), and transition to the Section 2 clinical and viva voce examination is dependent upon candidates passing the Section 1 written component.

The Exam Format

Section 1 is the written component of the Intercollegiate Examination in Trauma and Orthopaedic Surgery.

Section 1 examinations are currently held at Pearson VUE Test Centres at multiple locations throughout the United Kingdom and Ireland. Candidates can choose their preferred centre during registration. These test centres often host unrelated tests (e.g. driving theory, USMLE) that take place alongside the Section 1 examination. Computer stations are separated by dividers to help minimise visual distraction. Be prepared to focus so as not to be distracted by the movements of others. Some candidates may choose to travel further to utilise quieter test centres.

Candidates should bring photographic identification on the day of the exam. This is checked at registration and again before entry into the examination room. Exam conditions are strict. Bags and all but essential items will be stored in the lockers provided at most centres. Unsurprisingly, no mobile devices are permitted in the examination room. Video surveillance of candidates is common. Depending on the location, it is recommended to bring lunch, as some centres do not have local facilities to purchase food. Paper and a pencil are provided for making notes.

The computer-based questions include multimedia images such as radiographs and clinical photographs. Candidates are not permitted to read ahead but will be able to flag difficult or ambiguous questions for later review.

Overview

At the time of publication, the Section 1 examination consists of two papers as follows:

Paper 1 Single best answer (SBA) – 120 questions (2 hours 15 minutes)

Paper 2 Single best answer (SBA) – 120 questions (2 hours 15 minutes)

Total 4 hours 30 minutes – 240 questions

Candidates will have a 7-year period to complete the examination process for Section 1 (written SBAs) and Section 2 (clinicals). Please check the JCIE website for up to date candidate information and guidance (www.jcie.org.uk).

Candidates will have a maximum of 4 attempts in total at each Section across both the Intercollegiate Specialty Examinations and the Joint Surgical Colleges Fellowship Examinations (i.e., the total of 4 attempts applies to the Intercollegiate Specialty Examinations and the Joint Surgical Colleges Fellowship Examinations alone or any combination of the two).

Candidates with proven dyslexia may be eligible for the Section 1 and Section 2 examination times to be extended and this should be highlighted in advance of the exam.

There is no negative marking; therefore, all questions should be attempted. Sample questions can be viewed on the JCIE website. Experienced examiners perform a formal process of standard setting to decide the final pass mark for each paper. The SBA questions are subject to quality assurance procedures, including feedback from both examiners and candidates. Difficulty level, content, discrimination index and internal consistency are analysed. Ambiguous questions or those deemed insufficient to differentiate between candidates are removed through this process.

The SBA questions consist of an introductory theme, a question stem and five possible responses (listed A–E), of which one is the most appropriate answer. SBA questions are exactly what the name suggests: candidates choose the best from five possible answers. It is important to note that this is not a 'single

correct answer' but a 'single best answer'. Moreover, all five possible answers could be considered correct, but candidates are asked which is best, or most appropriate, given the information provided. As questions are designed to test higher order thinking, this could mean that limited or irrelevant information is provided. Questions require a judgement based on interpretation of the available evidence. Questions that candidates later complain about, for example, 'there was more than one correct answer' or that a question was 'too ambiguous', can often prove the best performing questions. Although the standard is widely publicised to be set at the level of a day one consultant working in the generality of trauma and orthopaedics, candidates should appreciate that some questions will appear more niche and stretch them more than others.

At the time of publication, consideration is being made to reduce the total number of SBAs in Section 1 (perhaps reducing from 240 to 180 questions). We await to see future developments and candidates should review the JCIE website for any future changes.

Advantages of SBA questions:

- They can assess higher order learning and discriminate between candidates of differing ability.
- They can assess a broad sample of the curriculum within a relatively short period of time, which helps to improve reliability and validity.
- With all trainees assessed using the same highly standardised questions, they make for a fair assessment.
- Automated marking helps to remove examiner subjectivity and reduce costs.
- The pitfalls of other question formats (e.g. extended matching, true/false) make SBA questions a popular choice for high-stakes examinations such as the FRCS.

Disadvantages of SBA questions:

- A candidate's reasoning for selecting a particular answer cannot be assessed.
- Despite permitting a broad assessment of the curriculum, there is little opportunity to focus in-depth on a particular subject.
- They rarely reflect the real-life practices of surgical diagnosis and management, which are varied and nuanced.

The five example SBA questions provided on the JCIE website are shown opposite.

1. A 35-year-old man has a combined ACL rupture and posterolateral instability. There is a bony varus knee deformity with lateral thrust in the stance phase of gait.

   What is the most appropriate treatment for this patient?

   A. ACL reconstruction alone
   B. Distal femoral osteotomy
   C. Reconstruction of the posterolateral corner alone
   D. Simultaneous reconstruction of the ACL and the posterolateral corner
   E. Valgus osteotomy and ligament reconstruction simultaneously

2. A 4-year-old girl has had a swollen, painless left knee joint for eight weeks. In the last ten days her left ankle has become swollen. It is uncomfortable after she has been sitting for twenty minutes. Examination of her eyes shows an irregular pupil on the right side.

   What is the most appropriate first step in the management of this patient?

   A. A painful heel due to enthesiopathy is a common associated condition.
   B. Her pupillary abnormality is likely to be due to a dislocated lens
   C. Synovectomy leads to improved joint function over the short and medium term
   D. The HLA B27 gene is a strong marker for this condition
   E. This child is likely to be rheumatoid factor negative

3. A 25-year-old man had an acute dislocation of his shoulder, which was reduced. During the follow-up visit he was found to have wasting of the deltoid and the infraspinatus muscles.

   Injury to which one of the following neural structure accounts for this finding?

   A. Axillary nerve
   B. Lateral cord of the brachial plexus
   C. Posterior cord of the brachial plexus
   D. Suprascapular nerve
   E. Upper trunk of the brachial plexus

4. A 20-year-old woman has had low back pain for the last six months. She has no fever or constitutional symptoms. Radiographs of her thoracic

spine show coarse striations of the vertical trabeculae of the 12th thoracic vertebra. Her ESR is normal.

What is the most likely diagnosis?

A. Bone cyst
B. Fibrous dysplasia
C. Haemangioma
D. Non-ossifying fibroma
E. Osteoblastoma

5. **Considering Hawkins type 3 talar neck fractures, which of the following statements is correct?**
   A. Medial malleolar osteotomy should be avoided because of danger to the blood supply
   B. Talar osteoporosis after three months indicates satisfactory fracture healing
   C. The rate of talar avascular necrosis is related to the rapidity of reduction
   D. The risk of avascular necrosis is 90%
   E. The sub-talar joint is not involved

What is the Relevance of the FRCS (Tr&Orth) Examination?

The FRCS (Tr&Orth) examination helps to reassure patients, the GMC and employers that a candidate has reached the necessary standard required for independent practice as a consultant surgeon. The reference level is that of a day one consultant working in a district general hospital in the generality of trauma and orthopaedic surgery. It is important for the public to have confidence in the process. The exam assesses knowledge and judgement, clinical acumen, management and treatment planning, in addition to communication skills.

Bloom's Level 1, 2 and 3 Questions

The Section 1 examination is designed to test knowledge from across the Trauma and Orthopaedics (T&O) curriculum by using questions that require higher order thinking. Bloom's Taxonomy defines six cognitive categories: knowledge, comprehension, application, analysis, synthesis and evaluation. The taxonomy presents a cumulative hierarchy, with categories ordered from simple to complex and concrete to abstract. The five categories that follow knowledge cover skills and abilities, with mastery of simpler levels considered a prerequisite for mastery of the next more complex level. Rather than assessing factual recall (level 1 questions), the FRCS (Tr&Orth) examination aims to assess each candidate's ability to apply their knowledge to solve a clinical scenario or problem (level 2 and 3 questions). Higher order questions make up most of the question bank, and the aim is to increase the proportion further.

The difference between level 1 and level 2 questions is best illustrated with an example. For a tibial shaft fracture:

> Level 1: How do you classify (knowledge), how are you going to manage the fracture and what is your operative technique?
>
> Level 2: What will be your treatment plan for the patient?

Higher order thinking is being replaced with the term 'higher order judgement'. The difference is best illustrated with an example. For a tibial plateau fracture, higher order thinking may test why the fracture is classified as a Schatzker type III rather than type II. With higher order judgement the patient is presented as a 46-year-old man with a tibial plateau fracture that has 4 mm of articular depression. This fracture would normally require operative fixation with grafting and elevation of the articular surface. However, the scenario is expanded to include the patient's medical history, which includes diabetes, peripheral vascular disease and chronic alcohol abuse. Candidates are expected to make a judgement based on clinical experience. How one manages this patient in reality may differ significantly from what is outlined in the textbooks! The examination is designed to assess real-life decision-making.

Multilogical thinking is a new and evolving concept in exam theory that pertains to questions requiring knowledge of more than one fact to logically and systematically apply concepts to solve a problem or clinical scenario. Such questions present multiple viable answers and are highly valued for their capacity to differentiate between candidates.

Shifting Challenges of the Section 1 and Section 2 Examination

During the Covid pandemic, patients were removed from the Section 2 examination and replaced with clinical photographs and images. This unsettling period required new clinical VIVA questions to be written for the new exam format. Candidate

unfamiliarity with the new format created anxiety, and patients returned to the Section 2 intermediate cases in November 2022. At the time of publication, the short cases continue without patient involvement and the long-term plan for patient involvement remains unconfirmed. Many of the short case clinical pictures are to be replaced with short video clips.

For the International FRCS (Tr&Orth) examination it is likely that patients will not be reintroduced and that the Covid format will continue indefinitely.

Due to reduced patient involvement in Section 2, it is felt that candidates will need to be more robustly tested on clinical examination scenarios in the Section 1 examination. Traditionally, Section 1 had high pass rates and was considered as passable for most candidates to progress to the more difficult Section 2 examination. Following the Covid-era format changes, there has been a move to ensure Section 1 provides a more rigorous assessment of candidate knowledge and clinical understanding. This has proven a shock to many candidates expecting to sail through their Section 1 examination with minimum of effort. In addition, SBAs are now more clinically focused, with each requiring higher order thinking to work out the 'most correct' answer rather than the learning of facts from traditional orthopaedic revision textbooks that had proven sufficient when preparing for previous Section 1 examinations.

General Advice

The Section 1 examination seeks to test background knowledge and judgement that will have developed during daily clinical work, rather than abstract facts from a book. The exam, and the preceding revision period, will be stressful and exhausting. Plan upcoming clinical rotations to ensure that they will permit the necessary time for revision and cover gaps in clinical knowledge and experience. Such placements should also allow for the clustering of annual and study leave for revision and courses in the weeks leading up to both parts of the examination. It is generally recommended to start revising at least 6 months before the Section 1 examination. Candidates who report preparing for just a few months are either superbly talented, incredibly lucky or inappropriately misleading. Avoid accepting unrelated projects, such as research or audits, in the months ahead of your revision.

Candidates should ensure that they are physically and mentally prepared. Eating a well-balanced diet, keeping hydrated, minimising alcohol intake and taking regular revision breaks are all advised. Engaging with regular physical activity and hobbies will also help to improve concentration and well-being. It will prove helpful to allocate an evening or afternoon per week to spend with family and friends. Concentrate on sleep hygiene in the weeks and months preceding the examination. Remember that caffeine has a half-life of 4–6 hours, meaning that it will take up to 24 hours for it to be cleared. Additionally, maintain a clear distinction between revision and relaxation by avoiding bedroom-based revision if possible.

After completing a bank of questions, it is important to allocate sufficient time to review the answers, which can take far longer than expected. With this in mind, consider supplementing evening revision with early morning revision. Every candidate will have different home circumstances and revision preferences, so it is important to create a personal schedule that suits. Identify areas of knowledge that are lacking early in your revision journey and tackle these subjects head-on (i.e. do not delay congenital hand, stress-strain theory or brachial plexus revision until the weeks before Section 1!). Avoid wasting time by reading around answers for questions that were answered correctly and with relative certainty. There is insufficient time for this feel-good approach given the breadth of the T&O curriculum. It is a valuable revision strategy to review correctly answered questions that were based on a lucky or best guess. Reviewing these questions will help consolidate your knowledge. Many candidates soon realise that practising questions must be prioritised over reading or making detailed notes.

The following advice may be useful:

- Troublesome questions are made more difficult if candidates are underprepared. Understand the breadth of the T&O curriculum and practice the SBA question format to develop the required exam technique.
- Confront difficult areas of the curriculum early and avoid burying topics for the few weeks preceding the examination, as this consolidation stage is associated with its own stresses.
- One mark can make the difference between a pass and a fail. Practice questions at the correct knowledge level and under timed conditions. Some websites permit the setting of a time limit for each question. At the start of your revision,

consider allocating 70–80 seconds per question and reduce this to 50–60 seconds as your knowledge and familiarity improve.
- Efficient time management during the Section 1 examination is important. Go fast. Candidates have only one minute to read and interpret each question, consider the options and indicate an answer. Some questions will present cases with a longer stem.
- Each question carries a 1 in 5 chance of being correct, so be sure to provide an answer for every question. There is no negative marking.
- If an answer is not immediately clear, flag the question, mark a best guess (preferred to leaving it unanswered) and move on promptly with the foresight that returning later may not be possible. Flagging a question electronically will help expedite later review. Marking a best guess will avoid the common error of running out of time and throwing away marks.
- Read questions carefully and understand fully what the question stem is asking. All of the options presented may not be ideal, but one must be selected from the options available. Additionally, the answer to questions requesting the 'most appropriate management' may differ from those asking the 'next most appropriate step in management'.
- Candidate feedback suggests that around 20% of questions are straightforward. These test standard textbook knowledge, with answers easily narrowed down to perhaps two options (level 1). The remaining questions are less obvious, with detailed or ambiguous stems and similar answers requiring a more considered judgement (levels 2 and 3).
- Do not assume that ambiguous questions will be removed during the final quality assurance process, as very few questions are actually removed.
- In recent examinations there has been a greater emphasis on higher order anatomy questions. Consider reading an anatomy textbook and practice anatomy questions.

The Build-Up to the Examination

Much of the knowledge and judgement required for the FRCS (Tr&Orth) examination will have been acquired during training; however, the T&O syllabus is extensive, and the examination requires a lot of preparation. Applications are made through the JCIE website, where guidance notes, eligibility criteria and future dates for Sections 1 and 2 can be reviewed. Candidates should plan their preferred date or 'diet' for Section 1 after considering their likely personal and professional circumstances. For UK trainees with a National Training Number (NTN), the date of their ST6 ARCP review is an important waypoint. NTN trainees must achieve an Outcome 1 at their ST6 ARCP before they are eligible to apply. Those not in training are required to demonstrate a level of competence and knowledge equivalent to that achieved by NTN trainees at the end of ST6.

Be sure to read the JCIE 'Guidance Notes for Applicants' document far in advance of making an application.

The Section 1 examination is usually timed a few months ahead of the next Section 2 (clinical and viva voce) examination. The preferred exam dates for both parts are requested at the time of initial application; however, the date for Section 2 will only be confirmed after Section 1 is passed. First-time applicants must submit their application with full payment for both Sections ahead of the published deadlines, which are set approximately 10–12 weeks ahead of each Section 1 examination. The number of candidates permitted to complete Section 2 at each diet is capped and it is widely understood that candidates who apply far in advance of the application deadline are more likely to secure their preferred Section 2 date if successful at Section 1.

The following must be satisfied when completing the online application:

- Payment in full (covering Sections 1 and 2)
- Three completed Structured Reference forms
- Curriculum vitae
- Summary of operative experience
- Photographic identification

NTN trainees should submit three Structured Reference forms, including one completed by their Training Programme Director (TPD) and two by other consultants. Applicants not in training should provide structured references from the head of department (clinical lead) and two other consultants. To avoid unnecessary delays, candidates should contact potential referees far in advance of their planned application date.

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  This comprehensive and well-presented three-volume text is designed for the American Board examination. The final volume is dedicated to multiple choice question practice. An excellent but expensive resource.
- **Succeeding in the FRCS T&O Part 1 Exam**[3]
  This book has received mixed reviews, with the majority proving highly critical. Questions concentrate on factual recall and explanations can be confusing, unfocused and contradictory. It is perhaps a book to consider borrowing rather than buying and should not form a significant part of one's Section 1 preparation.
- **Practice Questions in Trauma and Orthopaedics for the FRCS**[4]
  The questions in this outdated book more closely reflect the standard of the MRCS examination and are far removed from that of the FRCS (Tr&Orth) Section 1 examination. Poor online reviews reflect the low level of knowledge examined.
- **First Aid for the Orthopaedic Boards (2nd Edition)**[5]
  This book is written for the in-service examinations (Orthopaedic In-Training Exam [OITE]) of the American Board. It receives mixed reviews, with the question style and depth differing from that observed in the FRCS (Tr&Orth) Section 1 examination. Although it is easy to read and may help you score a few extra points, it is expensive for what it provides.
- **Review Questions in Orthopaedics**[6]
  Originally written for orthopaedic residents preparing for the in-training (OITE) examinations of the American Board, this book (often termed the 'black book' by UK candidates) has remained a favourite supplementary question bank for the FRCS (Tr&Orth) Section 1 examination. Despite having been published in 2001, the comprehensive SBA questions and accompanying high-quality explanations have helped maintain its popularity. However, it may be time to re-evaluate, with recent candidates suggesting that the questions are outdated, difficult and esoteric when compared with the Section 1 examination.
- **1000 EMQs in Trauma and Orthopaedic Surgery**[7]
  This book does not reliably recreate the questions found in today's Section 1 examination and is of limited use. Some trainees have found the questions confusing and overly complicated. Perhaps doubly obsolete when considering that the EMQ format has been phased out.
- **FRCS (Tr&Orth): MCQ and Clinical Cases**[8]
  This book includes around 60 SBA questions and a similar number of worked viva voce cases taken from the *Bone & Joint Journal* (*BJJ*). Although most SBAs rely on factual recall (level 1), the book's primary merit lies with the good-quality explanations. Online reviews are mixed, with many preferring to use the book when preparing for the Section 2 examination.

Other Sources

- **Orthobullets**
  This website is an essential tool for the Section 1 examination. The generous question bank provides detailed explanations that link to the subject areas or chapters on the website. Candidates can revise topics and then construct sets of questions relevant to the area of focus (i.e. paediatric orthopaedics or arthroplasty). The website resembles a virtual textbook with topics generally covered in sufficient detail to guide revision. Topics appear to be loosely based on *Miller's Review of Orthopaedics*; however, bullet points largely replace the textbook prose, with a focus on American practice and the Board examination.

  The primary advantage of Orthobullets is the functionality that permits candidates to create bespoke SBA test papers. Candidates can set the

number and focus of the questions tested (i.e. random or subject-specific) and the time allocated per question. The site also maintains a record of performance, with scores presented according to test date and subject area. The primary disadvantage is that the free questions (more than 2,000) rely heavily on factual recall (level 1) and are generally of a standard below that required for the FRCS (Tr&Orth) examination. The paid-for premium content provides a higher standard but they still more closely resemble the style of the American Board examination.

- **UKITE**
  The United Kingdom In-Training Examination (UKITE) was established by the British Orthopaedic Association (BOA) in 2007 as a curriculum-based self-assessment tool for the FRCS (Tr&Orth) examination. It has evolved to emulate the Section 1 examination more closely. Although the breadth of the T&O curriculum is sampled, the UKITE assessment relies more heavily on questions testing factual recall. Completing the annual UKITE assessment during orthopaedic training is a useful formative assessment tool for monitoring progression and understanding the breadth of the T&O curriculum.
- **Postgraduate Orthopaedics**
  The newly revamped website includes SBA questions and case-based discussions that complement core revision material to help reinforce difficult key concepts and develop higher order thinking skills.

The Week of the Examination

As the Section 1 examination approaches, consider reducing exam day anxiety by travelling to the test centre in advance. Candidates should consider familiarising themselves with the venue, its surroundings and the available services (i.e. transport, parking, refreshments). For Section 2, consider arriving a day or more in advance of the exam for the reasons outlined above. Get into 'exam mode' by minimising distractions and arranging to meet other candidates for face-to-face practice.

Finally, good luck when revising for both parts of the FRCS (Tr&Orth) examination. It is a fair exam that represents the pinnacle of T&O surgical assessment and practice worldwide.

Notes

1 Dawson-Bowling SJ et al. *Orthopaedic Basic Science for the Postgraduate Examination: Practice MCQs and EMQs*. Gloucester: Orthopaedic Research UK Publishing; 2012.

2 Lieberman JR, ed. *AAOS Comprehensive Orthopaedic Review*. Rosemont, IL: American Academy of Orthopaedic Surgeons; 2009.

3 Gulam Attar F, Ibrahim T. *Succeeding in the FRCS T&O. Part 1: Exam*. London: BPP Learning Media; 2011.

4 Sharma P. *Practice Questions in Trauma and Orthopaedics for the FRCS (Master Pass Series)*. Milton Keynes: Radcliffe Publishing Ltd; 2007.

5 Mallinzak RA, Albritton MJ, Pickering TR. *First Aid for the Orthopaedic Boards*. 2nd ed. Bronson, TX: McGraw-Hill Medical; 2009.

6 Wright JM, Millett PJ, Crockett HC, Craig EV. *Review Questions in Orthopaedics*. Rosemont, IL: American Academy of Orthopaedic Surgeons; 2001.

7 Sharma H. *1000 EMQs in Trauma and Orthopaedic Surgery*. Glasgow: FRCS Orth Exam Education; 2008.

8 Khanduja V. *FRCS (Tr&Orth): MCQs and Clinical Cases*. London: JP Medical Ltd; 2014.

Chapter 2

SBA Writing Process

Paul Banaszkiewicz

Introduction

The National Board of Medical Examiners (NBME) item-writing manual is an excellent starting point for a more detailed analysis of the MCQ writing process.[1] It is widely referenced in this chapter, being a mainstay of guidance for question writers aiming to produce high-quality questions. The original 'red book' was updated to a 4th edition in 2016,[2] continuing to be the gold standard guidance book for improving the quality of multiple choice items.

The main question is: Do candidates really need to know the finer details of how to write good-quality SBAs and the processes involved in constructing the Section 1 paper? The answer is definitely yes, if you experience any major difficulties with this type of summative high-stakes exam. Some candidates do poorly with MCQ type questions, so any guidance is better than nothing.

For most candidates, some general information for the written paper is always useful, especially if it neatly summarises information from a variety of different sources that may be difficult or time-consuming to find otherwise.

Aims

By the end of this chapter, candidates should have a greater appreciation of the complexity of constructing SBAs to ensure a fair, valid and reliable Section 1 exam.

Going through the process of how SBAs are constructed will provide general guidance to a candidate in their overall preparation for Section 1.[3]

Investing extra time working through this chapter may score a candidate the extra couple of marks that may pull them over the line as a borderline pass.[4]

This chapter will make clear why there are so many poor-quality orthopaedic MCQ books out on the market. It is very difficult to construct a good-quality, new and relevant SBA and much easier to plagiarise existing questions already out there or spend an evening producing some poor-quality questions without understanding the sophisticated nuances of SBA construction.

Constructing good-quality SBAs needs considerable examiner training and question writers need to initially attend workshops for training and advice in their construction before being allowed to start contributing to the question bank.

Looking ahead, this chapter may prove useful reading if you end up writing MCQ type questions for exams in the future.

For aspiring TPDs or future examiners, it is important to know the intricacies of how to write SBAs and the processes involved in constructing the Section 1 paper. This will allow you to give more specific and useful advice to candidates who may be repeated failures on this section of the exam.

In any detailed lecture on Section 1 of the FRCS (Tr&Orth) exam reliability, content validity and educational theory (Miller's pyramid, Bloom's Taxonomy) are all discussed. Therefore, it is worth going over these terms since if unfamiliar these concepts can be difficult to grasp.

Last, those candidates with an educational slant will find the whole process of constructing the Section 1 exam fascinating.

Educational Theory

Miller in 1990 introduced an important framework that can be presented as four tiers/levels of a pyramid to categorise the different levels at which trainees needed to be assessed. Although SBAs can be used to test application of knowledge and higher order thinking, their construction is difficult and in general they assess the bottom two levels of 'knows' and 'knows how' in Miller's pyramid (Figure 2.1).[5]

Knows – Knowledge or information that the candidate has learned.

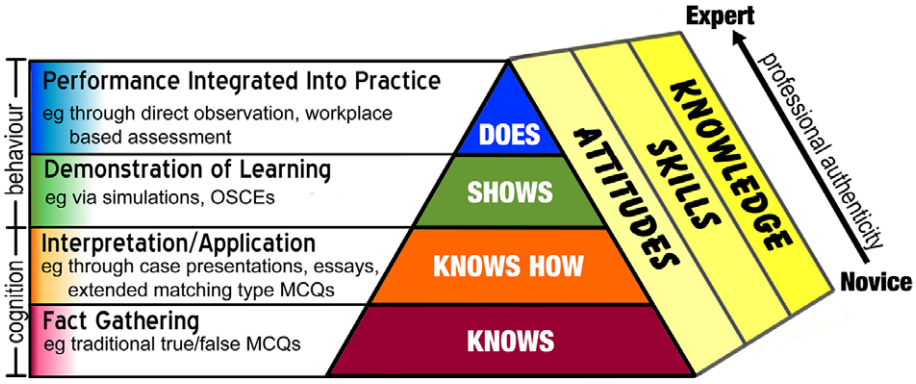


Figure 2.1 Miller's pyramid. The different layers represent the different components of clinical competency and how they can be assessed. WBAs attempt to assess how an individual performs in the workplace, i.e. what they actually do.

Knows how – Application of knowledge to medically relevant situations.

Shows how – Simulated demonstration of skills in an examination situation.

Does – Behaviour in real-life situations

Workplace-based assessments (WBAs) were introduced into the postgraduate curriculum because there were concerns that high-stakes examinations that used tests such as single best answers or EMI encouraged rote learning. It is also known that performance in a controlled assessment correlates poorly with actual performance in professional practice.

In 1956, Bloom et al.[6] described six levels in the cognitive domain: (1) knowledge recall; (2) comprehension; (3) application; (4) analysis; (5) evaluation; and (6) synthesis. Over the years Bloom's Taxonomy has been revised and alternative taxonomies created. A substantial revision occurred in 2001 to a more dynamic classification that uses action verbs to describe the cognitive processes and a rearrangement of the sequence within the taxonomy (Figure 2.2; Table 2.1).

More recently, the shape of Bloom's Taxonomy has been represented not as a pyramid – where there is a large base composed of facts and a tiny peak of creativity (which someone might interpret to mean that we should spend the majority of our time focusing purely on knowledge) to a broad wedge that better highlights the value of creating, evaluating and analysing (Figure 2.3).

Remembering: the candidate can remember previously learned material from long-term memory by recalling facts, terms, basic concepts and answers, e.g.

List the causes of . . .
What are the steps in . . . ?

Understanding: the candidate can explain ideas or concepts by organising, translating, interpreting, giving descriptions and stating main ideas, e.g.

Discuss the causes of . . .
Explain the pathophysiology.

Applying: the candidate can solve problems by applying acquired knowledge, facts, techniques and rules in a different way, e.g.

Provide a differential diagnosis.

Analysing: the candidate can distinguish between the different parts, how they relate to each other and to the overall structure and purpose. This involves examining and breaking information into parts by identifying motives or causes, making comparisons and finding evidence to support generalisations, e.g.

How will your differential diagnosis be altered in the light of investigation findings?

Evaluating: the candidate makes judgements and justifies decisions about information, presenting and defining opinions by making judgements about information, validity of ideas or quality of work based on a set of criteria e.g.

Justify your management of this patient.

Creating: the candidate puts elements together to form a functional whole, create a new product or point of view, e.g.

What will be your plan of management?

Bloom's Taxonomy is a hierarchical classification, with the lowest cognitive level being 'remembering' and the highest being 'creating'. The lower three levels

Table 2.1 Bloom's Taxonomy. Key words to use in questions pitched at each level.

Remember	Understand	Apply	Analyse	Evaluate	Create
Who	Demonstrate	Solve	Differentiate	Check	Design
What	Explain	Illustrate	Distinguish	Coordinate	Compose
When	Describe	Calculate	Analyse	Reframe	Create
Define	Interpret	Execute	Compare	Defend	Plan
Identify	Clarify	Carry out	Classify	Rate	Design
Describe	Classify	Discover	Contrast	Appraise	Formulate
Label	Categorise	Show	Separate	Critique	Produce
List	Differentiate	Examine	Explain	Judge	Construct
Name	Discuss	Choose	Select	Support	Organise Generate
State	Distinguish	Schedule	Categorise	Decide	Hypothesise
Match	Infer	Implement	Divide	Recommend	Develop
Recognise	Predict	Use	Order	Summarise	Assemble
Select	Identify	Make use of	Prioritise	Assess	Rearrange
Examine	Report	Employ	Divide	Choose	Modify
Locate	Select	Organise	Inspect	Defend	Improve
Memorise	Outline		Make assumptions	Estimate	Adapt
Quote	Review		Draw conclusions	Grade	Elaborate
Recall	Express			Find errors	
Retrieve	Translate			Compare	
Reproduce				Rate	
Tabulate				Measure	
Copy				Provide opinion	

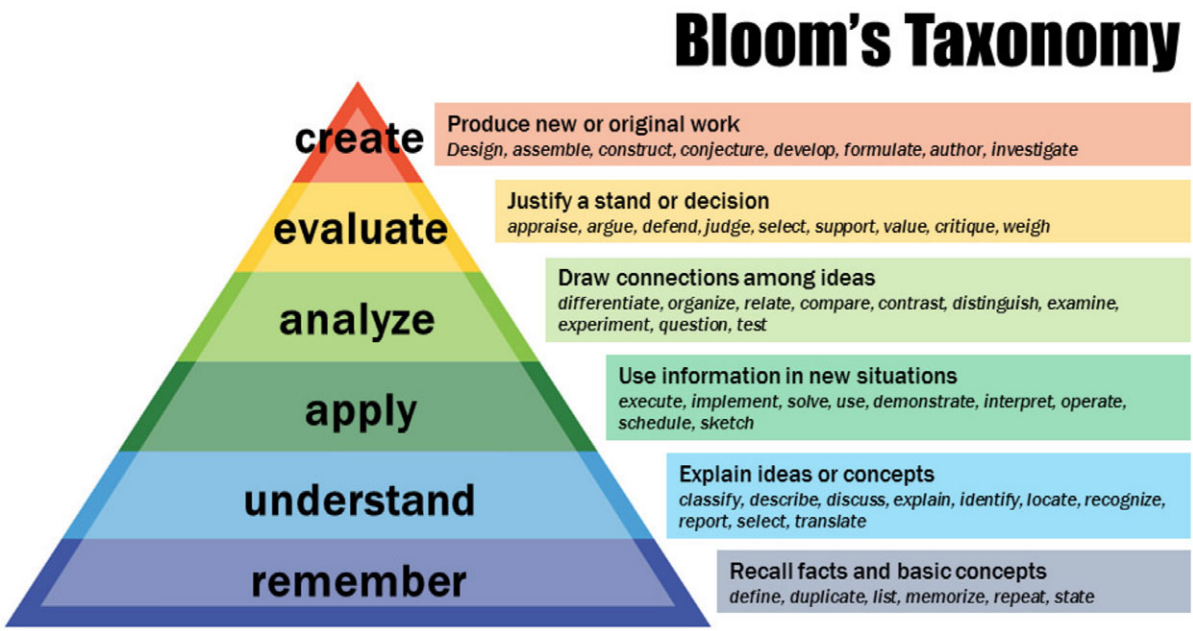


Figure 2.2 Bloom's Taxonomy

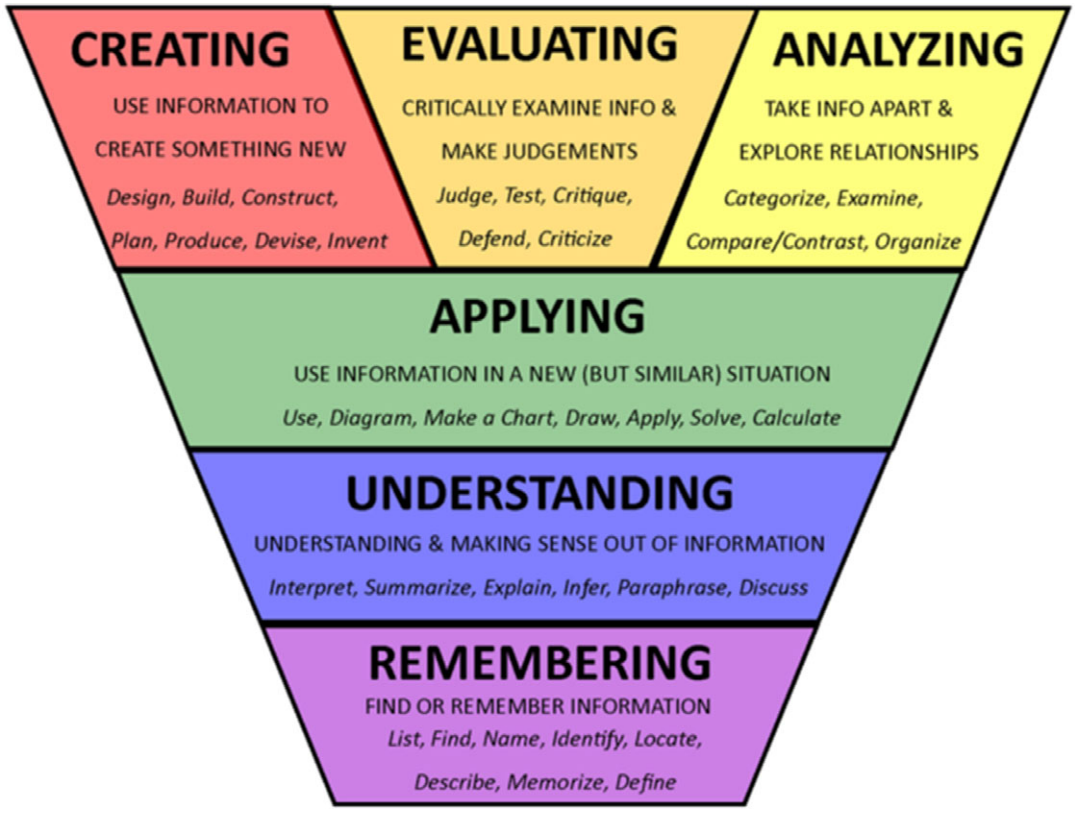


Figure 2.3 Modification of pyramid shape of Bloom's Taxonomy into broad wedge to better emphasise the value of creating, evaluating and analysing.

can be attained with superficial learning using so-called Lower Order Thinking Skills (LOTS) such as memorisation. The upper three levels involve Higher Order Thinking Skills (HOTS) and can only be attained by deep learning.

An ongoing development of the examination is the progressive rewriting of questions in the bank that are currently recorded as level 1 questions (factual knowledge) into higher order questions.

In constructing multiple choice items to test higher order thinking, it is helpful to design problems that require multilogical thinking, along with designing alternatives that require a high level of discrimination.

Higher Order Thinking

This is integration/interpretation (questions which require 'putting the pieces together') and problem solving (questions which require 'clinical judgement'), not simple recall (questions which can be answered with a Google search).

Multilogical Thinking

Multilogical thinking is defined as 'thinking that requires knowledge of more than one fact to logically and systematically apply concepts to a problem'.[7] There has been a conscious move to rewrite the question bank with SBAs that require multilogical thinking to answer.

Highly Discriminating Questions

These are questions that provide viable alternatives so that they require a high degree of discrimination to answer.

SBAs

Advantages of SBAs

- SBAs can assess a wide sample of curriculum content within a relatively short period of time.

This leads to high reliability and improved validity.
- They are a highly standardised form of assessment where all the trainees are assessed with the same questions. It is a fair assessment in that all the trainees sit the same exam.
- They are easy to administer and mark.
- SBA marking is mostly automated and hence examiner subjectivity is removed from the assessment process.

Main Disadvantages of SBAs

- The trainee's reasons for selecting a particular option/response cannot be assessed.
- Although a wide sample of assessment material can be assessed, the assessment does not provide an opportunity for an in-depth assessment of the content.
- Constructing good SBAs needs considerable examiner training.

Exam boards use a utility model to analyse different assessment tools:

Utility = (R) × (V) × (A) × (E) × (C) × (P)

R – Reliability. Can the exam results of a given candidate in a given context be reproduced? To what extent can we trust the results?

V – Validity. Does the assessment assess what it purports to assess?

A – Acceptability. How comfortable are the different stakeholders (candidates, examiners, examination boards, public, National Health Service) with the examination system?

E – Educational impact. Does the exam drive the trainees towards educationally and professionally valuable training?

C – Cost effectiveness. Is the expenditure– in terms of money, time and manpower– to develop, run and sustain the examination process worthwhile in relation to what is learned about the candidate?

P – Practicability. How 'doable or workable' is the assessment instrument, given the circumstances? Are there sufficient resources to mount the exam?

Applying the utility model for SBAs we get

Reliability: high

The SBA results are highly reliable, as almost identical scores can be obtained if a similar candidate with similar ability is given the same set of SBAs, regardless of who marks the questions.

Validity: high for knowledge recall

An SBA is good at testing factual recall of knowledge. They can also be used to test application of knowledge and higher order thinking, although the construction of such SBAs is difficult and requires training.

Acceptability: high

SBAs have been used extensively in medical education. Both trainees and examiners have come to accept them. Constructing good SBAs, however, is difficult.

Educational impact: (moderately)

Properly constructed SBAs will drive the learner towards learning important information.

However, SBAs developed to test trivial knowledge will lead to rote learning. Fragmentation of knowledge is another criticism.

Cost: moderate

The cost of administering an SBA test is low. In contrast, face-to-face peer review meetings of submitted SBAs are expensive to hold, as they involve substantial travel and accommodation costs. However, the quality of scrutiny that can be brought to bear on the question material justifies this outlay and affords considerable confidence in the quality of the product.

Practicability: high

SBAs are easy to administer as a computer-based assessment.

Item Analysis of SBAs

Item analysis output indicates the percentage of candidates in the various subgroups who selected each option of an SBA.

Each SBA is analysed as to the percentage of candidates scoring it correctly from each subgroup. The test group is usually divided into fifths, as this allows more detailed analysis around the pass/fail than if quartiles were used.

The spread should be like a Gaussian curve. The exam board members are not very interested in distinguishing the very best or worst candidates. The curve is concentrated in the centre and the exam board members want to spread this middle area out so that one question cannot decide if a candidate passes or fails the exam.

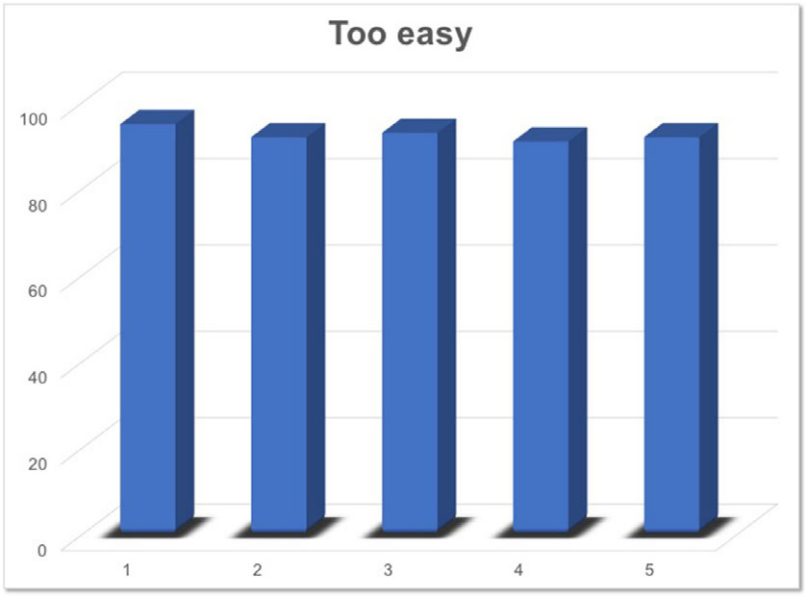


Figure 2.4 Easy SBA

Point biserial is a measure of the correlation between a candidate's score in that question and their overall score. You would expect a high point biserial – this means that good candidates did well in it.

A low point biserial – the good candidates did badly in it.

A negative (or zero) point biserial is flagged up because the question is doing the opposite of what it should – i.e. the poor candidates are getting it correct and the good candidates are getting it wrong.

Easy Questions

With these questions (Figure 2.4), around 90% of candidates get the correct answer. As such, easy questions do not discriminate between the performance of a very good or very bad candidate. More importantly, an easy question does not differentiate between candidates around the level of minimal competence required for a pass. When paper 1 analysis flags up these questions, they are either scrapped or have to be extensively reworked.

Difficult Questions

These questions (Figure 2.5) are just as useless as an easy question. Again, they do not differentiate between a good or bad candidate or, more importantly, make a distinction between borderline candidates – those who can be passed and those who must re-sit. As with easy SBAs, difficult SBAs are discarded if they are also of poor quality and require very extensive rewriting.

Poorly Performing Questions

These questions (Figure 2.6(a) and (b)) may involve the bottom 20% of candidates getting an SBA mainly correct while the top 20% of candidates mainly get it incorrect. It is a poor SBA, as overall it is not following candidate form. Another example is where there has been a random spread of correct answers between groups.

Usually the question is poorly written, the wrong answer has been selected by the examiners or there has been an error of typing.

Poorly performing questions are removed. Questions that have more than 90% or 10% failed/pass are also removed.

All questions that score poorly, i.e. where the percentage of correct responses to that alternative is below 30%, are checked. Questions where the top 20% of candidates score significantly lower than average are also reviewed.

Good Performing Questions

There is a gradation in candidates obtaining the correct answer from the top one-fifth mainly scoring the question correctly to the bottom one-fifth with candidates mainly scoring it incorrectly (Figure 2.7).

This question discriminates. There is point by point discrimination; if it is >0.3, it is a good question.

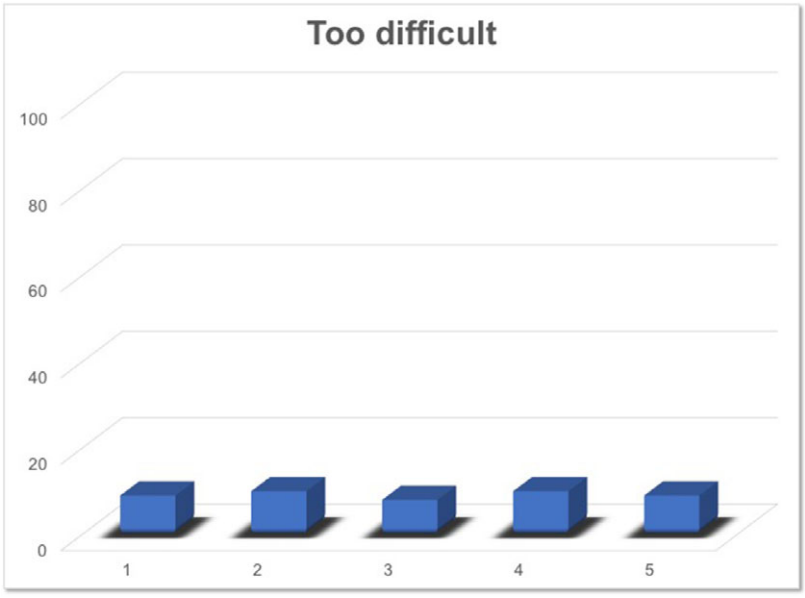


Figure 2.5 Difficult SBA

Ideal SBA

These questions (Figure 2.8) discriminate candidates at the pass/fail mark. A good quality question should be answered correctly by 35–85% of just passing candidates (defined as those scoring an overall mark within 10% of the pass mark).

There should also be an obvious positive correlation between the performance of the cohort on the individual question and in the examination as a whole (i.e. the question should be answered correctly by appreciably more passing candidates than failing candidates). A reasonable proportion of candidates (especially those who did not pass) should also have chosen each incorrect option.

Item analysis determines difficulty index (DIF I) (p-value), discrimination index (DI) and distractor efficiency (DE).

Difficulty Index (DIF I)

DIF I measures the difficulty of an individual item on the test paper. It is calculated by adding the correctly answered items by the upper 33% and lower 33% of candidates' performance divided by total number of candidates in both the groups:

DIF I = [(H+L)/T] × 100,

where H and L are number of correct responses in the high and low achiever groups, and T is the total number of responses in both the groups. Thus, the higher the score is, the easier the item.

Discrimination Index (DI)

DI is a measure of how well an individual item can differentiate between the high and low performing students (top and bottom 33%):

DI = [(H-L)/T] × 2

DI >0.35 is acceptable and the higher the DI, the more differentiating is the item.

Distractor Efficiency (DE)

Plausible distractors are defined as the distractors selected by >5% of candidates.

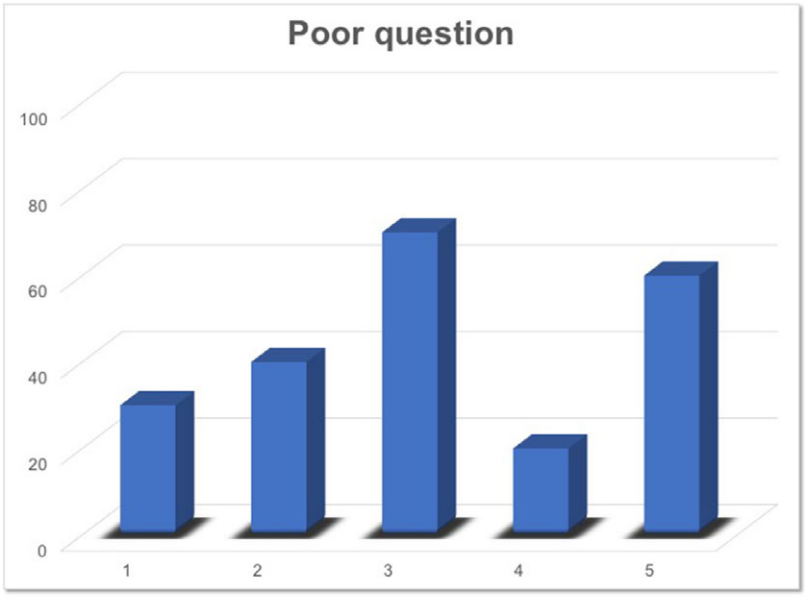
Non-functional distractors (NFDs) are the options selected by <5% of candidates.

Distractor efficiency (DE) for any item is calculated by the numbers of NFD contained in it and ranges from 0–100%.

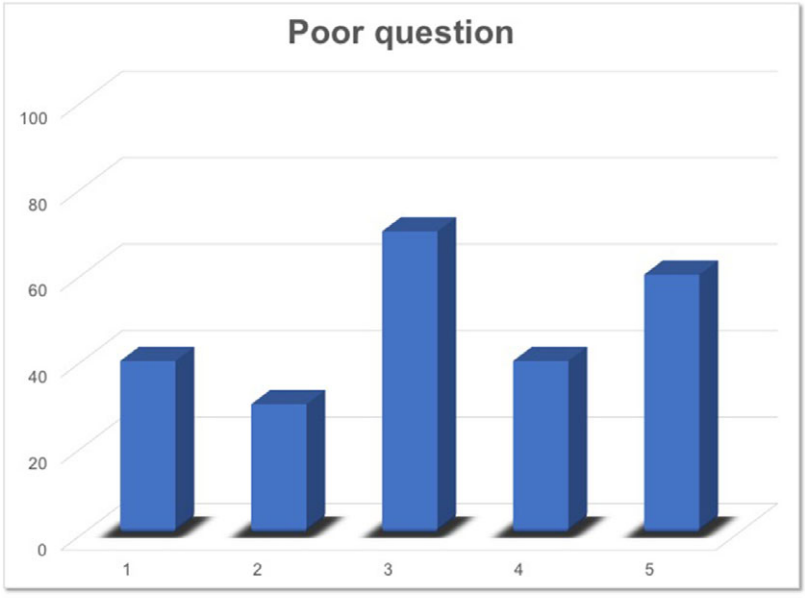
DE is expressed as 0%, 33.3%, 66.6% and 100% depending on the number of NFDs as 3, 2, 1 and 0, respectively.

NFDs are replaced with better plausible distractors by experts involved in rewriting the items.

A low DIF I (very difficult item) and a low DI (poorly discriminating item) ultimately leads to applying corrective measures to readjust and



(a)



(b)

Figure 2.6 (a) and (b) Poorly performing SBAs

administer the item again. Items that have DI <0.2 are either too easy, too difficult, have confusing wording or several correct answers.

Every question in every exam is statistically dissected, and each exam compared with all previous exams.

The cut score

Who should pass the exam?

- Option 1: The top 30%.
- Option 2: Those who get over 60% of questions correct.

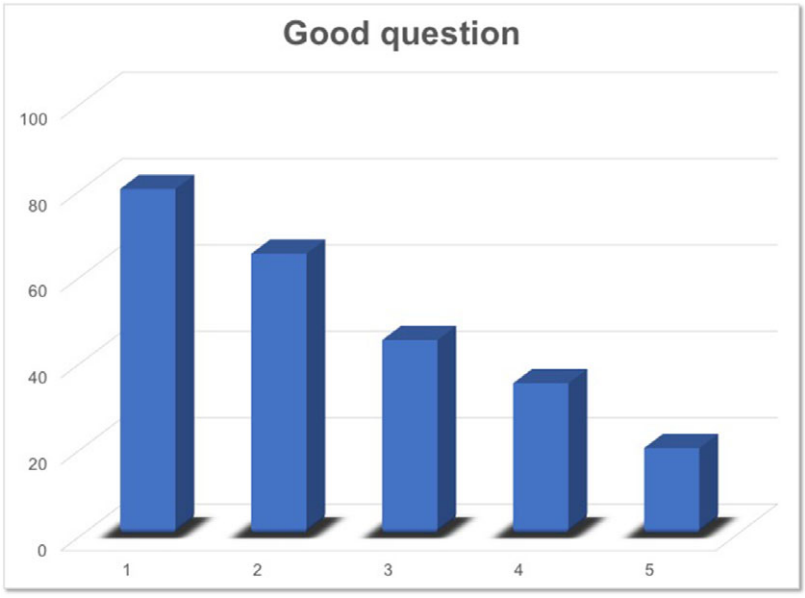


Figure 2.7 Good SBA

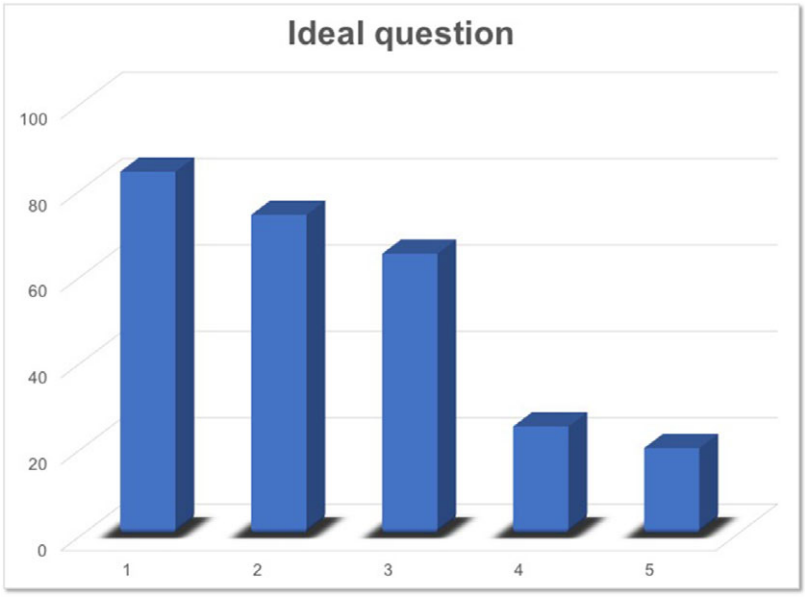


Figure 2.8 Ideal SBA

- Option 3: Those who have demonstrated an adequate level of competence in this exam.

Option 1 is flawed as this would mean that a candidate pass is based on who they had sat the exam with; it also means that the JCIE are not in control of the standard: who is to say that the top 30% of candidates actually met the minimum standard expected of a day one consultant?

Option 2 is flawed because it would mean that a candidate's pass or fail is based on the specific questions used in that diet; some sets of questions will be slightly easier or more difficult than others, so the pass mark needs to reflect the difficulty of the questions.

Option 3 is the correct option. This is based on the cut score.

The cut score is the minimum score/level of competence a candidate must achieve in order to have career progression.

The minimally competent candidate

The first step in standard setting is agreeing on the characteristics of the minimally competent candidate.

This is an imaginary candidate who you would be happy to see scrape through, but only just. Not the ideal average performance. A barely safe candidate.

'They would manage at the next level of career progression, but there's definitely still room for significant improvement.'

'The greenest of the red apples.'

Generating a cut score

Once the exam board have defined what a barely competent day one consultant is, they now have to decide on a 'cut score' or score which the barely competent consultant should achieve.

From 'how good is good enough' to 'how many points does a candidate need to pass'.

The Angoff method is used to determine this.

Angoff Method

The Angoff method is a widely used standard setting approach in test development. It is a type of test that the Intercollegiate Board (ICB) uses to determine the passing percentage (cut score) for a test.

It involves a cut-off mark based on the performance of candidates in relation to a defined standard (absolute) as opposed to how they perform in relation to their peers (relative). It involves a judgement being made on exam items (test-centred) as opposed to exam candidates (examinee-centred) and is widely used to standard set high-stakes examinations. It is most reliable when supported by another standard setting method.

How is Angoff Calculated?

A group of senior examiners are asked, 'What percentage of borderline candidates would answer this SBA correctly?' Before making a judgement, the examiners must agree on the definition of a 'borderline' candidate.

All examiners must have the same definition of a borderline candidate for the Angoff cut-off score to be reliable. This requires a good understanding of what makes a candidate competent enough to be passed, hence why the examiners must be experienced.

Each examiner works independently and considers each question in turn. Each expert's judgement for an item should be the same or within a close, defined range (around 10%). The mean of everyone's judgement is calculated for each item; this is often referred to as the 'predicted difficulty'. Each predicted difficulty (mean) is added together and divided by the total number of items in the exam to get the cut-off percentage. This percentage of the total marks for the exam indicates the cut-off mark (Table 2.2).

If the examiners' judgements are not unanimous, they discuss how they came to their decision in an effort to come to an agreement. The Angoff is then recalculated based on the new judgements. This process may be repeated.

Remember that there are 5 options in a multiple choice question, and the probability of answering correctly by chance is 2/10. Therefore, we would not expect an SBA to score below 2 for minimally competent candidates to choose the correct option. This is not a hard rule but an SBA scored lower than 2 means that this is lower than the probability of guessing, which is unusual.

Equally, there is no rule against using 10 as the score a minimally competent candidate should score, but this should not be the norm. What the exam board is looking for is the probability that a day one consultant 'would' answer correctly, not what we think they 'should' do in an ideal world.

An additional method of supporting the Angoff method is to use another standard-setting method, such as borderline regression to provide results based on real candidate data for comparison. Also, if the final candidate results do not reflect the standard that would be expected of the candidates taking the exam, the standard-setting method can be re-evaluated.

Advantages of Using Angoff

The advantages include the following:

- Holds up in court – Angoff is the most widely used, formal method of standard setting. There are many published works on Angoff, and it is justifiable for use in high-stakes examinations. If questioned, the Angoff method would hold up in court.
- Reflects the difficulty of the content – Angoff focuses on just the content of the exam and the

Table 2.2 Table 2.2. Angoff method. The total average percentage is 56.7. This can be rounded to 57, giving a cut-off percentage of 57%. If the test were out of 100 marks, a borderline candidate would be expected to get 57/100 marks.

Q.	Examiner 1 (%)	Examiner 2 (%)	Examiner 3 (%)	Examiner 4 (%)	Examiner 5 (%)	Examiner 6 (%)	Examiner 7 (%)	Examiner 8 (%)	Examiner 9 (%)	Examiner 10 (%)	Mean (%)
1	60	60	55	60	65	60	55	60	60	60	59.5
2	70	70	70	70	70	70	70	70	70	70	70
3	55	50	55	50	55	55	55	50	55	50	53
4	60	60	60	65	60	60	60	60	65	60	61
5	60	65	70	70	60	70	65	70	65	70	66.5
6	50	45	50	50	45	50	45	50	45	50	48
7	60	60	60	60	60	60	60	60	60	60	60
8	50	50	50	50	50	50	50	50	50	50	50
9	55	60	55	55	55	55	55	60	55	60	56.5
10	40	40	45	45	40	40	45	45	45	40	42.5
Cut-off percentage											57

level at which candidates should be performing to meet a certain standard.
- Simple when you know how – This is a fairly straightforward process once all judges are trained.
- Recyclable – If an item is reused in another exam with the same context (same year group), the Angoff 'predicted difficulty' can be re-used so subject experts have fewer items to judge.

Disadvantages of Using Angoff

The disadvantages include the following:

- Needs back-up – It does not use real exam data to estimate a cut-off mark, so it is considered more accurate and reliable if backed up by a criterion-referenced method, e.g. borderline regression.
- Long process – The process can be time consuming and labour intensive, as examiners must look at every test item. This can lead to examiners becoming fatigued and impatient and can encourage rushing through the items.
- Confidence is key – Examiners must be experts in their field. This method relies on the examiners being confident and consistent with their definition of a 'borderline' candidate, and not just assuming an 'average' candidate.
- Time and a place – You need a large number of examiners for accuracy and reliability.

Reducing the Effect of Outliers

If the examiner is a hawk . . . they would score high . . . so the cut score would be too high . . . so many good candidates may not pass.

If the examiner is a dove . . . they would score low . . . so cut score would be low . . . so some poor candidates will get through!

Therefore, outlier scored questions may need to be removed or rewritten to get a more consistent examiner response.

Removing the Effect of Outliers

Removing negative or low point biserial questions.

Construction of the Paper

- The full curriculum will be sampled and usually 320 SBAs are submitted for consideration of inclusion into the paper.
- This will be a mixture of new SBAs and well performing SBAs.
- Around 60 SBAs will be removed as they are too easy, difficult, ambiguous etc.
- Another 20 SBAs are removed after further analysis.
- This leaves the required 240 SBA questions needed for each diet of exams.

SBA Checks before Finalisation of the Paper

- The paper is sat by at least 10 examiners with feedback obtained about the suitability of the included questions. A number of the included questions will be removed.
- Paper scrutiny by a senior experienced group of examiners and removal of further SBAs that are deemed necessary.
- Head examiner. He/she has the final say for approving the paper.

Standard Error of Measurement (SEM) and the GMC

If we consider that the whole exam had only 10 questions and all of the examiners independently concluded that 6 of every 10 borderline candidates would get each question correct, then a pass mark of 6 out of 10 (60%) would mean that 50% of borderline candidates would pass and 50% would fail. The pass mark therefore divides the borderline candidates down the middle. If the exam has a lot of hard questions, the pass mark will be lower. If there are a lot of easy questions, it will be higher. The mark is unique to each diet.

The Angoff-derived pass mark is not the mark determining eligibility to proceed, however. The GMC argue that there is some uncertainty in judgements made in this way, which can be expressed statistically as the Standard Error of Measurement (SEM). For patient safety reasons, the GMC would not want incompetent candidates being allowed to proceed, even if removing them means some potentially competent candidates are prevented from doing so.

The exam boards emphasis must be on patient safety. It is much more defensible to fail a candidate who is just more than competent than to pass one who is not competent.

The eligibility to proceed mark is therefore the Angoff-derived mark plus one SEM. When this step was first introduced, the historical performance of candidates scraping through was reviewed and it was noted that they went on to fail Section 2, so this rule in fact saves some candidates a whole lot of money!

The SEM allows us to identify what the GMC refer to as 'borderline candidates' either side of the cut score.

Borderline Candidates

There is an attempt to standardise the exam so that around 33% (1 standard deviation) of borderline (just competent) candidates will pass.

The exam mark is adjusted to prevent a large percentage of borderline candidates passing.

Consider Figure 2.9. If the middle dotted line is the Angoff determined 'cut score' of the 'barely competent day one consultant' then the SEM represents what the GMC classes as the 'borderline candidate'.

Applied to a bell-shaped curve then 34 +16 = 50% of time a barely competent candidate will pass.

If we were to add one SEM to the 'cut score' then only 16% of time will the barely competent candidate pass.

- Anyone whose 'true score' is below the 'true score' of the 'day one consultant' therefore has less than a 16% probability of achieving a score above cut score + 1 SEM.

The emphasis must be on patient safety. It is much more defensible to fail a candidate who is just more than competent than to pass one who is not

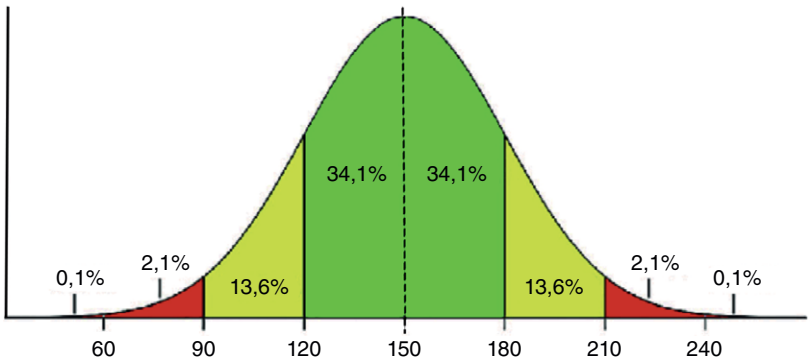


Figure 2.9 Classic 'bell curve' shape of normal distribution. The mean (or average) is the vertical line at the centre, and the vertical lines to either side represent intervals of one, two and three SDs. The percentage of data points that would lie within each segment of that distribution are shown.

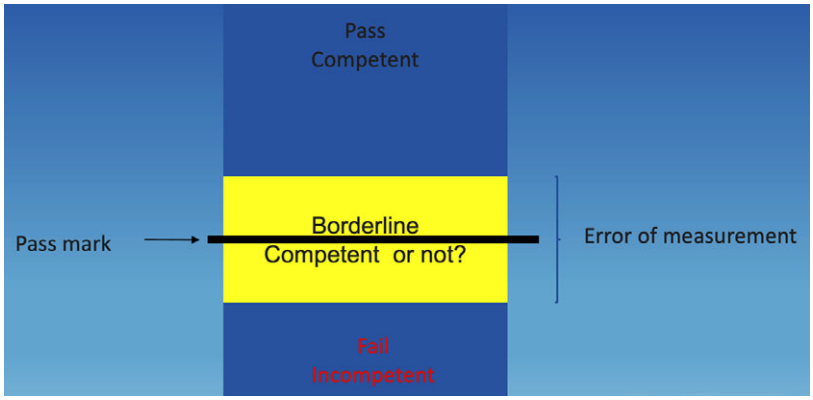


Figure 2.10 Borderline candidate and Angoff-derived mark plus one SEM.

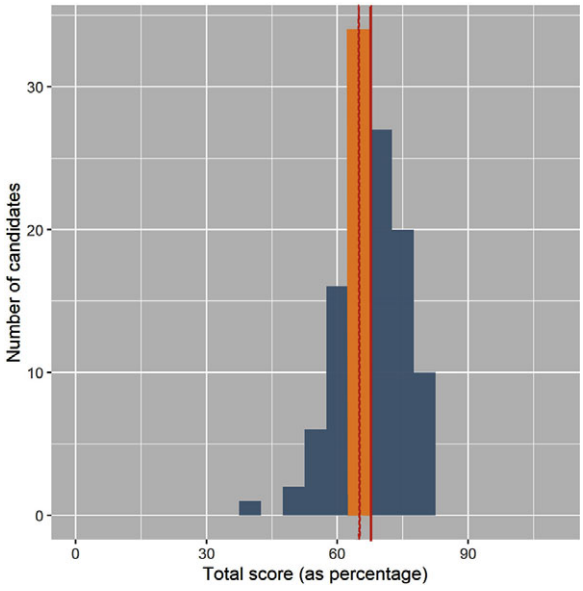


Figure 2.11 Borderline candidates and Angoff-derived mark plus one SEM added to the cut score.

competent (Figure 2.10). Therefore we add 1 SEM to the cut score (Figure 2.11).

Reliability

Reliability is a Measure of Consistency

It is useful to think of kitchen scales. For weighing scales to be reliable, you would expect that if you weighed 80 kg 10 minutes ago you would still weigh the same now. If the scales said you weighed 40 kg now, you would not rely on those scales.

If the scale is reliable, then when you put a bag of flour on the scale today and the same bag of flour on tomorrow, then it will show the same weight. But if the scale is not working properly and is not reliable, it could give you a different weight each time.

A reliable exam paper should produce the same result if the test is repeated. Ideally, for an exam to be highly reliable, it should produce the same result if the candidate takes the same test on two different occasions. If it produces very different results on separate occasions, it can be argued that the exam has low reliability and can therefore not be trusted as a means of grading or judging whether a candidate is competent.

How Can You Tell if a Test is Reliable (Cronbach's alpha)?

In most cases, we cannot get candidates to take the same test twice to measure reliability, so the internal consistency is measured with an alternative method. Internal consistency reliability measures the degree to which every test item measures the same construct.

The closer the score is to 1, the higher the reliability will be. As a rough guide, exams should have a Cronbach's alpha of 0.8 or greater. With high-stakes exams, the reliability needs to be high because one exam is usually used to decide whether a student passes or fails. Around the world, few professional examinations, particularly in medical specialties, achieve a Cronbach's alpha of 0.8.

Validity

As well as being reliable, it is important that a test is valid, i.e. measures what it is supposed to measure. Continuing the kitchen scale metaphor, a scale might consistently show the wrong weight; in such a case, the scale is reliable but not valid.

There are a number of ways in which validity can be increased. These include the following:

Item analysis reporting. This flag questions that do not correlate well with the rest of the assessment. One of the reasons a question might get flagged is because participants who do well on other questions do not do well on this question – this could indicate the question lacks content validity.

Item bank. Use an item bank to store well-performing, defined topic questions.

Review and update the question bank frequently. Orthopaedic knowledge base can change quickly with changing technology and changing regulations. Many questions that were valid 2 years ago are outdated today. Using an item bank allows you to update or retire questions that are no longer relevant.

Use assessment blueprinting. The blueprint confirms that the exam tests a representative sample of all the appropriate curriculum outcomes and a representative sample of all the curriculum content.

Involve subject matter experts (SMEs). The more you involve senior exam writers in assessment development, the more content validity you are likely to get. Get a panel of SMEs to rate each question as to whether it is 'essential', 'useful, but not essential', or 'not necessary' to the performance of what is being measured. The more SMEs who agree that items are essential, the higher the content validity will be.

Blueprinting the Curriculum

To ensure adequate content coverage and, therefore, that the exam is a valid test of the breadth of knowledge of orthopaedics, the process of blueprinting occurs. A spreadsheet is created that maps each of the questions to a learning objective on the curriculum. The assessment blueprint is a grid that plots the curriculum/assessment outcomes in columns against the curriculum content in rows.

Constructing SBAs

In order for an SBA to be good, it must fulfil two basic criteria: (1) what the question tests should be important and (2) the question is well structured.

SBAs consist of a stem (e.g. a clinical case presentation) and a lead-in question, followed by a series of choices, typically one correct answer and four distractors.

The following sections outline an example of an SBA.

Stem

A 60-year-old man presents to casualty 5 days following left ceramic on ceramic total hip replacement with increasing left hip pain. He was discharged from hospital 2 days after surgery with a plan for follow-up at 3 months. On examination, he is apyrexial, normotensive with modest hip discomfort with movement.

Lead-In

Which of the following is the most likely diagnosis?

Options

A. Ceramic head fracture
B. Ceramic liner fracture
C. PJI
D. Non-specific hip pain
E. Squeaking ceramic interface

All options may be correct, but at 5 days non-specific hip pain is the most likely diagnosis. The patient has been discharged from hospital after 2 days and increased their activity levels. While it is important to rule out early periprosthetic joint infection (PJI), it should be rare, under 1%, and there would be more clues towards this in the stem such as a leaky wound or high temperature. Likewise, ceramic head or liner fractures are rare but possible causes of hip pain. With the fourth-generation Bioloc Delta ceramics, the incidence of ceramic head fractures has significantly reduced but there has been no corresponding change in liner fracture incidence. Likewise, if there was a ceramic fracture a bit more would be given in the history to point candidates in this direction. Squeaking is not uncommon following ceramic on ceramic total hip arthroplasty (CoC THA) (around 7%), and while it can be annoying is usually not painful.

Even though the less likely answers are not wrong, they are less correct than the 'keyed answer'. The candidate is instructed to select the most likely diagnosis and experts would all agree that the most likely diagnosis is D. They would also agree that the other diagnoses are somewhat likely, but less likely than D. As long as the options can be laid out on a single continuum, in this case from 'Most Likely Diagnosis'

A	B	C	E	D
Least Correct				Most Correct

Figure 2.12 SBA construction

to 'Least Likely Diagnosis', options in one-best-answer questions do not have to be totally wrong (Figure 2.12).

Options are homogeneous (i.e. all possible diagnoses) and high-calibre candidates will be able to rank-order the options along a single dimension.

Well-constructed one-best-answer questions satisfy the 'cover-the-options' rule. The questions could be administered as write-in questions. The entire question is included in the stem.

Example of Poorly Constructed SBA

Which of the following is true about pseudogout?

A. It occurs frequently in men.
B. It is seldom associated with acute pain in a joint.
C. It may be associated with a finding of chondrocalcinosis.
D It is clearly hereditary in most cases.
E. It responds well to treatment with naproxen.

This item is flawed. There is no lead-in. After reading the stem, the candidate has an unclear idea what the question is about. In an attempt to determine the 'best' answer, candidates have to decide whether 'it occurs frequently in men' is more or less true than 'it is seldom associated with acute pain in a joint'. This is a comparison of apples and pears. Why are you trying to compare those things which you can't?

In order to rank-order the relative correctness of options, the options must differ on a single dimension or else all options must be absolutely 100% true or false.

The diagram of these options would look like Figure 2.13. The options are heterogeneous and deal with miscellaneous facts; they cannot be rank ordered from least to most true along a single dimension. Although this question appears to assess knowledge of several different points, its inherent flaws preclude this. The question by itself is not clear; the item cannot be answered without looking at the options.

It has also been proposed by the ICB to avoid using negative A-type questions in SBAs.

The most problematic are those that take the form: 'Each of the following is correct EXCEPT' or 'Which of the following statements is NOT correct?'

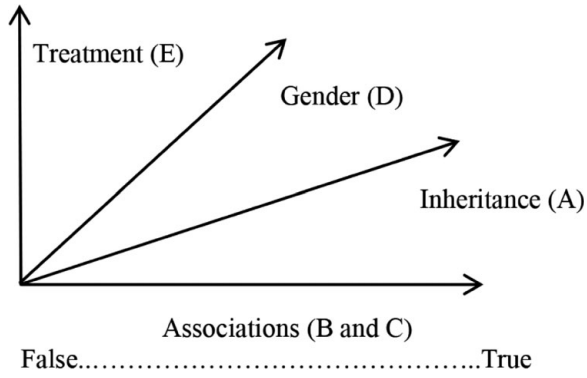


Figure 2.13 SBA formats

These suffer from the same problem as true/false questions: if options cannot be rank ordered on a single continuum, the examinees cannot determine either the 'least' or the 'most' correct answer.

On the other hand, the ICB occasionally uses well-focused negative A-types with single-word options, largely as a (poor) substitute for items that instruct the examinee to select more than one response.

Technical Item Flaws

This section is based on technical item flaws from chapter 3 in Paniagua and Swygert, constructing written test questions for the basic and clinical sciences.[8] The chapter provides specific examples of technical item flaws.[9]

Two important types of technical item flaws are (1) testwiseness and (2) irrelevant difficulty.

Flaws related to testwiseness make it easier for some students to answer the question correctly, based on their test-taking skills alone. These flaws commonly occur in items that are unfocused.

Flaws related to irrelevant difficulty make the question difficult for reasons unrelated to the trait that is the focus of assessment.

Examination boards are keen to eliminate flaws to provide a level playing field for testwise and not so testwise candidates.

Flaws Related to Testwiseness

Grammatical Cue

One or more distractors do not follow grammatically or logically from the stem. Testwise candidates are able to spot this and eliminate them from the options.

Logical Cue

If several but not all of the options are very similar, this can suggest that the answer is in this subset. Try to make the options as homogeneous as possible.

Longest Answer is 'Single Best Answer'

The correct answer is longer, more specific or more complete than the other options.

Repeated Words

A word or phrase included in both the stem and the correct answer can act as a clue towards a correct guess.

Use of Absolute Terms

Absolute terms such as 'always' or 'never' should not be used in options.

Presence of Convergence

This is less obvious to spot but occurs fairly commonly. The correct answer includes the most elements in common with the other options. The underlying premise is that the correct answer is the option that has the most in common with the other options; it is not likely to be an outlier.

Presence of Grouped or Collectively Exhaustive Options

A testwise student can identify a subset of options that cover all the possible outcomes (are collectively exhaustive) and rule out the options not in that subset.

Flaws Related to Irrelevant Difficulty

Overly Complicated or Long Questions

The stem contains extraneous reading and the options are very long and complicated. Trying to decide among these options requires a significant amount of reading because of the number of elements in each option.

Numerical Data are Not Consistently Presented

Numerical options should be listed in a consistent manner and not mixed (ranges and percentages).

Terms in the Options or the Stem are Vague

Vague frequency terms in the options such as 'often' or 'usually' are used. Value frequency terms are not consistently defined or interpreted even by experts.

'True/False'

If the options are all either completely correct or completely incorrect, the question does not follow the 'single best answer' approach and is most likely pitched at the recall level. Options should be on a continuum from least to most appropriate.

These types of questions are found in some orthopaedic MCQ books.

'None of the Above' is Used as an Option

The phrase 'none of the above' is problematic in items where judgement is involved and the options are not absolutely true or false. Use of 'none of the above' essentially turns the item into a true/false item; each option has to be evaluated as more or less true than the universe of unlisted options.

Language or Structure of the Options is Not Homogeneous or Parallel

The format and structure of each option is different.

Window Dressing

Window dressing in an MCQ is information in the item itself which is superfluous to the content being assessed. It is not about shorter versus longer stems but about the relevance of what is there.

Unnecessarily Complicated Stems

Stems should be meaningful by themselves and should present a definite problem.

They should not contain irrelevant material that may decrease a test score's reliability and validity. Stems should include as much of the item as possible; stems should be long and the options short.

Stems Contain Negative Phrasing

Items which ask a question in the negative (e.g. 'which is the least appropriate . . .') are confusing to candidates who have to switch between best and worst answers and are contrary to the mode of reasoning in most clinical situations. The stem should be

negatively stated only when a significant learning outcome requires it.

Alternatives/Distractors

All alternatives should be plausible. Alternatives should be stated clearly and concisely. Items that are excessively wordy assess a candidate's reading ability rather than the attainment of the learning objective.

They should be homogeneous in content. Alternatives that are heterogeneous in content can provide cues to candidates about the correct answer.

Alternatives should be free from clues about which response is correct. Sophisticated test takers are alert to inadvertent clues to the correct answer, such as differences in grammar, length, formatting and language choice in the alternatives.

General Guidelines

Avoid using absolutes such as 'always', 'never', and 'all' in the options; also avoid using vague terms such as 'usually' and 'frequently'.

Avoid using 'all of the above' and 'none of the above'. They are problematic in items where judgement is involved, and the options are not absolutely true or false. In either case, candidates can use partial knowledge to arrive at a correct answer.

Focus on important concepts; do not waste time testing trivial facts.

MCQ Question Writing Committee

This committee meets every 3 months with around 20 or so experienced examiners attending.

They begin by looking at some of the SBAs that have been flagged statistically as possibly poor performers. Some questions will already have been removed automatically – for example, all of the questions that proved too easy or too hard (usually new questions, as any question previously used would have passed this hurdle already).

The examiners will review each question and decide whether it is a fair question that should stay in the exam or is flawed and should be removed and returned to the question writers. Typical reasons for the latter would be ambiguity that had not previously been recognised, new evidence that has challenged the previously decreed correct answer, or simply that the answer in the bank is wrong.

It is worth noting that some very good questions end up being flagged as having possible wrong answers yet remain in the exam. If a question is hard so that only 20% of candidates answer it correctly, then 80% will choose a wrong response. Let's say 40% chose one of the incorrect options – this flags as a possible wrong answer automatically, as more candidates have chosen a specific incorrect response than the correct one.

Once the poorly performing questions have been dealt with, the Angoff procedure is performed.

New speciality question writers need to attend workshops in how to write SBAs before being allowed to submit questions. Existing question writers need to attend face-to-face meetings every 3 months. At these meetings, new questions are submitted to the panel for review and possible inclusion in the question bank. These meetings are expensive to hold, involving travel and possibly accommodation expenses but deemed worthwhile as they allow face-to-face scrutiny of the questions submitted for the question bank.

Basic Rules for Writing SBAs

- Each item should focus on an important concept or testing point.
- Each item should assess application of knowledge, not recall of an isolated fact.
- The item lead-in should be focused, closed and clear; the test taker should be able to answer the item based on the stem and lead-in alone.
- All options should be homogeneous and plausible, to avoid cueing to the correct option.
- Always review items to identify and remove technical flaws that add irrelevant difficulty or benefit savvy test takers.

One minute rule

- Each question should be able to be read by the candidate within 1 minute maximum.
- If the stem is too lengthy it will need to be edited into a readable length.

SBA Writing Guidelines: Dos and Don'ts

Getting Started

1. Identify an area of the curriculum blueprint that is to be sampled.
2. Identify the topic area and the level of thinking that you want to test and write a question around this

which mimics tasks that successful candidates must be able to undertake at the next stage of training.

Ideally, questions should be pitched at the level of integration/interpretation (questions which require 'putting the pieces together') and problem solving (questions which require 'clinical judgement'), not simple recall (questions which can be answered with a Google search).

Examples of recall questions to avoid:

- What are the symptoms of X?
- Which of the following is a contraindication of X?
- What is the name/definition of this procedure?
- Which of the following is correct?

Examples of higher order ('putting the pieces together' and 'clinical judgement') questions:

- In this procedure, which structure is most at risk in this patient?
- What is the most likely diagnosis?
- What is the most useful investigation to carry out at this stage?
- What is the most appropriate first step in the management of this patient?

3. Construct the stem. This should present a single, clearly formulated problem, possibly in the form of a patient vignette. The stem should contain enough information to allow candidates to answer without referring to the options.

   Patient vignettes may include any subset of the following information:

   a. The patient (age, gender), the presenting complaint and its duration; any other relevant information a competent day one consultant would typically need to piece together to determine the best course of action.
   b. Relevant details of the patient's history, possibly including details of family history.
   c. Relevant physical findings, results of diagnostic studies, initial treatment, subsequent findings, images, etc.

4. Construct the lead-in in such a way that it builds on the information in the stem and poses a clear question. Candidates should be able to answer without looking at the options and should not be able to answer if the information in the stem is masked.

5. Write the options. These should be of similar length, along a continuum, grammatically consistent and logically compatible. If appropriate, order the options in a logical order (e.g. numeric, alphabetical or anatomical). All the distractors must be plausible (think of the educational impact of suggesting that something potentially dangerous is plausible but not the best answer!).

Reviewing the Item

- Does it focus on important problems relevant to clinical practice?
- Can it be answered without looking at the options?
- Are all the relevant facts included in the stem?
- Can it be read and answered within approximately one minute?
- Are all the options plausible, with one of them standing out as being the best option?
- Does the question successfully avoid the pitfalls listed in the Question Writing Checklist?

Question Writing Checklist

For a deeper dive, see Table 2.3.

A statistical analysis is performed on the candidate scores to determine the mean, standard deviation, standard error, variation, quarterly percentiles and normality testing with histograms and normal probability plots. These results are used to test the calibre and spread of candidates compared with previous groups.

Question-writing workshops provide detailed guidance on the design of questions that discriminate between candidates of differing ability, in a format and a style that aid speed reading and comprehension.

Summary

There are many different types of MCQs. The traditional multiple true/false type that asks candidates to identify all the correct statements listed can assess knowledge and comprehension but is limited to these objectives.

By contrast, the single best answer question, which asks candidates to choose the best answer from, say, five plausible alternatives, assesses not only knowledge and comprehension but also the application of this knowledge to the synthesis of deductions from

Table 2.3 SBA question writing checklist

Checks across all question formats	
Alignment	Is the task required by the question congruent with the learning objectives at this stage of career progression (e.g. interpretation of information, decision making)?
Blueprinting	Are the topic and task listed in the exam syllabus and is the blueprint code provided?
Level of competence	Is the question pitched to discriminate around the level of minimal competence required for a pass?
Spelling and grammar	Is the question free from spelling mistakes and grammatical errors?
Jargon	Is the question jargon free (as much as possible within the topic area)? Is it free from idioms which might unfairly disadvantage non-native English speakers?
Timing	Can the question be read and answered within approximately 1 minute (for SBAs)?
Clarity	Is it clear from the question what candidates are expected to do?
Additional checks: common pitfalls in writing questions	
Grammatical cue	The sentence structure can sometimes allow candidates to exclude a subset of the options. To avoid this, make the lead-in a whole question rather than a sentence continuation.
Logical cue	If several but not all of the options are very similar, this can suggest that the answer is in this subset. Try to make the options as homogeneous as possible.
Absolute or vague terms	'Never' and 'always' are almost never true; vague terms make it difficult to know what the question writer meant (e.g. how often is 'often'?).
Longest answer is 'single best answer'	The answer with the most information/the highest level of precision is often the correct answer. Try to give all options a similar length and similar level of precision.
Repeated words	Repeated words (or related words) between the stem and the options can point to the answer.
Convergence strategy	By looking at how many times each term is repeated across the set of options, candidates select the option which contains all the most frequently repeated terms.
Overly complicated questions	Questions which are too long or present information in overly complex forms are in danger of testing skills which are not in line with the purpose of the exam (e.g. reading speed, working memory).
Negatively phrased items	Items which ask a question in the negative (e.g. 'which is the least appropriate . . .') are confusing to candidates who have to switch between best and worst answer and are contrary to the mode of reasoning in most clinical situations.
'True/false'	If the options are all either completely correct or completely incorrect, the question does not follow the 'single best answer' approach and is most likely pitched at the recall level. Options should be on a continuum from least to most appropriate.
Option-dependent question	Candidates should be able to answer the question without referring to the options. This encourages them to think of the answer for themselves based on the information provided in the stem and lead-in.
Window dressing	Questions which can be answered without referring to the stem are typically pitched at the recall level. They also use up precious time in the examination by giving candidates irrelevant information to read.

several assorted pieces of information and the evaluation of laboratory and other numerical data. It can assess the problem-solving skills vital to the practising clinician.

Answering 120 questions in two hours allows an average of one minute to read a question and select an answer.

Candidates need to speed-read in order to save extra time for questions that require more thought. This is facilitated by arranging the clinical information (history, examination findings, listed investigations) in a strict order, as succinctly as possible, as well as presenting it in a way that does not disadvantage dyslexic candidates or those whose first language is not English.

Notes

1 Case, S, Swanson D. *Item Writing Manual. 3rd ed.* Philadelphia, PA: National Board of Medical Examiners; 2002. (available online).

2 Paniagua MA, Swygert KA. *Constructing Written Test Questions for the Basic and Clinical Sciences*. Philadelphia, PA: National Board of Medical Examiners; 2016.

3 At the least it is an interesting read.

4 That in itself is definitely time well spent rather than having to revise and sit Section 1 all over again.

5 Miller GE. The assessment of clinical skills/competence/performance, *Acad Med*. 1990;**65**(9):S63–S67. Adapted by Drs R Mehay & Burns.

6 Bloom BS. *Taxonomy of Educational Objectives*. Vol. 1: *Cognitive Domain*. New York: McKay; 1956:20–24 at 3.

7 Morrison S, Free K. Writing multiple-choice test items that promote and measure critical thinking, *J Nurs Educ*. 2001;**40** (1):17–24.

8 Paniagua MA, Swygert KA. *Constructing Written Test Questions,* 4th Ed. Philadelphia, PA: National Board of Medical Examiners; 2016. Chapter 3, Technical item flaws.

9 We have omitted examples of these flaws due to space constraints, but it is recommended that you read pages 19–26. Flaws are much better appreciated with examples.

Chapter 3

Hip I Structured SBA

Edward Holloway

HIP I STRUCTURED SBA QUESTIONS

1. An imaging report refers to a pathological avulsion at the insertion of the Iliopsoas tendon.
   What Gruen zone does this correspond to?
   A. Zone 1
   B. Zone 2
   C. Zone 4
   D. Zone 6
   E. Zone 7

2. A patient with painful osteoarthritis of their hip underwent femoral nailing, for a mid diaphyseal fracture 15 years previously. Their surgeon plans to perform hip replacement surgery while keeping the nail in place.
   What is the most suitable type of patient for this procedure?
   A. Large BMI >35 female over 65 years
   B. Large BMI >35 male over 65 years
   C. Large BMI >35 male under 65 years
   D. Low BMI female under 65 years
   E. Low BMI male under 65 years

3. A nerve is damaged during the direct lateral hip approach when muscles are inadvertently split more than 5cm proximal to the greater trochanter.
   Asking the patient to perform which of the following movements is most likely to reveal a deficit?
   A. Dorsiflex ankle
   B. Extend great toe
   C. Extend hip
   D. Extend knee
   E. Stand on one leg

4. A patient received a hip arthroplasty typically reserved for younger patients with good femoral head bone stock which comprises approximately 3.5% of all hip arthroplasties.
   What follow-up is recommended for an asymptomatic patient with an ODEP 10 or 10A* rated implant?
   A. Annually, for as long as the device is implanted
   B. Annually for the first 5 years, two yearly to 10 years
   C. Annually for the first 5 years, two yearly to 10 years and three after
   D. First year, once at 7 years, and once at 10 years
   E. First year, once at 7 years, and three yearly thereafter

5. You are consenting a 45-year-old patient with a Garden II neck of femur fracture for surgery.
   What is the most common risk of this surgery?
   A. Avascular necrosis
   B. Femoral nerve injury
   C. Leg length discrepancy
   D. Sciatic nerve injury
   E. Trendelenburg gait

6. A patient has a hip arthroplasty through an approach that is designed to be soft tissue preserving and is sometimes performed utilising a fracture table.
   The nerve most commonly at risk during this approach crosses, in the majority of patients, the lateral border of which muscle?
   A. Rectus femoris
   B. Sartorius
   C. Tensor fascia lata
   D. Vastus intermedius
   E. Vastus lateralis

7. After inserting an uncemented cup, you carefully define quadrants by drawing a line from the ASIS to the centre of the cup and a second line perpendicular to this. You turn your back and your registrar inserts a screw in the anterosuperior quadrant.

What structure is most at risk?
A. External iliac vessels
B. Inferior gluteal nerve and vessels
C. Internal pudendal nerve and vessels
D. Obturator nerve and vessels
E. Sciatic nerve

8. An audit of a department's THA complications reveals a spike in intraoperative periprosthetic femoral fractures (IOPFF) equivalent to intraoperative Vancouver Type A2.
Which factor is associated with the highest relative risk of this complication?
A. Age 41–49 years
B. Cementless stem
C. Female sex
D. Paediatric disease
E. Previous trauma

9. A 45-year-old welder with a history of steroid use presents with groin pain and an MRI that shows a 20% area of femoral head collapse.
What is the most appropriate management?
A. Bisphosphonate infusion
B. Core decompression
C. Proximal femoral osteotomy
D. Total hip arthroplasty
E. Vascularised fibular graft

10. An 80-year-old patient listed for a THA has had previous lumbar spine surgery. Concerned about dislocation risk, you request sitting and standing lateral lumbar spine radiographs.
What is the name of the angle that is formed for a line passing from the centre of the S1 end plate and the centre of the segment between the two femoral heads (the bicoxofemoral axis), and the vertical?
A. APPt (anterior pelvic plane tilt)
B. FPP (functional pelvic plane)
C. PI (pelvic incidence)
D. SPT (spinopelvic tilt)
E. SS (sacral slope)

11. A 55-year-old patient with Parkinson's disease presents with a Garden 4 neck of femur fracture. Radiographs show that the ratio of the inner canal diameter at the midportion of the lesser trochanter, divided by the diameter 10 cm distal is >0.75.
What is the most appropriate management?
A. Cemented dual mobility THA
B. Cemented THA
C. Two-hole DHS
D. Uncemented dual mobility THA
E. Uncemented THA

12. After thorough discussion, it is decided that the best option for a 20-year-old manual labourer with post-traumatic hip OA is a fusion.
What is the most appropriate position of fusion?
A. 0° external rotation, 0° adduction, 5° flexion
B. 5° external rotation, 5° adduction, 25° flexion
C. 10° external rotation, 15° abduction, 25° flexion
D. 15° external rotation, 0° abduction, 5° flexion
E. 15° external rotation, 15° abduction, 5° flexion

13. A patient underwent a THA for a NOF fracture while abroad on holiday. The patient was given strict rehabilitation instructions to avoid flexion beyond 90° and extreme internal rotation.
What structure was most likely to have been injured during the patient's surgery?
A. Femoral nerve
B. Lateral cutaneous nerve
C. Pudendal nerve
D. Sciatic nerve
E. Superior gluteal nerve

14. A 77-year-old man presents with an insidious onset of hip and anterior thigh pain 15 years after a total hip arthroplasty. He denies fever or systemic upset, and initial bloods show normal inflammatory markers. Figure 3.1 is an anteroposterior radiograph of the left hip.

Figure 3.1 Anteroposterior (AP) radiograph left hip

You advise the patient that he should undergo revision surgery as he is at risk of what complication?

A. Dislocation
B. Infection
C. Periprosthetic acetabular fracture
D. Periprosthetic femur fracture
E. Pseudotumour formation

15. You review a patient following hip arthroscopy and extensive debridement of a labral cyst. He has weakness of ankle dorsiflexion.

Injury has most likely occurred as a result of what?

A. Excessive traction at groin post
B. Placement of anterior portal
C. Placement of anterolateral portal
D. Placement of distal anterolateral portal
E. Placement of posterolateral portal

16. During intraoperative assessment for stability of a THA you have implanted through a modified Hardinge approach, you notice that the hip is unstable in extension and external rotation.

What change will increase the primary arc of hip motion?

A. 20° versus 0° liner
B. 36mm versus 32mm head
C. High versus standard offset stem
D. Lateralised versus standard liner
E. Skirted head

17. A 70-year-old woman presents with a red, swollen and painful area around the incision site of a THR performed 8 weeks earlier. She has a CRP of 78, WCC of 16 and temperature of 37.4°C. Her other observations are unremarkable. She did not attend 6-week follow-up and says the wound has not stopped leaking since she left hospital.

What is the most appropriate management?

A. Aspiration and culture-specific long-term antibiotic suppression
B. Debridement, antibiotics, implant retention with exchange of modular components
C. Debridement, antibiotics, implant retention with retention of modular components
D. Empiric antibiotics
E. Revision arthroplasty

18. A 53-year-old man with severe ulcerative colitis is referred for a THA. His pelvic X-ray shows Brooker grade 3 changes on the ipsilateral side replaced 4 years earlier.

Which of the following prophylactic treatments is most appropriate?

A. Diphosphonate 20mg/kg for 21 days
B. Ibuprofen 400mg TDS for 4 weeks
C. Indomethacin 25mg TDS for 6 weeks
D. Single 2 500cGy radiotherapy dose
E. Three 1 500cGy radiotherapy doses

19. A 23-year-old woman has been referred by her physiotherapist with symptoms of hip impingement. A radiograph of her left hip is shown here (Figure 3.2).

Figure 3.2 Anteroposterior (AP) radiograph left hip

What is marked on her radiograph?

A. Alpha angle
B. Lateral centre edge angle
C. Sharp's angle
D. Tonnis angle
E. Vertical centre edge angle

20. A young man with cerebral palsy is referred with hip pain. You want to examine for contracture in a muscle with an origin at the inferior pubic symphysis and inferior pubic rami, which attaches to a point just posterior to the attachment of sartorius.

What is the most appropriate test?

A. Ely's test
B. Ober's test
C. Phelp's test
D. Thomas' test
E. Trendelenburg test

21. A 24-year-old woman falls while mountain biking and sustains the injury shown in this radiograph (Figure 3.3). In theatre, you struggle to reduce the fracture with in-line traction and rotation.

Figure 3.3 Anteroposterior (AP) radiograph left hip

What is the most appropriate next step?

A. Extension, abduction, in-line traction, then external rotation
B. Fixation in best position achieved
C. Flexion to 90°, adduction, in-line traction, then internal rotation
D. Open reduction using a modified Smith-Petersen approach
E. Total hip arthroplasty

22. A 30-year-old woman is referred for consideration of THA. Her radiographs have been classified as a Type B using the Hartofilakidis classification.
What anatomical characteristic of the femur is most commonly associated with this?

A. Excessive anteversion
B. Excessive femoral bow
C. Excessive retroversion
D. Excessive valgus
E. Excessive varus

23. The diagram shown here represents the scratch profile of a material used in THA femoral heads (Figure 3.4).

Figure 3.4 Scratch profile

If such a component fractures, what bearing couple should be used during revision surgery?

A. Ceramic on ceramic
B. Ceramic on poly
C. Metal on metal
D. Metal on poly
E. Oxinium on poly

24. A 45-year-old presents with symptoms of hip impingement, and radiographs show the femoral head to be medial to Kohler's line.
What is the most likely diagnosis?

A. Acetabular retroversion
B. Coxa magna
C. Coxa valga
D. Coxa vara
E. Otto pelvis

25. A 60kg woman develops progressive pain and numbness in the lateral calf with weakness of ankle dorsiflexion 48 hours after THA.
Which of the following is the most appropriate action?

A. Book for emergency surgery
B. Nurse prone and review the following morning
C. Nurse with knee in flexion and review the following morning
D. Urgent MRI scan
E. Withhold prophylactic LMWH

26. A surgeon admits a mistake was made during a THA. The patient complains that their operated leg feels short.
What is most likely to have resulted in this?

A. +8mm versus 0mm femoral head
B. 125° versus 135° neck-shaft angle implant
C. High versus standard offset stem
D. Incomplete insertion of an uncemented stem
E. Size 4 rather than size 3 implant inserted

27. One of your patients 3 months post-THA is aspirated because of signs of PJI.
What organism would be associated with the lowest chance of infection eradication with a DAIR procedure?

A. Acinetobacter
B. Coagulase negative *Staphylococcus*
C. Corynebacterium
D. *Staphylococcus aureus*
E. *Streptococcus*

28. You start a job as a Hip Consultant. Your clinical lead advises that you use an implant with a ODEP 10A* rating.
What does the * indicate?
A. Acceptable evidence
B. Being evaluated through the Beyond Compliance initiative
C. Benchmark revision rate less than 1 in 10 at 10 years
D. Benchmark revision rate less than 1 in 20 at 10 years
E. Strong evidence

29. You aspirate a THA that has become acutely painful in a patient with systemic symptoms.
According to the 2018 Musculoskeletal Infection Society (MSIS) criteria for the diagnosis of periprosthetic joint infection, which of these findings carries least weight in making a diagnosis of infection?
A. Elevated CRP or D-dimer (serum)
B. Elevated ESR (serum)
C. Elevated synovial PMN (%) (synovial)
D. Elevated synovial WBC count or LE (synovial)
E. Positive alpha-defensin (synovial)

30. A well-read 38-year-old patient with AVN of his hip asks you why you have not suggested a core-decompression procedure.
You explain that for this to be an option, his disease should not have progressed beyond which Steinberg stage?
A. 1
B. 2
C. 3
D. 4
E. 5

31. **Early intra-prosthetic dislocation of dual mobility hip replacements is likely to be most commonly due to what?**
A. Iatrogenic injury
B. Modular designs
C. Non-highly crosslinked polyethylene
D. Skirted heads
E. Smaller diameter inner bearings

32. A frail 88-year-old undergoing cemented hip hemiarthroplasty for an intracapsular NOF fracture becomes severely hypoxic and hypotensive when the stem is inserted.
What is the most likely causative mechanism?
A. Anaphylaxis to antibiotic in the bone cement
B. Complement activation
C. Direct effect of exothermic
D. Multiple emboli
E. Vasodilatation caused by circulating methyl methacrylate monomers

33. Whilst washing the femoral canal during a first stage revision for infection you are offered a choice of irrigation solutions.
Which would be least suitable?
A. Acetic acid
B. Chlorhexidine
C. Hydrogen peroxide
D. Polyhexanide-betaine
E. Povidone-iodine

34. This 69-year-old lady had a THA 20 years ago. She presents with start-up pain in the thigh and groin. Her blood tests are unremarkable, and an aspiration is negative. Figure 3.5 is an anteroposterior radiograph of her right hip.
Which approach to revision of the femoral component would be most appropriate?

Figure 3.5 Anteroposterior (AP) radiograph right hip

A. Cement-in-cement
B. Long, fully coated uncemented stem
C. Primary cemented stem

D. Proximal femur replacement
E. Removal of cement and long cemented stem

35. A fit and well 74-year-old gentleman had a revision THA 7 months ago for aseptic loosening of a 25-year-old Charnley THA. He presents with a week of thigh pain and mild systemic upset. CRP is 350 and an aspirate reveals frank pus in the joint.

What is the most suitable management?

A. Debridement, antibiotics, and implant retention
B. Excision arthroplasty
C. Single stage revision
D. Suppressive antibiotics
E. Two stage revision

36. **When examining for contractures around the hip, which eponymous test is performed by lying the patient supine, and abducting the affected hip as far as possible, then assessing if more abduction is possible when the knee is flexed?**

A. Bryant's
B. Ely's
C. Ober's
D. Patrick's
E. Phelp's

HIP I STRUCTURED SBA ANSWERS

1. Answer E. **Zone 7**
   Iliopsoas originates from the anterior and inferior aspects of the transverse processes of L1–L5 and the bodies and discs of T12–L5. It inserts into the lesser trochanters and is innervated by direct fibres from the lumbar plexus (L1/L2/L3). It acts as a flexor of the hip.

   Gruen zones are used to describe areas of loosening around a femoral stem. Zone 1 relates to the greater trochanter, zone 7 the lesser trochanter and zones 6 and 5, and zones 2 and 3 on the medial and lateral aspects of the femur, respectively. Zone 4 is at the tip of the stem (Figure 3.6).

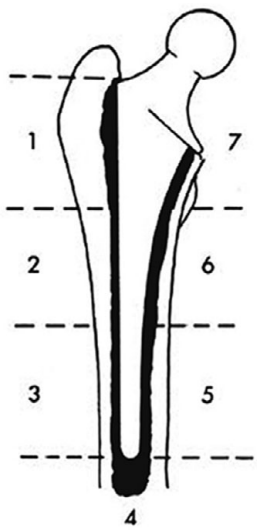


Figure 3.6 Gruen zones

2. Answer C. **Large BMI >35 male under 65 years**
   An important indication of hip resurfacing is patients with pre-existing metalwork in the medullary canal of the femur which precludes a metaphyseal stem. Advantages of a hip resurfacing over a THA include increased stability due to a larger head size, preservation of femoral head and neck bone stock, simpler femoral revision, lower mortality and the potential of a more normal gait pattern and participation in high-demand activities.

   After high-profile failures including certain implants the most suitable patient group to benefit from resurfacing is being redefined, but it is generally considered to be most suitable for younger, larger male patients.

   Logishetty K, Muirhead-Allwood SK, Cobb JP. Hip resurfacing – what is its role in modern orthopaedics? *Bone & Joint 360*. 2020 Feb;**9**(1):4–9.

3. Answer E. **Stand on one leg**
   The superior gluteal nerve is at risk during deep dissection in the direct lateral approach to the hip. The fibres of gluteus medius are split from the middle of the greater trochanter proximally. If the split is continued more than 3–5cm proximal to the trochanter there is risk of nerve damage. The superior gluteal nerve originates from the lumbosacral plexus with contribution from nerve roots L4–S1 and innervates gluteus medius, gluteus minimus, and tensor fascia lata. Weakness will manifest clinically during Trendelenburg test or hip abduction.

4. Answer E. **First year, once at 7 years and three yearly thereafter**
   ODEP 10A or 10A* rated hip resurfacing devices are the MatOrtho Adept Resurfacing Head (48–58mm) and Smith & Nephew Birmingham Hip Resurfacing Head (48–62mm). It is recommended that they be followed up during the first year, once at 7 years and three yearly thereafter. Patients at risk of adverse reaction to metal debris (ARMD) (female patients, males with femoral components smaller than 48mm and those with a DePuy ASR implant) should be reviewed annually for as long as the device is implanted. Those not at risk but symptomatic should also be seen annually. Other implants in asymptomatic patients not at risk should be seen annually for the first 5 years, two yearly to 10 years, and then three yearly thereafter.

   Logishetty K, Muirhead-Allwood SK, Cobb JP. Hip resurfacing – what is its role in modern orthopaedics? *Bone & Joint 360*. 2020;**9**(1):4–9.

5. Answer A. **Avascular necrosis**
   Garden classified femoral neck fractures into four types depending on the degree of displacement seen on an anteroposterior radiograph. Type I are incomplete fractures, type II are complete but non-displaced fractures, type III are complete and partially displaced fractures and type IV are complete and fully displaced.

   Young patients with Garden II neck of femur fractures would most commonly be managed with closed reduction and fixation with either cannulated hip screws or an alternate device, unless the patient

had significant comorbidities making an arthroplasty with a lower risk of reoperation a better option.

Leg length discrepancy, sciatic nerve palsy injury and Trendelenburg gait would all be complications of THR.

Parker MJ, Gurusamy KS. Internal fixation versus arthroplasty for intracapsular proximal femoral fractures in adults. *Cochrane Database Syst Rev*. 2006;**4**:CD001708.

6. Answer B. **Sartorius**

The direct anterior approach (DAA) to the hip is performed with the aim of reducing muscle damage, length of stay, pain and complication rate. A fracture table with specific attachments is used by some to assist in femoral exposure.

There is a risk of damage to the lateral cutaneous nerve of the thigh. This nerve arises from the lumbar plexus, or more rarely the femoral nerve itself, and travels through the pelvis on the iliacus muscle. It enters the thigh under the inguinal ligament at a point anywhere between the anterior superior iliac spine (ASIS) and the midinguinal point. The nerve then pierces the fascia lata medial and inferior to the ASIS. From here, the nerve takes a variable course but most commonly the medial border of sartorius.

Meermans G, Konan S, Das R, Volpin A, Haddad FS. The direct anterior approach in total hip arthroplasty: a systematic review of the literature. *Bone Joint J*. 2017;**99-B**(6):732–740.

7. Answer A. **External iliac vessels**

This SBA topic is of significant practical importance and is also frequently asked in *viva* examinations.

The posterior superior and posterior inferior acetabular quadrants contain the best available bone stock and are relatively safe for the transacetabular placement of screws. The anterior superior and anterior inferior quadrants should be avoided whenever possible, because screws placed improperly in these quadrants may endanger the external iliac artery and vein, as well as the obturator nerve, artery, and vein.

The acetabular-quadrant system provides the surgeon with a simple intraoperative guide to the safe transacetabular placement of screws during primary and revision acetabular arthroplasty. A constant relationship was found to exist between specific acetabular quadrants and specific intrapelvic structures.

Screws originating from the **anterior superior quadrant** were found to lie near the external iliac artery and vein. However, because of the more medial position of the vein with respect to the artery and the paucity of interposed tissue along the pelvic brim, the external iliac vein was more in danger of injury than was the artery.

Screws originating from the **anterior inferior quadrant** were directed toward the obturator nerve and vascular structures. This is most evident at the superolateral aspect of the obturator foramen, where the nerve, artery, and vein exit the true pelvis through the obturator canal.

When an anatomical variant was present (the aberrant obturator artery or accessory obturator vein) these vessels were even more susceptible to injury. The accessory or aberrant obturator vessels travel across a section of the pelvic brim (located just opposite the anterior inferior quadrant) with little interposed soft tissue. This section of the osseous acetabulum is thin (6–12 mm), which increases the possibility of vascular injury.

Screws that are located centrally in the **posterior superior quadrant** may be directed toward the superior gluteal nerve, artery and vein as they exit the pelvis through the greater sciatic notch.

Screws that are located centrally in the **posterior inferior quadrant** are directed toward the inferior gluteal and internal pudendal nerves and vessels. These structures are rarely endangered, due to surrounding intrapelvic tissue and their distance from the posterior column.

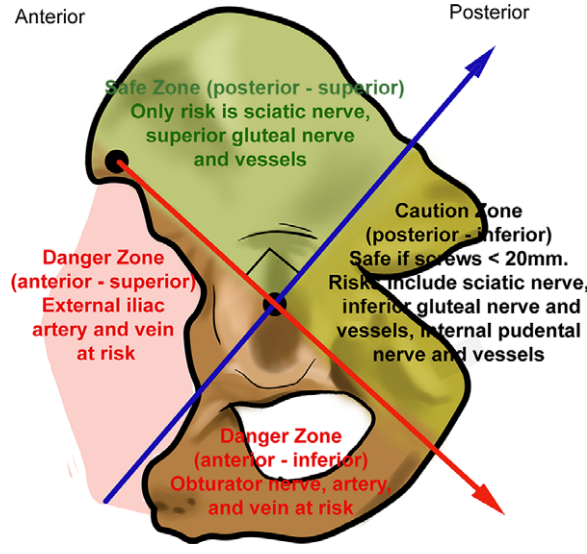


Figure 3.7 Safe acetabular quadrants for screw placement

The acetabular-quadrant system. The quadrants are formed by the intersection of lines A and B. Line A extends from the anterior superior iliac spine (ASIS) through the centre of the acetabulum to the posterior aspect of the fovea, dividing the acetabulum in half. Line B is drawn perpendicular to line A at the mid-point of the acetabulum, dividing it into four quadrants.

8. Answer B. **Cementless stem**
Intraoperative Vancouver A2 fractures are non-displaced fractures of the proximal metaphysis. All answers are associated with an increased relative risk of calcar fracture, but cementless stems give the greatest relative risk (RR) (RR = 3.8). Age 11–49 RR = 1.5, female sex RR = 1.9, paediatric disease RR = 2.6, previous trauma RR = 3.6.

9. Answer D. **Total hip arthroplasty**
Avascular necrosis of the hip is predominantly idiopathic but may be associated with alcohol abuse, steroid use, hypercoagulability, Caisson's disease and sickle cell disease. Treatment options depend upon the clinical and radiographic stage (Ficat, Steinberg) of the disease and age/comorbidities of the patient. The relatively conservative options listed would be options in younger patients or those with earlier stages of disease. Once any significant amount of collapse has occurred in a patient over 40, the most likely option is an arthroplasty procedure.

Petek D, Hannouche D, Suva D. Osteonecrosis of the femoral head: pathophysiology and current concepts of treatment. *EFORT Open Rev*. 2019;**4**:85–97.

10. Answer D. **SPT (spinopelvic tilt)**
Increasingly, the relationship between the spine, hip and knee is assessed and considered in how it may affect the functionality and stability of a THR as the patient moves from lying to standing and from sitting to standing. All options can be measured radiographically to this end.

APPt (anterior pelvic plane tilt) refers to the rotation of the pelvis in the sagittal plane as measured by the angle formed between the coronal plane and a line from the anterior superior iliac spine (ASIS) to pubic symphysis.

The APP (anterior or anatomical pelvic plane) is defined by the pubic symphysis and the two anterior superior iliac spines. The FPP (functional pelvic plane) rotates this plane according to an individual's pelvic tilt. It is considered a more accurate reference plane for assessing acetabular component position. PI (pelvic incidence) is the angle between two lines: one from the centre of the femoral head to the centre of the S1 end plate, and a second perpendicular to a line across the S1 end plate, intersecting the centre of the end plate. SPT (spinopelvic tilt) is the angle between a line from the centre of the S1 end plate and the centre of the segment between the two femoral heads (the bicoxofemoral axis), and the vertical. SS (sacral slope) is the angle between two lines: one parallel to the S1 end plate, and a second along a horizontal reference plane.

Ike H et al. Spine-pelvis-hip relationship in the functioning of a total hip replacement. *J Bone Joint Surg Am*. 2018;**100**:1606–1615.

11. Answer A. **Cemented dual mobility THA**
The Dorr classification depends upon the ratio between the inner canal diameter at the level of the midpoint of the lesser trochanter and a point 10cm below that. Dorr C femurs as defined as a ratio >0.75 are most suitable for a cemented prosthesis. A patient with significant risk of dislocation and a grossly displaced NOF fracture would be a good candidate for a dual-mobility acetabular component.

Our preferred choice in view of the patient's young age (55 years) would be for a dual motion hydrid THA (cup being uncemented). A cemented dual motion cup would be at risk of medium term failure. The possibility of using a hybrid THA dual motion THA was not given in the options.

12. Answer B. **5° external rotation, 5° adduction, 25° flexion**
This is the most appropriate position of hip fusion.

13. Answer D. **Sciatic nerve**
The position of greatest risk of dislocation for a posterior approach THA is flexion and internal rotation. The structure most at risk during this approach is the sciatic nerve.

14. Answer D. **Periprosthetic femur fracture**
The radiograph shows a loose Charnley femoral stem which is close to fracturing through the posterior cortex of the femur (Figure 3.6). The THA may be infected but the fact that the

Figure 3.8 Lateral radiograph of left hip

acetabulum does not look loose goes against this. Pseudotumour formation is associated with metal-on-metal bearing couples.

15. Answer E. **Placement of posterolateral portal**
By far the most common direct nerve injury resulting from hip arthroscopy portal placement is of the lateral femoral cutaneous nerve when placing or working through the anterior portal. Sciatic nerve injury causing a foot drop is a rare complication of posterolateral portal placement, made more likely by placing the leg in external rotation.

Papavasiliou AV, Bardakos NV. Complications of arthroscopic surgery of the hip. *Bone Joint Res*. 2012;**1**:131–144.

16. Answer B. **36mm versus 32mm head**
Scenarios of hip instability are regularly asked in the Part 1 paper. It is an extremely important topic as surgeons need to know how to deal with an on table unstable hip.

The primary arc of hip motion is the range that the hip can move before the neck impinges upon the acetabulum and is an important determinant of THA stability. A lipped or angled liner may improve stability by increasing coverage but actually decreases the primary arc of motion and, in this instance, may make anterior dislocation more likely by causing posterior impingement levering the hip out of joint. A high offset stem or lateralised liner will not alter the primary arc of movement but may improve stability by moving the femoral neck away from impinging soft tissues or osteophytes (potential to the detriment of proper restoration of hip biomechanics). A skirted head (as found on the longer lengths) decreases the primary arc. A bigger head size increases the impingement-free range of motion and jumping distance of THA (Sariali et al. 2009).

Sariali E, Lazennec J Y, Khiami F, Catonne Y. Mathematical evaluation of jumping distance in total hip arthroplasty: influence of abduction angle, femoral head offset, and head diameter. *Acta Orthop*. 2009;**80**:277–282.

17. Answer E. **Revision arthroplasty**
All the options are valid in managing the infected joint replacement. Patients not sufficiently fit to do well with further significant or potentially multiple procedures can be managed with culture-specific, long-term suppressive antibiotics or an excision arthroplasty, if the infection is not able to be suppressed or the patient is unable to take long-term antibiotics.

The success rates of DAIR (debridement, antibiotics, and implant retention) procedures vary enormously in the literature, from 11–100%.

The success rate is correlated with type of organism (*Streptococcus* species tend to do better), exchange of modular components and time from procedure in early infection, or time from first presentation of symptoms in late infection.

An older patient with long duration of symptoms is less likely to have successful infection eradication with a DAIR so may be best served with a one- or two-stage revision procedure depending upon the infecting organism and the surgeon's preference.

Grammatopoulos G et al. Outcome following debridement, antibiotics, and implant retention in hip periprosthetic joint infection – an 18-year experience. *J Arthroplasty* 2017;**32**:2248–2255.

Kunutsor SK, Beswick AD, Whitehouse MR, Wylde V, Blom AW. Debridement, antibiotics and implant retention for periprosthetic joint infections: a systematic review and meta-analysis of treatment outcomes. *J Infect*. 2018;**77**:479–488.

18. Answer E. **Three 1 500cGy radiotherapy doses**
Heterotopic ossification (HO) following THA occurs with an incidence of 5–90% and is associated with the risk factors of male sex, history of previous HO, older age, previous hip fusion, hypertrophic OA, ankylosing spondylitis, post-traumatic OA, Paget's disease, osteonecrosis, and rheumatoid arthritis.

It is classified according to the Brooker classification according to the extent of heterotopic bone formation on an AP radiograph.

Prophylaxis can be considered for patients at high risk of HO and the main forms are

radiotherapy and non-steroidal anti-inflammatory drugs (NSAIDs). Diphosphonates have not been shown to be effective. NSAIDs would be contra-indicated in a patient with severe inflammatory bowel disease. Multiple doses of radiation therapy have been shown to be more effective than single doses.

Board TN, Karva A, Board RE, Gambhir AK, Porter ML. The prophylaxis and treatment of heterotopic ossification following lower limb arthroplasty. *J Bone Joint Surg Br*. 2007;**89**:434–440.

19. Answer D. **Tonnis angle**
The following are measured during the radiographic assessment of patients with symptoms of femoroacetabular impingement:

The Tonnis angle (also called the acetabular index or acetabular roof angle) is the angle between the horizontal and a tangential line from the medial to the lateral sourcil (weight bearing zone of the acetabulum).

Alpha angle is measured on a Dunn view by drawing a line from the centre of the narrowest point of the femoral neck to the centre of the femoral head using a best-fit circle. The angle is between the line down the axis of the femoral neck and a line drawn to the location where the femoral head becomes 'out of round'.

The lateral centre edge angle (of Wiberg) is the angle between a line drawn from the centre of the femoral head to the lateral edge of the acetabulum and a second line that is parallel to the longitudinal pelvic axis.

Sharp's angle, or acetabular angle, is the angle between a horizontal line drawn through the teardrops and a line drawn from the teardrop to the lateral acetabular roof.

The vertical centre edge angle is measured from a false profile radiograph and is between a vertical line through the centre of the femoral head and a line from the centre of the femoral head to the anterior-most point on the acetabulum.

Mannava S et al. Comprehensive clinical evaluation of femoroacetabular impingement: part 2, plain radiography. *Arthrosc Tech*. 2017;**6**: e2003–e2009.

20. Answer C. **Phelp's test**
Phelp's test assesses gracilis tightness. Ely's test assesses rectus femoris tightness. Ober's test assesses tightness of the tensor fascia lata. Thomas' test assesses fixed flexion of the hip. Trendelenburg test assesses hip abductor dysfunction.

21. Answer C. **Flexion to 90°, adduction, in-line traction, then internal rotation**
Leadbetter described a technique in 1939 to aid in the reduction of intracapsular neck of femur fractures. The limb is flexed to relax the musculature around the hip and then internal rotation functions to relax the ligamentous structures. From the above position, further flexion and adduction open the fracture, allowing reduction to be achieved by maintaining traction while bringing the limb into extension with slight abduction and continued internal rotation.

22. Answer A. **Excessive anteversion**
The Hartofilakidis classification recognises three types of congenital hip disease in adults: type A – dysplasia, type B – low dislocation, and type C – high dislocation. In type A disease, the femoral head remains within the original acetabulum. In type B, it articulates with a false acetabulum which partially covers the original acetabulum. In type C, the femoral head has migrated superiorly and posteriorly to the hypoplastic original acetabulum. Adult hip dysplasia is most commonly associated with excessive femoral anteversion.

23. Answer A. **Ceramic on ceramic**
Figure 3.4 (see Questions section) represents the scratch profile of ceramic.

Revision surgery for fractured or damaged ceramic components requires thorough debridement and removal of ceramic fragments. Revision with metal heads should be avoided and ceramic components used wherever possible. Trunnions that are damaged need to be replaced, but if only minimal damage exists; then a ceramic head with a titanium liner or trunnion adapter can be used.

Rambani R et al. Revision total hip arthroplasty for fractured ceramic bearings: a review of best practices for revision cases. *J Arthroplasty* 2017;**32**:1959–1964.

24. Answer E. **Otto pelvis**
Otto pelvis (arthrokatadysis or protrusio acetabuli) is a rare condition associated with hip osteoarthritis. Protrusio acetabuli is defined

radiographically when the medial aspect of the femoral head projects beyond the ilioischial (Kohler's) line. Though sometimes idiopathic, acetabular protrusion is more usually associated with inflammatory arthropathies, osteoporosis, osteomalacia, and Paget's disease. When performing THR, care must be taken to lateralise the medialised hip centre.

25. Answer A. **Book for emergency surgery**
Nerve dysfunction following THR may be a result of intraoperative compression from retractors, traction injury secondary to manipulation or lengthening.

If noted in the immediate postoperative period, tension can be taken off the sciatic nerve by nursing the patient with the knee in flexion.

Progressive, painful sciatic nerve dysfunction should raise the suspicion of compression from haematoma. This is associated with patients of lower mass, and with anticoagulant use. Improved outcomes are associated with prompt exploration and evacuation of haematoma.

Butt AJ, McCarthy T, Kelly IP, Glynn T, McCoy G. Sciatic nerve palsy secondary to postoperative haematoma in primary total hip replacement. *J Bone Joint Surg Br.* 2005;**87**:1465–1467.

Su EP. Post-operative neuropathy after total hip arthroplasty. *Bone Joint J.* 2017;**99-B**(Suppl. 1):46–49.

26. Answer B. **125° versus 135° neck–shaft angle implant**
A longer femoral head length and incomplete insertion of an uncemented femoral stem will lengthen the patient. A larger sized femoral stem or increased offset stem will not generally change leg length.

27. Answer: D. ***Staphylococcus aureus***
Outcomes of DAIR procedures are dictated by many surgical and patient factors. Unsurprisingly, age, frailty, immunity, diabetes, and nutritional status are all associated with chances of a successful DAIR procedure. Paramount to success are a radical debridement and exchange of modular components (to reduce biofilm and remove the fibrin layer between components that supports infection). Most studies suggest a lower chance of infection eradication with staphylococcal, and especially MRSA, infection.

Staphylococcus aureus or coagulase-negative staphylococci (CNS) are the most common causative pathogens of PJI, accounting for approximately two-thirds of all cases. Despite gradually improving success rates for DNIR over the years, the reported outcome of staphylococcal PJI is still heterogeneous, ranging from 23–90%.

Coagulase-negative staphylococci (CoNS) such as *S. epidermidis* can be divided into methicillin-resistant coagulase-negative staphylococci (MRSE) and methicillin-susceptible coagulase-negative staphylococci (MSSE).

Scheper H et al. in a meta-analysis on the success rates with DNIR for PJI reported considerably better results for hip and coagulase negative staphylococci (CNS) PJI than for knee and *S. aureus* PJI. Success rates of MRSA and MSSA PJI after DAIR were similar.

Coagulase-negative staphylococcus bacteria represent a concerning cohort of increasingly common and decreasingly treatment-susceptible pathogens in PJI. Both biofilm production and avidity towards antibiotic resistance acquisition enhance the virulence of CNS.

Methicillin-resistance is not decisive for virulence, but methicillin-resistant *S. aureus* (MRSA) strains often express a higher level of virulence factors that facilitate their survival and spread.

In summary, literature is confusing and often non-committal. The approach shared by many PJI revision groups, is to go for a DAIR ASAP whenever they are confident that they are dealing with an acute PJI, regardless of the pathogen. A speedy response combined with the experience of the surgeon performing the DAIR and a good MDT support are probably more important factors when it comes to achieving a successful outcome than the pathogen.

Xu Y, Wang L, Xu W. Risk factors affect success rate of debridement, antibiotics and implant retention (DAIR) in periprosthetic joint infection. *Arthroplasty* 2020;**2**:37.

Scheper H et al. Outcome of debridement, antibiotics, and implant retention for staphylococcal hip and knee prosthetic joint infections, focused on rifampicin use: a systematic review and meta-analysis. *Open Forum Infect Dis.* 2021;**8**(7).

Hays MR et al. Increased incidence of methicillin-resistant *Staphylococcus aureus* in knee and hip prosthetic joint infection. *J Arthroplasty* 2023;**38**(6S):S326–S330.

28. Answer: D. **Benchmark revision rate less than 1 in 20 at 10 years**
ODEP (Orthopaedic Data Evaluation Panel) is an independent group of clinical and non-clinical experts who invite implant manufacturers to supply data regarding their implants. The data are assessed and an ODEP rating is awarded (or not). The number, 3, 5, 7, 10 (full compliance with NICE benchmark), 13 or 15, signifies the number of years of data available. 'A' signifies strong evidence, 'B' acceptable strength of evidence. A '*' is awarded for an implant revision rate of less than 1 in 20 (5%) at 10 years. The Beyond Compliance initiative is a post-market surveillance service supported by ODEP. Implants registered with The National Joint Registry and being evaluated through Beyond Compliance are recognised with the rating 'Pre-entry A*'.

29. Answer B. **Elevated ESR (serum)**
The 2018 criteria are a development of the 2011 definitions and have higher sensitivity (97.7%) and specificity (99.5%) for the diagnosis of periprosthetic joint infection. A diagnosis is made either with one major criterion being met (two positive cultures of the same organism, or a sinus tract with evidence of communication to the joint or visualisation of the prosthesis), or a score of equal or greater than 6 from minor criteria. An elevated CRP or D-dimer (serum) scores 2, an elevated ESR (serum) scores only 1, an elevated synovial PMN (%) (synovial) scores 2, an elevated synovial WBC count or LE (Leucocyte esterase) (synovial) scores 3, and a positive alpha-defensin (synovial) scores 3.

Parvizi J et al. The 2018 definition of periprosthetic hip and knee infection: an evidence-based and validated criteria. *J Arthroplasty* 2018;**33**:1309–1314.e2.

30. Answer B. **2.**
Core decompression is a treatment option for AVN of the femoral head before subchondral collapse has occurred. Steinberg (a modification of the Ficat classification) stage 3 is defined by the radiographic 'Crescent Sign', indicating subchondral collapse.

Chughtai M et al. An evidence-based guide to the treatment of osteonecrosis of the femoral head. *Bone Joint J.* 2017;**99-B**(10):1267–1279.

31. Answer A. **Iatrogenic injury**
Intra-prosthetic dislocation is a complication unique to dual mobility (DM) designs where the larger diameter polyethylene bearing becomes detached from the smaller diameter metal or ceramic bearing: the most common cause is likely to be iatrogenic, when closed reduction of a dislocated dual mobility THR is attempted, and the outer bearing is levered off the acetabular component dislocating it from the inner bearing: the so-called 'bottle-opener' effect. Modular DM implants may be more prone to failure through other mechanisms. Non-highly crosslinked polyethylene bearings are more prone to later intra-prosthetic dislocation. Skirted heads and smaller diameter heads are less likely to be associated with early intra-prosthetic dislocation.

De Martino I et al. Early intraprosthetic dislocation in dual-mobility implants: a systematic review. *Arthroplasty Today* 2017;**3**:197–202.

32. Answer D. **Multiple emboli**
Bone Cement Implantation Syndrome (BCIS) is a rare, potentially fatal, complication of surgery using bone cement. Its aetiology is incompletely understood and likely to be multi-factorial. The most likely causative mechanism is the creation of emboli of marrow, bone, cement, air, platelet-aggregates, due to the high intra-medullary pressures generated whilst cementing, and especially, inserting the prosthesis. These emboli have mechanical and mediator induced effects.

Hines CB. Understanding bone cement implantation syndrome. *AANA J.* 2018;**86**:433–441.

33. Answer: C **Hydrogen peroxide**
There is no clear evidence to support the use of one irrigation solution over another. These solutions may be effective in breaking down biofilm in established infection and preventing infection in primary joint replacements by reducing bacterial burden prior to wound closure. One ml of hydrogen peroxide produces 10 ml of oxygen, and there have been reports of fatal complications relating to air emboli when used in enclosed anatomical spaces, such as the femoral canal.

Christopher ZK., Deckey DG., Pollock JR, Spangehl MJ. Antiseptic irrigation solutions used in total joint arthroplasty: a critical analysis review. *JBJS Rev.* 2022;**10**(3):10.2106/JBJS.RVW.21.00225.

34. Answer B. **Long, fully coated uncemented stem**
The radiograph shows a loose femoral stem with extensive metaphyseal bone loss and more than 4cm of intact diaphysis. This could be classified as Paposky Type 3A. The most suitable revision would be to a long uncemented, extensively coated stem that could be modular or non-modular. A cement-in-cement revision would require an intact proximal cement-bone interface. A primary cemented stem would require an intact metaphysis. A proximal femur replacement would be more suitable for 3B and 4 defects. Removal of cement and a long-cemented stem is associated with less favourable outcomes.

Suleiman LI, Erivan R, Paprosky WG. Classifying femoral bone deficiency: picking the right tool for the job. *Semin. Arthroplasty* 2018;**29**:172–176.

35. Answer A. **Debridement, antibiotics, and implant retention**
Debridement, antibiotics, and implant retention is an established treatment for infections in primary joint replacements, but also has similar indications in revision arthroplasties. One would expect a lower chance of success in infection eradication compared with that in a primary hip or knee replacement. Factors associated with worse outcomes are delays to DAIR from start of symptoms, multiple DAIRs, antibiotic mismatch.

Veerman K, Raessens J, Telgt D, Smulders K, Goosen JHM. Debridement, antibiotics, and implant retention after revision arthroplasty: antibiotic mismatch, timing, and repeated DAIR associated with poor outcome. *Bone Joint J.* 2022;**104-B**(4):464–471.

36. Answer E. **Phelp's**
Phelps test evaluates for tightness in the gracilis muscle (adductor). The patient lies supine and the affected hip is abducted as far as possible. The knee is then flexed over the side of the couch. If more abduction is possible by flexing the knee (and relaxing the gracilis) then this signifies that the gracilis is tight.

Bryant described an anatomical triangle useful in the assessment of limb length inequality.

Ely described a test for rectus femoris tightness. Passive flexion of the knee in the presence of a tight rectus femoris leads to ipsilateral buttock rising.

Ober described a test for contracture of the fascia lata or iliotibial band. The patient lies on the unaffected side. The affected hip is flexed and abducted 45°. This hip is then slowly extended. Normally in bringing the hip into extension, it will be possible to adduct the hip to the midline. In the presence of a tight iliotibial band, the leg remains abducted.

Patrick described a test to distinguish between pain originating from the sacroiliac joint versus the posterior hip. The patient lies supine while placing the ipsilateral foot on the contralateral knee – the figure of four position. The examiner places one hand on the flexed knee and the other on the ASIS of the contralateral side and presses gently downwards on the flexed knee.

Chapter 3

Hip I Structured SBA

Edward Holloway

HIP I STRUCTURED SBA QUESTIONS

1. An imaging report refers to a pathological avulsion at the insertion of the Iliopsoas tendon.
   What Gruen zone does this correspond to?
   A. Zone 1
   B. Zone 2
   C. Zone 4
   D. Zone 6
   E. Zone 7

2. A patient with painful osteoarthritis of their hip underwent femoral nailing, for a mid diaphyseal fracture 15 years previously. Their surgeon plans to perform hip replacement surgery while keeping the nail in place.
   What is the most suitable type of patient for this procedure?
   A. Large BMI >35 female over 65 years
   B. Large BMI >35 male over 65 years
   C. Large BMI >35 male under 65 years
   D. Low BMI female under 65 years
   E. Low BMI male under 65 years

3. A nerve is damaged during the direct lateral hip approach when muscles are inadvertently split more than 5cm proximal to the greater trochanter.
   Asking the patient to perform which of the following movements is most likely to reveal a deficit?
   A. Dorsiflex ankle
   B. Extend great toe
   C. Extend hip
   D. Extend knee
   E. Stand on one leg

4. A patient received a hip arthroplasty typically reserved for younger patients with good femoral head bone stock which comprises approximately 3.5% of all hip arthroplasties.
   What follow-up is recommended for an asymptomatic patient with an ODEP 10 or 10A* rated implant?
   A. Annually, for as long as the device is implanted
   B. Annually for the first 5 years, two yearly to 10 years
   C. Annually for the first 5 years, two yearly to 10 years and three after
   D. First year, once at 7 years, and once at 10 years
   E. First year, once at 7 years, and three yearly thereafter

5. You are consenting a 45-year-old patient with a Garden II neck of femur fracture for surgery.
   What is the most common risk of this surgery?
   A. Avascular necrosis
   B. Femoral nerve injury
   C. Leg length discrepancy
   D. Sciatic nerve injury
   E. Trendelenburg gait

6. A patient has a hip arthroplasty through an approach that is designed to be soft tissue preserving and is sometimes performed utilising a fracture table.
   The nerve most commonly at risk during this approach crosses, in the majority of patients, the lateral border of which muscle?
   A. Rectus femoris
   B. Sartorius
   C. Tensor fascia lata
   D. Vastus intermedius
   E. Vastus lateralis

7. After inserting an uncemented cup, you carefully define quadrants by drawing a line from the ASIS to the centre of the cup and a second line perpendicular to this. You turn your back and your registrar inserts a screw in the anterosuperior quadrant.

What structure is most at risk?
A. External iliac vessels
B. Inferior gluteal nerve and vessels
C. Internal pudendal nerve and vessels
D. Obturator nerve and vessels
E. Sciatic nerve

8. An audit of a department's THA complications reveals a spike in intraoperative periprosthetic femoral fractures (IOPFF) equivalent to intraoperative Vancouver Type A2.
Which factor is associated with the highest relative risk of this complication?
A. Age 41–49 years
B. Cementless stem
C. Female sex
D. Paediatric disease
E. Previous trauma

9. A 45-year-old welder with a history of steroid use presents with groin pain and an MRI that shows a 20% area of femoral head collapse.
What is the most appropriate management?
A. Bisphosphonate infusion
B. Core decompression
C. Proximal femoral osteotomy
D. Total hip arthroplasty
E. Vascularised fibular graft

10. An 80-year-old patient listed for a THA has had previous lumbar spine surgery. Concerned about dislocation risk, you request sitting and standing lateral lumbar spine radiographs.
What is the name of the angle that is formed for a line passing from the centre of the S1 end plate and the centre of the segment between the two femoral heads (the bicoxofemoral axis), and the vertical?
A. APPt (anterior pelvic plane tilt)
B. FPP (functional pelvic plane)
C. PI (pelvic incidence)
D. SPT (spinopelvic tilt)
E. SS (sacral slope)

11. A 55-year-old patient with Parkinson's disease presents with a Garden 4 neck of femur fracture. Radiographs show that the ratio of the inner canal diameter at the midportion of the lesser trochanter, divided by the diameter 10 cm distal is >0.75.
What is the most appropriate management?
A. Cemented dual mobility THA
B. Cemented THA
C. Two-hole DHS
D. Uncemented dual mobility THA
E. Uncemented THA

12. After thorough discussion, it is decided that the best option for a 20-year-old manual labourer with post-traumatic hip OA is a fusion.
What is the most appropriate position of fusion?
A. 0° external rotation, 0° adduction, 5° flexion
B. 5° external rotation, 5° adduction, 25° flexion
C. 10° external rotation, 15° abduction, 25° flexion
D. 15° external rotation, 0° abduction, 5° flexion
E. 15° external rotation, 15° abduction, 5° flexion

13. A patient underwent a THA for a NOF fracture while abroad on holiday. The patient was given strict rehabilitation instructions to avoid flexion beyond 90° and extreme internal rotation.
What structure was most likely to have been injured during the patient's surgery?
A. Femoral nerve
B. Lateral cutaneous nerve
C. Pudendal nerve
D. Sciatic nerve
E. Superior gluteal nerve

14. A 77-year-old man presents with an insidious onset of hip and anterior thigh pain 15 years after a total hip arthroplasty. He denies fever or systemic upset, and initial bloods show normal inflammatory markers. Figure 3.1 is an anteroposterior radiograph of the left hip.

Figure 3.1 Anteroposterior (AP) radiograph left hip

You advise the patient that he should undergo revision surgery as he is at risk of what complication?

A. Dislocation
B. Infection
C. Periprosthetic acetabular fracture
D. Periprosthetic femur fracture
E. Pseudotumour formation

15. You review a patient following hip arthroscopy and extensive debridement of a labral cyst. He has weakness of ankle dorsiflexion.

Injury has most likely occurred as a result of what?

A. Excessive traction at groin post
B. Placement of anterior portal
C. Placement of anterolateral portal
D. Placement of distal anterolateral portal
E. Placement of posterolateral portal

16. During intraoperative assessment for stability of a THA you have implanted through a modified Hardinge approach, you notice that the hip is unstable in extension and external rotation.

What change will increase the primary arc of hip motion?

A. 20° versus 0° liner
B. 36mm versus 32mm head
C. High versus standard offset stem
D. Lateralised versus standard liner
E. Skirted head

17. A 70-year-old woman presents with a red, swollen and painful area around the incision site of a THR performed 8 weeks earlier. She has a CRP of 78, WCC of 16 and temperature of 37.4°C. Her other observations are unremarkable. She did not attend 6-week follow-up and says the wound has not stopped leaking since she left hospital.

What is the most appropriate management?

A. Aspiration and culture-specific long-term antibiotic suppression
B. Debridement, antibiotics, implant retention with exchange of modular components
C. Debridement, antibiotics, implant retention with retention of modular components
D. Empiric antibiotics
E. Revision arthroplasty

18. A 53-year-old man with severe ulcerative colitis is referred for a THA. His pelvic X-ray shows Brooker grade 3 changes on the ipsilateral side replaced 4 years earlier.

Which of the following prophylactic treatments is most appropriate?

A. Diphosphonate 20mg/kg for 21 days
B. Ibuprofen 400mg TDS for 4 weeks
C. Indomethacin 25mg TDS for 6 weeks
D. Single 2 500cGy radiotherapy dose
E. Three 1 500cGy radiotherapy doses

19. A 23-year-old woman has been referred by her physiotherapist with symptoms of hip impingement. A radiograph of her left hip is shown here (Figure 3.2).

Figure 3.2 Anteroposterior (AP) radiograph left hip

What is marked on her radiograph?

A. Alpha angle
B. Lateral centre edge angle
C. Sharp's angle
D. Tonnis angle
E. Vertical centre edge angle

20. A young man with cerebral palsy is referred with hip pain. You want to examine for contracture in a muscle with an origin at the inferior pubic symphysis and inferior pubic rami, which attaches to a point just posterior to the attachment of sartorius.

What is the most appropriate test?

A. Ely's test
B. Ober's test
C. Phelp's test
D. Thomas' test
E. Trendelenburg test

21. A 24-year-old woman falls while mountain biking and sustains the injury shown in this radiograph (Figure 3.3). In theatre, you struggle to reduce the fracture with in-line traction and rotation.

Figure 3.3 Anteroposterior (AP) radiograph left hip

What is the most appropriate next step?

A. Extension, abduction, in-line traction, then external rotation
B. Fixation in best position achieved
C. Flexion to 90°, adduction, in-line traction, then internal rotation
D. Open reduction using a modified Smith-Petersen approach
E. Total hip arthroplasty

22. A 30-year-old woman is referred for consideration of THA. Her radiographs have been classified as a Type B using the Hartofilakidis classification.
What anatomical characteristic of the femur is most commonly associated with this?

A. Excessive anteversion
B. Excessive femoral bow
C. Excessive retroversion
D. Excessive valgus
E. Excessive varus

23. The diagram shown here represents the scratch profile of a material used in THA femoral heads (Figure 3.4).

Figure 3.4 Scratch profile

If such a component fractures, what bearing couple should be used during revision surgery?

A. Ceramic on ceramic
B. Ceramic on poly
C. Metal on metal
D. Metal on poly
E. Oxinium on poly

24. A 45-year-old presents with symptoms of hip impingement, and radiographs show the femoral head to be medial to Kohler's line.
What is the most likely diagnosis?

A. Acetabular retroversion
B. Coxa magna
C. Coxa valga
D. Coxa vara
E. Otto pelvis

25. A 60kg woman develops progressive pain and numbness in the lateral calf with weakness of ankle dorsiflexion 48 hours after THA.
Which of the following is the most appropriate action?

A. Book for emergency surgery
B. Nurse prone and review the following morning
C. Nurse with knee in flexion and review the following morning
D. Urgent MRI scan
E. Withhold prophylactic LMWH

26. A surgeon admits a mistake was made during a THA. The patient complains that their operated leg feels short.
What is most likely to have resulted in this?

A. +8mm versus 0mm femoral head
B. 125° versus 135° neck-shaft angle implant
C. High versus standard offset stem
D. Incomplete insertion of an uncemented stem
E. Size 4 rather than size 3 implant inserted

27. One of your patients 3 months post-THA is aspirated because of signs of PJI.
What organism would be associated with the lowest chance of infection eradication with a DAIR procedure?

A. Acinetobacter
B. Coagulase negative *Staphylococcus*
C. Corynebacterium
D. *Staphylococcus aureus*
E. *Streptococcus*

28. You start a job as a Hip Consultant. Your clinical lead advises that you use an implant with a ODEP 10A* rating.
What does the * indicate?
A. Acceptable evidence
B. Being evaluated through the Beyond Compliance initiative
C. Benchmark revision rate less than 1 in 10 at 10 years
D. Benchmark revision rate less than 1 in 20 at 10 years
E. Strong evidence

29. You aspirate a THA that has become acutely painful in a patient with systemic symptoms.
According to the 2018 Musculoskeletal Infection Society (MSIS) criteria for the diagnosis of periprosthetic joint infection, which of these findings carries least weight in making a diagnosis of infection?
A. Elevated CRP or D-dimer (serum)
B. Elevated ESR (serum)
C. Elevated synovial PMN (%) (synovial)
D. Elevated synovial WBC count or LE (synovial)
E. Positive alpha-defensin (synovial)

30. A well-read 38-year-old patient with AVN of his hip asks you why you have not suggested a core-decompression procedure.
You explain that for this to be an option, his disease should not have progressed beyond which Steinberg stage?
A. 1
B. 2
C. 3
D. 4
E. 5

31. **Early intra-prosthetic dislocation of dual mobility hip replacements is likely to be most commonly due to what?**
A. Iatrogenic injury
B. Modular designs
C. Non-highly crosslinked polyethylene
D. Skirted heads
E. Smaller diameter inner bearings

32. A frail 88-year-old undergoing cemented hip hemiarthroplasty for an intracapsular NOF fracture becomes severely hypoxic and hypotensive when the stem is inserted.
What is the most likely causative mechanism?
A. Anaphylaxis to antibiotic in the bone cement
B. Complement activation
C. Direct effect of exothermic
D. Multiple emboli
E. Vasodilatation caused by circulating methyl methacrylate monomers

33. Whilst washing the femoral canal during a first stage revision for infection you are offered a choice of irrigation solutions.
Which would be least suitable?
A. Acetic acid
B. Chlorhexidine
C. Hydrogen peroxide
D. Polyhexanide-betaine
E. Povidone-iodine

34. This 69-year-old lady had a THA 20 years ago. She presents with start-up pain in the thigh and groin. Her blood tests are unremarkable, and an aspiration is negative. Figure 3.5 is an anteroposterior radiograph of her right hip.
Which approach to revision of the femoral component would be most appropriate?

Figure 3.5 Anteroposterior (AP) radiograph right hip

A. Cement-in-cement
B. Long, fully coated uncemented stem
C. Primary cemented stem

D. Proximal femur replacement
E. Removal of cement and long cemented stem

35. A fit and well 74-year-old gentleman had a revision THA 7 months ago for aseptic loosening of a 25-year-old Charnley THA. He presents with a week of thigh pain and mild systemic upset. CRP is 350 and an aspirate reveals frank pus in the joint.

What is the most suitable management?

A. Debridement, antibiotics, and implant retention
B. Excision arthroplasty
C. Single stage revision
D. Suppressive antibiotics
E. Two stage revision

36. **When examining for contractures around the hip, which eponymous test is performed by lying the patient supine, and abducting the affected hip as far as possible, then assessing if more abduction is possible when the knee is flexed?**

A. Bryant's
B. Ely's
C. Ober's
D. Patrick's
E. Phelp's

HIP I STRUCTURED SBA ANSWERS

1. Answer E. **Zone 7**
   Iliopsoas originates from the anterior and inferior aspects of the transverse processes of L1–L5 and the bodies and discs of T12–L5. It inserts into the lesser trochanters and is innervated by direct fibres from the lumbar plexus (L1/L2/L3). It acts as a flexor of the hip.

   Gruen zones are used to describe areas of loosening around a femoral stem. Zone 1 relates to the greater trochanter, zone 7 the lesser trochanter and zones 6 and 5, and zones 2 and 3 on the medial and lateral aspects of the femur, respectively. Zone 4 is at the tip of the stem (Figure 3.6).

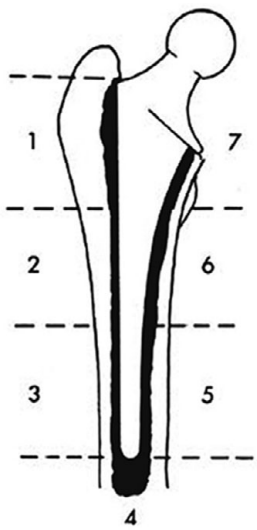


Figure 3.6 Gruen zones

2. Answer C. **Large BMI >35 male under 65 years**
   An important indication of hip resurfacing is patients with pre-existing metalwork in the medullary canal of the femur which precludes a metaphyseal stem. Advantages of a hip resurfacing over a THA include increased stability due to a larger head size, preservation of femoral head and neck bone stock, simpler femoral revision, lower mortality and the potential of a more normal gait pattern and participation in high-demand activities.

   After high-profile failures including certain implants the most suitable patient group to benefit from resurfacing is being redefined, but it is generally considered to be most suitable for younger, larger male patients.

   Logishetty K, Muirhead-Allwood SK, Cobb JP. Hip resurfacing – what is its role in modern orthopaedics? *Bone & Joint 360*. 2020 Feb;**9**(1):4–9.

3. Answer E. **Stand on one leg**
   The superior gluteal nerve is at risk during deep dissection in the direct lateral approach to the hip. The fibres of gluteus medius are split from the middle of the greater trochanter proximally. If the split is continued more than 3–5cm proximal to the trochanter there is risk of nerve damage. The superior gluteal nerve originates from the lumbosacral plexus with contribution from nerve roots L4–S1 and innervates gluteus medius, gluteus minimus, and tensor fascia lata. Weakness will manifest clinically during Trendelenburg test or hip abduction.

4. Answer E. **First year, once at 7 years and three yearly thereafter**
   ODEP 10A or 10A* rated hip resurfacing devices are the MatOrtho Adept Resurfacing Head (48–58mm) and Smith & Nephew Birmingham Hip Resurfacing Head (48–62mm). It is recommended that they be followed up during the first year, once at 7 years and three yearly thereafter. Patients at risk of adverse reaction to metal debris (ARMD) (female patients, males with femoral components smaller than 48mm and those with a DePuy ASR implant) should be reviewed annually for as long as the device is implanted. Those not at risk but symptomatic should also be seen annually. Other implants in asymptomatic patients not at risk should be seen annually for the first 5 years, two yearly to 10 years, and then three yearly thereafter.

   Logishetty K, Muirhead-Allwood SK, Cobb JP. Hip resurfacing – what is its role in modern orthopaedics? *Bone & Joint 360*. 2020;**9**(1):4–9.

5. Answer A. **Avascular necrosis**
   Garden classified femoral neck fractures into four types depending on the degree of displacement seen on an anteroposterior radiograph. Type I are incomplete fractures, type II are complete but non-displaced fractures, type III are complete and partially displaced fractures and type IV are complete and fully displaced.

   Young patients with Garden II neck of femur fractures would most commonly be managed with closed reduction and fixation with either cannulated hip screws or an alternate device, unless the patient

had significant comorbidities making an arthroplasty with a lower risk of reoperation a better option.

Leg length discrepancy, sciatic nerve palsy injury and Trendelenburg gait would all be complications of THR.

Parker MJ, Gurusamy KS. Internal fixation versus arthroplasty for intracapsular proximal femoral fractures in adults. *Cochrane Database Syst Rev*. 2006;**4**:CD001708.

6. Answer B. **Sartorius**

The direct anterior approach (DAA) to the hip is performed with the aim of reducing muscle damage, length of stay, pain and complication rate. A fracture table with specific attachments is used by some to assist in femoral exposure.

There is a risk of damage to the lateral cutaneous nerve of the thigh. This nerve arises from the lumbar plexus, or more rarely the femoral nerve itself, and travels through the pelvis on the iliacus muscle. It enters the thigh under the inguinal ligament at a point anywhere between the anterior superior iliac spine (ASIS) and the midinguinal point. The nerve then pierces the fascia lata medial and inferior to the ASIS. From here, the nerve takes a variable course but most commonly the medial border of sartorius.

Meermans G, Konan S, Das R, Volpin A, Haddad FS. The direct anterior approach in total hip arthroplasty: a systematic review of the literature. *Bone Joint J*. 2017;**99-B**(6):732–740.

7. Answer A. **External iliac vessels**

This SBA topic is of significant practical importance and is also frequently asked in *viva* examinations.

The posterior superior and posterior inferior acetabular quadrants contain the best available bone stock and are relatively safe for the transacetabular placement of screws. The anterior superior and anterior inferior quadrants should be avoided whenever possible, because screws placed improperly in these quadrants may endanger the external iliac artery and vein, as well as the obturator nerve, artery, and vein.

The acetabular-quadrant system provides the surgeon with a simple intraoperative guide to the safe transacetabular placement of screws during primary and revision acetabular arthroplasty. A constant relationship was found to exist between specific acetabular quadrants and specific intrapelvic structures.

Screws originating from the **anterior superior quadrant** were found to lie near the external iliac artery and vein. However, because of the more medial position of the vein with respect to the artery and the paucity of interposed tissue along the pelvic brim, the external iliac vein was more in danger of injury than was the artery.

Screws originating from the **anterior inferior quadrant** were directed toward the obturator nerve and vascular structures. This is most evident at the superolateral aspect of the obturator foramen, where the nerve, artery, and vein exit the true pelvis through the obturator canal.

When an anatomical variant was present (the aberrant obturator artery or accessory obturator vein) these vessels were even more susceptible to injury. The accessory or aberrant obturator vessels travel across a section of the pelvic brim (located just opposite the anterior inferior quadrant) with little interposed soft tissue. This section of the osseous acetabulum is thin (6–12 mm), which increases the possibility of vascular injury.

Screws that are located centrally in the **posterior superior quadrant** may be directed toward the superior gluteal nerve, artery and vein as they exit the pelvis through the greater sciatic notch.

Screws that are located centrally in the **posterior inferior quadrant** are directed toward the inferior gluteal and internal pudendal nerves and vessels. These structures are rarely endangered, due to surrounding intrapelvic tissue and their distance from the posterior column.

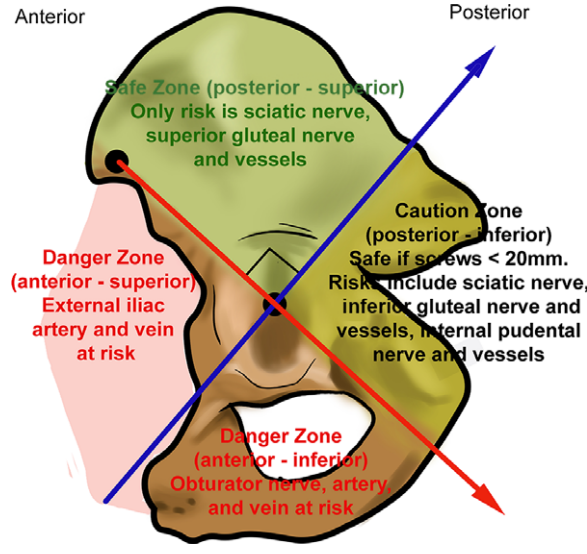


Figure 3.7 Safe acetabular quadrants for screw placement

The acetabular-quadrant system. The quadrants are formed by the intersection of lines A and B. Line A extends from the anterior superior iliac spine (ASIS) through the centre of the acetabulum to the posterior aspect of the fovea, dividing the acetabulum in half. Line B is drawn perpendicular to line A at the mid-point of the acetabulum, dividing it into four quadrants.

8. Answer B. **Cementless stem**
Intraoperative Vancouver A2 fractures are non-displaced fractures of the proximal metaphysis. All answers are associated with an increased relative risk of calcar fracture, but cementless stems give the greatest relative risk (RR) (RR = 3.8). Age 11–49 RR = 1.5, female sex RR = 1.9, paediatric disease RR = 2.6, previous trauma RR = 3.6.

9. Answer D. **Total hip arthroplasty**
Avascular necrosis of the hip is predominantly idiopathic but may be associated with alcohol abuse, steroid use, hypercoagulability, Caisson's disease and sickle cell disease. Treatment options depend upon the clinical and radiographic stage (Ficat, Steinberg) of the disease and age/comorbidities of the patient. The relatively conservative options listed would be options in younger patients or those with earlier stages of disease. Once any significant amount of collapse has occurred in a patient over 40, the most likely option is an arthroplasty procedure.

Petek D, Hannouche D, Suva D. Osteonecrosis of the femoral head: pathophysiology and current concepts of treatment. *EFORT Open Rev*. 2019;**4**:85–97.

10. Answer D. **SPT (spinopelvic tilt)**
Increasingly, the relationship between the spine, hip and knee is assessed and considered in how it may affect the functionality and stability of a THR as the patient moves from lying to standing and from sitting to standing. All options can be measured radiographically to this end.

APPt (anterior pelvic plane tilt) refers to the rotation of the pelvis in the sagittal plane as measured by the angle formed between the coronal plane and a line from the anterior superior iliac spine (ASIS) to pubic symphysis.

The APP (anterior or anatomical pelvic plane) is defined by the pubic symphysis and the two anterior superior iliac spines. The FPP (functional pelvic plane) rotates this plane according to an individual's pelvic tilt. It is considered a more accurate reference plane for assessing acetabular component position. PI (pelvic incidence) is the angle between two lines: one from the centre of the femoral head to the centre of the S1 end plate, and a second perpendicular to a line across the S1 end plate, intersecting the centre of the end plate. SPT (spinopelvic tilt) is the angle between a line from the centre of the S1 end plate and the centre of the segment between the two femoral heads (the bicoxofemoral axis), and the vertical. SS (sacral slope) is the angle between two lines: one parallel to the S1 end plate, and a second along a horizontal reference plane.

Ike H et al. Spine-pelvis-hip relationship in the functioning of a total hip replacement. *J Bone Joint Surg Am*. 2018;**100**:1606–1615.

11. Answer A. **Cemented dual mobility THA**
The Dorr classification depends upon the ratio between the inner canal diameter at the level of the midpoint of the lesser trochanter and a point 10cm below that. Dorr C femurs as defined as a ratio >0.75 are most suitable for a cemented prosthesis. A patient with significant risk of dislocation and a grossly displaced NOF fracture would be a good candidate for a dual-mobility acetabular component.

Our preferred choice in view of the patient's young age (55 years) would be for a dual motion hydrid THA (cup being uncemented). A cemented dual motion cup would be at risk of medium term failure. The possibility of using a hybrid THA dual motion THA was not given in the options.

12. Answer B. **5° external rotation, 5° adduction, 25° flexion**
This is the most appropriate position of hip fusion.

13. Answer D. **Sciatic nerve**
The position of greatest risk of dislocation for a posterior approach THA is flexion and internal rotation. The structure most at risk during this approach is the sciatic nerve.

14. Answer D. **Periprosthetic femur fracture**
The radiograph shows a loose Charnley femoral stem which is close to fracturing through the posterior cortex of the femur (Figure 3.6). The THA may be infected but the fact that the

Figure 3.8 Lateral radiograph of left hip

acetabulum does not look loose goes against this. Pseudotumour formation is associated with metal-on-metal bearing couples.

15. Answer E. **Placement of posterolateral portal**
By far the most common direct nerve injury resulting from hip arthroscopy portal placement is of the lateral femoral cutaneous nerve when placing or working through the anterior portal. Sciatic nerve injury causing a foot drop is a rare complication of posterolateral portal placement, made more likely by placing the leg in external rotation.

Papavasiliou AV, Bardakos NV. Complications of arthroscopic surgery of the hip. *Bone Joint Res*. 2012;**1**:131–144.

16. Answer B. **36mm versus 32mm head**
Scenarios of hip instability are regularly asked in the Part 1 paper. It is an extremely important topic as surgeons need to know how to deal with an on table unstable hip.

The primary arc of hip motion is the range that the hip can move before the neck impinges upon the acetabulum and is an important determinant of THA stability. A lipped or angled liner may improve stability by increasing coverage but actually decreases the primary arc of motion and, in this instance, may make anterior dislocation more likely by causing posterior impingement levering the hip out of joint. A high offset stem or lateralised liner will not alter the primary arc of movement but may improve stability by moving the femoral neck away from impinging soft tissues or osteophytes (potential to the detriment of proper restoration of hip biomechanics). A skirted head (as found on the longer lengths) decreases the primary arc. A bigger head size increases the impingement-free range of motion and jumping distance of THA (Sariali et al. 2009).

Sariali E, Lazennec J Y, Khiami F, Catonne Y. Mathematical evaluation of jumping distance in total hip arthroplasty: influence of abduction angle, femoral head offset, and head diameter. *Acta Orthop*. 2009;**80**:277–282.

17. Answer E. **Revision arthroplasty**
All the options are valid in managing the infected joint replacement. Patients not sufficiently fit to do well with further significant or potentially multiple procedures can be managed with culture-specific, long-term suppressive antibiotics or an excision arthroplasty, if the infection is not able to be suppressed or the patient is unable to take long-term antibiotics.

The success rates of DAIR (debridement, antibiotics, and implant retention) procedures vary enormously in the literature, from 11–100%.

The success rate is correlated with type of organism (*Streptococcus* species tend to do better), exchange of modular components and time from procedure in early infection, or time from first presentation of symptoms in late infection.

An older patient with long duration of symptoms is less likely to have successful infection eradication with a DAIR so may be best served with a one- or two-stage revision procedure depending upon the infecting organism and the surgeon's preference.

Grammatopoulos G et al. Outcome following debridement, antibiotics, and implant retention in hip periprosthetic joint infection – an 18-year experience. *J Arthroplasty* 2017;**32**:2248–2255.

Kunutsor SK, Beswick AD, Whitehouse MR, Wylde V, Blom AW. Debridement, antibiotics and implant retention for periprosthetic joint infections: a systematic review and meta-analysis of treatment outcomes. *J Infect*. 2018;**77**:479–488.

18. Answer E. **Three 1 500cGy radiotherapy doses**
Heterotopic ossification (HO) following THA occurs with an incidence of 5–90% and is associated with the risk factors of male sex, history of previous HO, older age, previous hip fusion, hypertrophic OA, ankylosing spondylitis, post-traumatic OA, Paget's disease, osteonecrosis, and rheumatoid arthritis.

It is classified according to the Brooker classification according to the extent of heterotopic bone formation on an AP radiograph.

Prophylaxis can be considered for patients at high risk of HO and the main forms are

radiotherapy and non-steroidal anti-inflammatory drugs (NSAIDs). Diphosphonates have not been shown to be effective. NSAIDs would be contra-indicated in a patient with severe inflammatory bowel disease. Multiple doses of radiation therapy have been shown to be more effective than single doses.

Board TN, Karva A, Board RE, Gambhir AK, Porter ML. The prophylaxis and treatment of heterotopic ossification following lower limb arthroplasty. *J Bone Joint Surg Br*. 2007;**89**:434–440.

19. Answer D. **Tonnis angle**
The following are measured during the radiographic assessment of patients with symptoms of femoroacetabular impingement:

The Tonnis angle (also called the acetabular index or acetabular roof angle) is the angle between the horizontal and a tangential line from the medial to the lateral sourcil (weight bearing zone of the acetabulum).

Alpha angle is measured on a Dunn view by drawing a line from the centre of the narrowest point of the femoral neck to the centre of the femoral head using a best-fit circle. The angle is between the line down the axis of the femoral neck and a line drawn to the location where the femoral head becomes 'out of round'.

The lateral centre edge angle (of Wiberg) is the angle between a line drawn from the centre of the femoral head to the lateral edge of the acetabulum and a second line that is parallel to the longitudinal pelvic axis.

Sharp's angle, or acetabular angle, is the angle between a horizontal line drawn through the teardrops and a line drawn from the teardrop to the lateral acetabular roof.

The vertical centre edge angle is measured from a false profile radiograph and is between a vertical line through the centre of the femoral head and a line from the centre of the femoral head to the anterior-most point on the acetabulum.

Mannava S et al. Comprehensive clinical evaluation of femoroacetabular impingement: part 2, plain radiography. *Arthrosc Tech*. 2017;**6**: e2003–e2009.

20. Answer C. **Phelp's test**
Phelp's test assesses gracilis tightness. Ely's test assesses rectus femoris tightness. Ober's test assesses tightness of the tensor fascia lata. Thomas' test assesses fixed flexion of the hip. Trendelenburg test assesses hip abductor dysfunction.

21. Answer C. **Flexion to 90°, adduction, in-line traction, then internal rotation**
Leadbetter described a technique in 1939 to aid in the reduction of intracapsular neck of femur fractures. The limb is flexed to relax the musculature around the hip and then internal rotation functions to relax the ligamentous structures. From the above position, further flexion and adduction open the fracture, allowing reduction to be achieved by maintaining traction while bringing the limb into extension with slight abduction and continued internal rotation.

22. Answer A. **Excessive anteversion**
The Hartofilakidis classification recognises three types of congenital hip disease in adults: type A – dysplasia, type B – low dislocation, and type C – high dislocation. In type A disease, the femoral head remains within the original acetabulum. In type B, it articulates with a false acetabulum which partially covers the original acetabulum. In type C, the femoral head has migrated superiorly and posteriorly to the hypoplastic original acetabulum. Adult hip dysplasia is most commonly associated with excessive femoral anteversion.

23. Answer A. **Ceramic on ceramic**
Figure 3.4 (see Questions section) represents the scratch profile of ceramic.

Revision surgery for fractured or damaged ceramic components requires thorough debridement and removal of ceramic fragments. Revision with metal heads should be avoided and ceramic components used wherever possible. Trunnions that are damaged need to be replaced, but if only minimal damage exists; then a ceramic head with a titanium liner or trunnion adapter can be used.

Rambani R et al. Revision total hip arthroplasty for fractured ceramic bearings: a review of best practices for revision cases. *J Arthroplasty* 2017;**32**:1959–1964.

24. Answer E. **Otto pelvis**
Otto pelvis (arthrokatadysis or protrusio acetabuli) is a rare condition associated with hip osteoarthritis. Protrusio acetabuli is defined

radiographically when the medial aspect of the femoral head projects beyond the ilioischial (Kohler's) line. Though sometimes idiopathic, acetabular protrusion is more usually associated with inflammatory arthropathies, osteoporosis, osteomalacia, and Paget's disease. When performing THR, care must be taken to lateralise the medialised hip centre.

25. Answer A. **Book for emergency surgery**
Nerve dysfunction following THR may be a result of intraoperative compression from retractors, traction injury secondary to manipulation or lengthening.

If noted in the immediate postoperative period, tension can be taken off the sciatic nerve by nursing the patient with the knee in flexion.

Progressive, painful sciatic nerve dysfunction should raise the suspicion of compression from haematoma. This is associated with patients of lower mass, and with anticoagulant use. Improved outcomes are associated with prompt exploration and evacuation of haematoma.

Butt AJ, McCarthy T, Kelly IP, Glynn T, McCoy G. Sciatic nerve palsy secondary to postoperative haematoma in primary total hip replacement. *J Bone Joint Surg Br.* 2005;**87**:1465–1467.

Su EP. Post-operative neuropathy after total hip arthroplasty. *Bone Joint J.* 2017;**99-B**(Suppl. 1):46–49.

26. Answer B. **125° versus 135° neck–shaft angle implant**
A longer femoral head length and incomplete insertion of an uncemented femoral stem will lengthen the patient. A larger sized femoral stem or increased offset stem will not generally change leg length.

27. Answer: D. ***Staphylococcus aureus***
Outcomes of DAIR procedures are dictated by many surgical and patient factors. Unsurprisingly, age, frailty, immunity, diabetes, and nutritional status are all associated with chances of a successful DAIR procedure. Paramount to success are a radical debridement and exchange of modular components (to reduce biofilm and remove the fibrin layer between components that supports infection). Most studies suggest a lower chance of infection eradication with staphylococcal, and especially MRSA, infection.

Staphylococcus aureus or coagulase-negative staphylococci (CNS) are the most common causative pathogens of PJI, accounting for approximately two-thirds of all cases. Despite gradually improving success rates for DNIR over the years, the reported outcome of staphylococcal PJI is still heterogeneous, ranging from 23–90%.

Coagulase-negative staphylococci (CoNS) such as *S. epidermidis* can be divided into methicillin-resistant coagulase-negative staphylococci (MRSE) and methicillin-susceptible coagulase-negative staphylococci (MSSE).

Scheper H et al. in a meta-analysis on the success rates with DNIR for PJI reported considerably better results for hip and coagulase negative staphylococci (CNS) PJI than for knee and *S. aureus* PJI. Success rates of MRSA and MSSA PJI after DAIR were similar.

Coagulase-negative staphylococcus bacteria represent a concerning cohort of increasingly common and decreasingly treatment-susceptible pathogens in PJI. Both biofilm production and avidity towards antibiotic resistance acquisition enhance the virulence of CNS.

Methicillin-resistance is not decisive for virulence, but methicillin-resistant *S. aureus* (MRSA) strains often express a higher level of virulence factors that facilitate their survival and spread.

In summary, literature is confusing and often non-committal. The approach shared by many PJI revision groups, is to go for a DAIR ASAP whenever they are confident that they are dealing with an acute PJI, regardless of the pathogen. A speedy response combined with the experience of the surgeon performing the DAIR and a good MDT support are probably more important factors when it comes to achieving a successful outcome than the pathogen.

Xu Y, Wang L, Xu W. Risk factors affect success rate of debridement, antibiotics and implant retention (DAIR) in periprosthetic joint infection. *Arthroplasty* 2020;**2**:37.

Scheper H et al. Outcome of debridement, antibiotics, and implant retention for staphylococcal hip and knee prosthetic joint infections, focused on rifampicin use: a systematic review and meta-analysis. *Open Forum Infect Dis.* 2021;**8**(7).

Hays MR et al. Increased incidence of methicillin-resistant *Staphylococcus aureus* in knee and hip prosthetic joint infection. *J Arthroplasty* 2023;**38**(6S):S326–S330.

28. Answer: D. **Benchmark revision rate less than 1 in 20 at 10 years**
ODEP (Orthopaedic Data Evaluation Panel) is an independent group of clinical and non-clinical experts who invite implant manufacturers to supply data regarding their implants. The data are assessed and an ODEP rating is awarded (or not). The number, 3, 5, 7, 10 (full compliance with NICE benchmark), 13 or 15, signifies the number of years of data available. 'A' signifies strong evidence, 'B' acceptable strength of evidence. A '*' is awarded for an implant revision rate of less than 1 in 20 (5%) at 10 years. The Beyond Compliance initiative is a post-market surveillance service supported by ODEP. Implants registered with The National Joint Registry and being evaluated through Beyond Compliance are recognised with the rating 'Pre-entry A*'.

29. Answer B. **Elevated ESR (serum)**
The 2018 criteria are a development of the 2011 definitions and have higher sensitivity (97.7%) and specificity (99.5%) for the diagnosis of periprosthetic joint infection. A diagnosis is made either with one major criterion being met (two positive cultures of the same organism, or a sinus tract with evidence of communication to the joint or visualisation of the prosthesis), or a score of equal or greater than 6 from minor criteria. An elevated CRP or D-dimer (serum) scores 2, an elevated ESR (serum) scores only 1, an elevated synovial PMN (%) (synovial) scores 2, an elevated synovial WBC count or LE (Leucocyte esterase) (synovial) scores 3, and a positive alpha-defensin (synovial) scores 3.

Parvizi J et al. The 2018 definition of periprosthetic hip and knee infection: an evidence-based and validated criteria. *J Arthroplasty* 2018;**33**:1309–1314.e2.

30. Answer B. **2.**
Core decompression is a treatment option for AVN of the femoral head before subchondral collapse has occurred. Steinberg (a modification of the Ficat classification) stage 3 is defined by the radiographic 'Crescent Sign', indicating subchondral collapse.

Chughtai M et al. An evidence-based guide to the treatment of osteonecrosis of the femoral head. *Bone Joint J.* 2017;**99-B**(10):1267–1279.

31. Answer A. **Iatrogenic injury**
Intra-prosthetic dislocation is a complication unique to dual mobility (DM) designs where the larger diameter polyethylene bearing becomes detached from the smaller diameter metal or ceramic bearing: the most common cause is likely to be iatrogenic, when closed reduction of a dislocated dual mobility THR is attempted, and the outer bearing is levered off the acetabular component dislocating it from the inner bearing: the so-called 'bottle-opener' effect. Modular DM implants may be more prone to failure through other mechanisms. Non-highly crosslinked polyethylene bearings are more prone to later intra-prosthetic dislocation. Skirted heads and smaller diameter heads are less likely to be associated with early intra-prosthetic dislocation.

De Martino I et al. Early intraprosthetic dislocation in dual-mobility implants: a systematic review. *Arthroplasty Today* 2017;**3**:197–202.

32. Answer D. **Multiple emboli**
Bone Cement Implantation Syndrome (BCIS) is a rare, potentially fatal, complication of surgery using bone cement. Its aetiology is incompletely understood and likely to be multi-factorial. The most likely causative mechanism is the creation of emboli of marrow, bone, cement, air, platelet-aggregates, due to the high intra-medullary pressures generated whilst cementing, and especially, inserting the prosthesis. These emboli have mechanical and mediator induced effects.

Hines CB. Understanding bone cement implantation syndrome. *AANA J.* 2018;**86**:433–441.

33. Answer: C **Hydrogen peroxide**
There is no clear evidence to support the use of one irrigation solution over another. These solutions may be effective in breaking down biofilm in established infection and preventing infection in primary joint replacements by reducing bacterial burden prior to wound closure. One ml of hydrogen peroxide produces 10 ml of oxygen, and there have been reports of fatal complications relating to air emboli when used in enclosed anatomical spaces, such as the femoral canal.

Christopher ZK., Deckey DG., Pollock JR, Spangehl MJ. Antiseptic irrigation solutions used in total joint arthroplasty: a critical analysis review. *JBJS Rev.* 2022;**10**(3):10.2106/JBJS.RVW.21.00225.

34. Answer B. **Long, fully coated uncemented stem**
The radiograph shows a loose femoral stem with extensive metaphyseal bone loss and more than 4cm of intact diaphysis. This could be classified as Paposky Type 3A. The most suitable revision would be to a long uncemented, extensively coated stem that could be modular or non-modular. A cement-in-cement revision would require an intact proximal cement-bone interface. A primary cemented stem would require an intact metaphysis. A proximal femur replacement would be more suitable for 3B and 4 defects. Removal of cement and a long-cemented stem is associated with less favourable outcomes.

Suleiman LI, Erivan R, Paprosky WG. Classifying femoral bone deficiency: picking the right tool for the job. *Semin. Arthroplasty* 2018;**29**:172–176.

35. Answer A. **Debridement, antibiotics, and implant retention**
Debridement, antibiotics, and implant retention is an established treatment for infections in primary joint replacements, but also has similar indications in revision arthroplasties. One would expect a lower chance of success in infection eradication compared with that in a primary hip or knee replacement. Factors associated with worse outcomes are delays to DAIR from start of symptoms, multiple DAIRs, antibiotic mismatch.

Veerman K, Raessens J, Telgt D, Smulders K, Goosen JHM. Debridement, antibiotics, and implant retention after revision arthroplasty: antibiotic mismatch, timing, and repeated DAIR associated with poor outcome. *Bone Joint J.* 2022;**104-B**(4):464–471.

36. Answer E. **Phelp's**
Phelps test evaluates for tightness in the gracilis muscle (adductor). The patient lies supine and the affected hip is abducted as far as possible. The knee is then flexed over the side of the couch. If more abduction is possible by flexing the knee (and relaxing the gracilis) then this signifies that the gracilis is tight.

Bryant described an anatomical triangle useful in the assessment of limb length inequality.

Ely described a test for rectus femoris tightness. Passive flexion of the knee in the presence of a tight rectus femoris leads to ipsilateral buttock rising.

Ober described a test for contracture of the fascia lata or iliotibial band. The patient lies on the unaffected side. The affected hip is flexed and abducted 45°. This hip is then slowly extended. Normally in bringing the hip into extension, it will be possible to adduct the hip to the midline. In the presence of a tight iliotibial band, the leg remains abducted.

Patrick described a test to distinguish between pain originating from the sacroiliac joint versus the posterior hip. The patient lies supine while placing the ipsilateral foot on the contralateral knee – the figure of four position. The examiner places one hand on the flexed knee and the other on the ASIS of the contralateral side and presses gently downwards on the flexed knee.

Chapter 4

Hip II Structured SBA

James Gill and Majeed Shakokani

HIP II STRUCTURED SBA QUESTIONS

1. **Metal hypersensitivity to orthopaedics implants is classed as what kind of sensitivity?**
   A. Type I
   B. Type II
   C. Type III
   D. Type IV
   E. Type V

2. A 78-year-old female has been listed for THA and noted to have protrusio on her anteroposterior (AP) radiograph.
   Which of the following conditions is not commonly associated with acetabular protrusio?
   A. Ankylosing spondylitis
   B. Marfan syndrome
   C. Neurofibromatosis
   D. Paget's disease
   E. Rheumatoid arthritis

3. A 42-year-old male presents to the orthopaedic clinic with a 2-month history of left hip pain. His anteroposterior radiograph is shown in Figure 4.1.

Figure 4.1 Anteroposterior (AP) radiograph hips

   Which of the following is not associated with his condition?
   A. Glucocerebrosidase gene
   B. HbSS
   C. Protein S deficiency
   D. Scleroderma
   E. Simvastatin

4. A 24-year-old manual labourer presents with severe post-traumatic arthritis hip. Hip fusion has been discussed by the regional MDT.
   What is the optimal position for hip arthrodesis?
   A. 10° flexion, 5° adduction, 5° external rotation
   B. 10° flexion, 10° adduction, 10° external rotation
   C. 25° flexion, 0° abduction, 10° internal rotation
   D. 25° flexion, 5° adduction, 5° external rotation
   E. 25° flexion, 10° abduction, 10° external rotation

5. **Which of the following results in increased abductor muscle force when performing a single leg stance after arthroplasty?**
   A. Carrying a bag of shopping with the ipsilateral arm
   B. Medialisation of the acetabular cup
   C. Reducing offset
   D. Trunk lean to the ipsilateral side upon single leg stance
   E. Walking with a stick in the contralateral hand post

6. A patient presents with a fractured metal stem of a total hip arthroplasty. On closer inspection of the previous anteroposterior radiographs of their hip taken 6 months ago, there was evidence of loosening.
   In which Gruen zones would loosening be expected in the pre-fracture radiographs in this scenario?

A. 1, 2, 3, 4, 5, 6 and 7
B. 1, 2, 6 and 7
C. 4 and 5
D. 4, 5 and 6
E. 4, 5, 6 and 7

7. **Which of the following is the best mode of imaging to assess for a pseudotumour associated with a metal-on-metal hip resurfacing?**
A. Computed tomography
B. MARS MRI
C. SPECT
D. Ultrasound
E. White cell scan

8. A 60-year-old male falls off a camel while on holiday in Lanzarote and suffers a fracture to the ceramic head of his left total hip arthroplasty (THA). The THA was performed 2 years previously; components included an uncemented titanium cup with polyethylene liner and an uncemented stem with a ceramic head. Prior to the fall, he was completely happy with the hip.
Which of the following is the most appropriate procedure?
A. Revise all implants
B. Revise to a cobalt-chrome head with change of polyethylene liner
C. Revise to a metal-lined ceramic head with change of polyethylene liner
D. Revise to a metal-on-metal bearing surface
E. Revision of ceramic head with change of polyethylene liner

9. **Which kind of lubrication predominates in a metal-on-polyethylene total hip arthroplasty?**
A. Boosted
B. Boundary
C. Elastohydrodynamic
D. Squeeze film
E. Weeping

10. One year after primary total hip arthroplasty performed using a Southern Moore approach a patient asks why his foot turns inwards when he walks.
Which of the following would be the most likely cause?
A. Excessive acetabular cup anteversion
B. Excessive retroversion of femoral stem
C. Failure of the repair of the short external rotators
D. Palsy of gluteus medius and minimus
E. Weakness of gluteus maximus

11. When drilling a screw to augment fixation of an uncemented acetabular cup, profuse bleeding is encountered and the patient becomes hypotensive.
Which vessel has been injured?
A. External iliac
B. Femoral
C. Internal iliac
D. Obturator
E. Pudendal

12. A 78-year-old male is listed for THA. He is a Jehovah's Witness and does not want any blood products to be given.
What is the best way to reduce blood transfusion requirement in a Jehovah's Witness undergoing total hip arthroplasty?
A. Autologous blood transfusion
B. Cell salvage
C. Erythropoietin
D. Hypotensive anaesthesia
E. Wound infiltration with local anaesthetic with adrenaline

13. You are beginning a THA in theatre in a diabetic. A ST3+ orthopaedic trainee is assisting you and asks about the infection risk.
Which factor has the biggest influence in reducing prosthetic joint infection?
A. Antibiotic loaded bone cement
B. Body exhaust suit
C. Plastic isolator
D. Systemic antibiotics
E. Ultraclean air

14. **What is the nerve supply to the superior gemelli?**
A. Nerve to gemelli
B. Nerve to obturator internus
C. Nerve to piriformis
D. Nerve to quadratus femoris
E. Obturator nerve

15. **Which of the following structures exits the greater sciatic foramen and does not re-enter the lesser sciatic foramen?**

A. Nerve to obturator internus
B. Nerve to quadratus femoris
C. Obturator externus
D. Obturator internus
E. Pudendal nerve

16. **Which anatomical structure does not enter the pelvis via the lesser sciatic foramen?**
A. Internal pudendal artery
B. Internal pudendal vein
C. Nerve to obturator internus
D. Obturator internus
E. Pudendal nerve

17. **Which anatomical variation of the sciatic nerve exiting the greater sciatic foramen is most frequently observed?**
A. Common peroneal division exiting above piriformis and tibial nerve division exiting beneath piriformis
B. Common peroneal division exiting above piriformis and tibial nerve exiting through piriformis
C. Common peroneal division passing through piriformis and tibial nerve division exiting beneath piriformis
D. Sciatic nerve exiting above piriformis
E. Sciatic nerve exiting through piriformis

18. In the days following a total hip arthroplasty, a patient was found to have 0/5 power in ankle dorsiflexion and foot eversion but 5/5 power in ankle plantar flexion.
Provided the injury was a neuropraxia at the level of the hip joint, which muscle would you expect to recover first on assessment with electromyography?
A. Adductor magnus
B. Peroneus longus
C. Popliteus
D. Short head of biceps femoris
E. Tibialis posterior

19. A professional tennis player develops pain around the hip 2 months after metal-on-metal hip resurfacing.
Which imaging modality can detect heterotopic ossification earliest?
A. Bone scintigraphy
B. Computed tomography
C. Magnetic resonance imaging
D. Radiographs
E. Ultrasound scan

20. **What structures form the teardrop on an anteroposterior radiograph of the pelvis?**
A. Calcified ligamentum teres
B. Cotyloid fossa, superior aspect of the obturator foramen and the cortical surface of the true pelvis
C. Dense trabeculae of the origin of the superior public ramus
D. Osteophyte within the cotyloid fossa
E. True floor of the acetabulum and the superior pubic ramus

21. **Which of the following conditions is associated with increased acetabular anteversion?**
A. Ankylosing spondylitis
B. Legg–Calvé–Perthes disease
C. Pincer femoral acetabular impingement
D. Rheumatoid arthritis
E. Slipped upper femoral epiphysis

22. **Acetabular protrusio can be defined using an anteroposterior radiograph as which of the following?**
A. Acetabular fossa medial to the ilioischial line
B. Acetabular fossa medial to the iliopectineal line
C. Centre-edge angle greater than 30 degrees
D. Femoral head medial to ilioischial line
E. Femoral head medial to iliopectineal line

23. A 37-year-old male who is training for the long-distance triathlon world championships, Ironman Hawaii, presents with a 6-week history of groin pain.
Which of the following diagnoses requires urgent operative intervention?
A. Cam lesion
B. Iliotibial band syndrome
C. Inferior medial femoral neck stress fracture involving 40% of neck width
D. Piriformis syndrome
E. Superior lateral femoral neck stress fracture involving 25% of neck width

24. **What mechanical property predisposes ceramic to fracture?**

A. Failure at a point below the ultimate tensile strength secondary to repetitive loading
B. Large area under the stress–strain curve
C. Low modulus of elasticity
D. Material that exhibits linear stress–strain relationship until the point of failure
E. Progressive deformation in response to a constant force over a prolonged period

25. **Sickle cell disease is associated with which complication following total hip arthroplasty?**
A. Early prosthetic loosening
B. Higher risk for heterotopic ossification
C. Increased blood loss
D. Nerve palsy
E. Periprosthetic infection

26. **Which of the following ligaments is the strongest?**
A. Iliofemoral
B. Ischiofemoral
C. Ischiosacral
D. Ligamentum teres
E. Pubofemoral

27. **Which of the following combinations of implant position is optimal for total hip arthroplasty?**
A. Cup inclination 30°, cup anteversion 20°, femoral stem anteversion 5°
B. Cup inclination 40°, cup anteversion 15°, femoral stem anteversion 15°
C. Cup inclination 40°, cup anteversion 20°, femoral stem anteversion 0°
D. Cup inclination 50°, cup anteversion 30°, femoral stem anteversion 25°
E. Cup inclination 50°, cup anteversion 40°, femoral stem anteversion 15°

28. **When performing a total hip arthroplasty, what is the optimal combined version of the acetabular cup and femoral stem?**
A. 5°
B. 20°
C. 35°
D. 50°
E. 65°

29. A patient has suffered multiple dislocations of a total hip arthroplasty and has failed conservative measures.
Which of the following is an indication for a constrained liner?
A. 60° acetabulum inclination
B. Femoral stem retroversion
C. Gluteus medius and minimus deficiency
D. Impingement of the femoral neck on a lipped liner
E. Neutral version of the acetabulum

30. When performing the Hardinge approach to the hip, neurovascular structures are placed in jeopardy if the gluteus medius is split too far proximally.
What is the maximum safe split above tip of the greater trochanter that does not place the nerve at risk?
A. 2cm
B. 3cm
C. 4cm
D. 5cm
E. 7cm

31. **Which of the following describes a Ward's triangle?**
A. A sign of osteoporosis
B. Lateral to the primary compressive trabeculae and medial to the secondary compressive trabeculae
C. Lateral to the secondary compressive trabeculae and superior to the primary trabeculae
D. Medial to the primary compressive trabeculae and inferior to the primary tensile trabeculae
E. Medial to the secondary tensile trabeculae and lateral to the secondary compressive trabeculae

32. Smith-Petersen first described a direct anterior approach to the hip.
Which vessel is sacrificed as part of this approach to the hip?
A. Ascending branch of the lateral femoral circumflex artery
B. Descending branch of the lateral femoral circumflex artery
C. Descending branch of the medial femoral circumflex artery
D. Superficial external pudendal artery
E. Transverse branch of the lateral femoral circumflex artery

33. **Which size of PE particles are thought to be most biologically active**
    A. 0.1μm
    B. 0.5μm
    C. 1.0μm
    D. 1.5μm
    E. 0.05μm

34. A 44-year-old male has deteriorating hip pain secondary to osteonecrosis. Symptoms have failed to improve despite conservative measures including protected weight bearing. A subchondral lucent line can be seen on the anteroposterior radiographs of the hip.
    What is the most appropriate management?
    A. Core decompression
    B. Free fibula graft
    C. Hip arthrodesis
    D. Rotational femoral osteotomy
    E. Total hip arthroplasty

35. **Which of the following factors is not responsible for osteolysis around a total hip arthroplasty secondary to polyethylene wear debris?**
    A. IL-1
    B. IL-6
    C. Osteoprotegerin
    D. PDGF
    E. Receptor activator of nuclear factor kappa-B ligand

36. **With which femoral component would the most proximal bone loss be anticipated as a result of stress shielding?**
    A. Cemented dual taper cobalt-chromium stem
    B. Cemented stainless steel composite beam stem
    C. Uncemented, fully porous coated cobalt-chromium stem
    D. Uncemented, fully porous coated titanium stem
    E. Uncemented proximally porous coated cobalt-chromium stem

37. **What is the intermuscular plane of the medial approach to the hip?**
    A. Adductor brevis and adductor longus
    B. Adductor brevis and adductor magnus
    C. Adductor longus and gracilis
    D. Gracilis and adductor magnus
    E. Sartorius and adductor longus

38. **Which muscle is paired with its correct innervation?**
    A. Adductor brevis – posterior division of obturator nerve
    B. Adductor longus – posterior division of obturator nerve
    C. Adductor magnus – tibial nerve and anterior division of obturator nerve
    D. Gracilis – posterior division of obturator nerve
    E. Pectineus – femoral nerve

39. **The femoral circumflex vessels are named according to the relationship with which anatomical structure?**
    A. Calcar femorale
    B. Iliopsoas
    C. Lesser trochanter
    D. Pectineus
    E. Profunda femoris artery

40. **Taper slip cemented stem fixation is optimised by all except which of the following?**
    A. Cement mantle >2mm
    B. Flexible femoral stem
    C. Limited porosity cement
    D. Smooth femoral stem
    E. Stem centralisation

41. **Which of the following is incorrect regarding the capsule of hip joint?**
    A. Gluteus minimus and rectus femoris have direct attachments onto the capsule
    B. The capsule attaches more distally on the neck posteriorly compared with anteriorly
    C. The iliofemoral ligament shares an attachment with the direct head of the rectus femoris
    D. The ischiofemoral ligament is divided as part of the Southern–Moore approach to the hip
    E. The Y-ligament of Bigelow is divided as part of the Smith-Petersen approach to the hip

42. A 58-year-old male was seen in the outpatient clinic with nonspecific complaints of pain in the lumbar spine, buttock, lateral hip and thigh.
    Nerve impingement of which nerve can mimic hip joint pathology?
    A. Femoral nerve
    B. L2

C. Lateral cutaneous nerve of the thigh
D. Obturator nerve
E. Posterior cutaneous nerve of the thigh

43. A 38-year-old female is diagnosed with pincer-type femoral acetabular impingement.
On MRI of the hip, what pattern of changes would be expected to be seen?
A. Anterior intrasubstance labral tear and a posterior acetabular cartilage lesion
B. Anterior intrasubstance labral tear and an anterior acetabular cartilage lesion
C. Anterior labral avulsion and anterior acetabular cartilage delamination
D. Posterior intrasubstance labral tear and posterior acetabular cartilage delamination
E. Posterior labral tear and an anterior acetabular cartilage lesion

44. You are performing a cemented THA for a 70-year-old retired farmer. A trial reduction is repeated with the definitive cup and stem cemented in place and a 32mm standard (neck length) head; however, stability is suboptimal. Stability is re-assessed with a 32mm 'plus 4mm' (neck length) head and stability is now satisfactory. The neck angle for the femoral implant is 125°.
How much will a 'plus 4mm' head increase leg length and offset, respectively, compared with a standard head?
A. 0mm, 4.0mm
B. 2.3mm, 3.3mm
C. 2.8mm, 2.8mm
D. 3.3mm, 2.3mm
E. 4.0mm, 0mm

45. A patient presents with pain 10 years following a THA and radiographs show lucency in Gruen zones 4 and 5.
Which mode of failure is the likely cause?
A. Bending cantilever
B. Calcar pivot
C. Medial mid stem pivot
D. Pistoning: Cement within bone
E. Pistoning: Stem within cement

46. You are reviewing the AP radiograph of patient who has been referred with thigh pain 5 years following cemented total hip arthroplasty. A fracture is seen in the cement mantle just distal to the prosthesis.
What mode of femoral stem loosening is this most likely to represent?
A. Bending cantilever (fatigue)
B. Calcar pivot
C. Medial midstem pivot
D. Pistoning: Stem within bone
E. Pistoning: Stem within cement

47. **Which of the following factors is not associated with increased risk of cemented stem fracture?**
A. Elongated femoral head
B. Increased body mass
C. Low neck cut
D. Poor distal cement fixation
E. Smaller stem size

48. **Which factor does not predispose to an increased risk of hip dislocation?**
A. Direct anterior approach
B. Elevated BMI
C. Parkinson's disease
D. Previous lumbar fusion
E. Total hip arthroplasty for hip fracture

49. A 75-year-old patient develops degenerative hip arthritis 8 years following an intertrochanteric fracture treated with a dynamic hip screw.
What is the correct surgical management plan?
A. Removal of all metalwork and cemented total hip arthroplasty bypassing the most distal crew hole by at least 1.5 femoral diameters
B. Removal of all metalwork and cemented total hip arthroplasty bypassing the most distal crew hole by at least 2.5 femoral diameters
C. Removal of all metalwork and cemented total hip arthroplasty bypassing the most distal crew hole by at least 3.5 femoral diameters
D. Removal of all metalwork and cemented total hip arthroplasty bypassing the most distal crew hole by at least 4.5 femoral diameters
E. Removal of all metalwork and cemented total hip arthroplasty bypassing the most distal crew hole by at least 5.5 femoral diameters

50. **Which of the following mechanical properties is not associated with the high cross-linking of polyethylene?**

A. Increased fracture toughness
B. Increased Young's modulus
C. Reduced ductility
D. Reduced linear wear
E. Smaller wear particles

51. Total hip arthroplasty is planned for a 40-year-old male with high developmental hip dysplasia (Crowe type IV).
What is the maximum amount of leg length correction that could be considered before proximal femoral osteotomy should be planned to reduce the risk of sciatic nerve palsy?
A. 3cm
B. 4cm
C. 5cm
D. 6cm
E. 7cm

52. When assessing a patient 1 day following total hip arthroplasty, there is absence of sensation over the dorsum of the foot and an MRC grade 0 power of ankle dorsiflexion. Total hip arthroplasty was performed under spinal anaesthetic via a posterior approach and the nerve was not encountered at any stage during the operation.
What is the most appropriate immediate management?
A. Computed tomography to assess for haematoma or cement
B. Foot drop splint and nerve conduction studies at 12 weeks if no clinical improvement
C. Magnetic resonance imaging to assess for tethering of the nerve
D. Plain film imaging
E. Surgical exploration of the sciatic nerve

53. **Which of the following factors increases primary arc range in total hip arthroplasty?**
A. Constrained liner
B. Extended lipped liner
C. Increased femoral neck length
D. Increased offset
E. Larger femoral head

54. Submicron particles generation results in osteolysis via the RANK ligand pathway.
What type of wear is the most important process that generates submicron-sized particles in a metal-on-polyethylene THA?
A. Abrasive wear
B. Adhesive wear
C. Corrosive wear
D. Mode 2 wear
E. Mode 3 wear

55. You are performing a hybrid THA for a 76-year-old female patient, when inserting the uncemented cup you notice a crack in the bone extending superiorly from the interface between the cup and bone. The fracture line extends 3cm superiorly. The cup is stable.
What is the most appropriate thing to do?
A. Continue with THA as planned
B. Fix the fracture with a compression plate
C. Insert screws into cup
D. Remove uncemented cup and insert cemented cup
E. Remove uncemented cup and insert triflange cage spanning fracture

56. **Which of the following patients would it be most appropriate to treat with THA for fractured intra-capsular neck of femur?**
A. A 55-year-old lady with multiple sclerosis who mobilises with a frame
B. A 65-year-old male who mobilises with a single walking stick
C. A 65-year-old smoker with lung cancer with a possible pathological fracture
D. A 65-year-old with Parkinson's disease
E. A 74-year-old lady with past medical history of rheumatoid arthritis

57. A patient reports a feeling like their native hip is dislocating.
What is the most likely diagnosis?
A. Hip micro instability
B. Iliopsoas impingement
C. Labral tear
D. Snapping iliotibial band
E. Torn ligamentum teres

58. Osteonecrosis of the femoral head can result in subchondral collapse.
What is the pathophysiological cause of the loss of trabecular structural integrity?
A. Decreased blood flow
B. Fat cell hypertrophy

C. Osteocyte necrosis
D. Reactive hyperaemia
E. Resorption of bone

59. **Which of the following pairings of causative factor and pathophysiological mechanism for femoral head osteonecrosis is incorrect?**
A. Corticosteroids – fat cell hypertrophy
B. Gaucher's disease – intravascular coagulation
C. Protein S deficiency – intravascular occlusion
D. Sickle cell disease – intravascular coagulation
E. Subcapital femur fracture – mechanical vascular interruption

60. **Which of the following mechanisms occurs in the reparative stage of osteonecrosis?**
A. Creeping substitution
B. Enchondral ossification
C. Intramembranous ossification
D. Primary bone healing
E. Secondary bone healing

61. A 70-year-old male patient wakes with severe groin pain the day after hip resurfacing surgery.
Which of the following complications is most likely?
A. Femoral neck fracture
B. Femoral nerve injury
C. Haematoma
D. Iliopsoas impingement
E. Sciatic nerve injury

62. A 45-year-old male reports severe pain around the hip and buttock area following a fall while water skiing.
Which of the following structures are you concerned might have been injured?
A. Gluteus maximus insertion avulsion
B. Greater trochanter fracture
C. Proximal hamstring avulsion
D. Rectus femoris avulsion
E. Transverse process fractures

63. During clinical examination you note a patient has a leg length discrepancy.
Which of the following is an apparent leg length discrepancy with the correct clinical findings?
A. Crowe IV dysplastic hip (superior subluxation) – positive *Galeazzi* test, asymmetrical Bryant's triangle, Thomas test negative
B. Hip arthrodesis – negative *Galeazzi* test, symmetrical Bryant's triangle, Thomas test negative
C. Hip fixed flexion deformity – *Galeazzi* test negative, asymmetrical Bryant's triangle, Thomas test negative
D. Previous distal femoral physeal injury – negative *Galeazzi* test, symmetrical Bryant's triangle, Thomas test negative
E. Previous tibia fracture malunion – positive *Galeazzi* test, asymmetrical Bryant's triangle, Thomas test negative

64. **Which is not a cause of a positive Trendelenburg sign?**
A. Hip abductor tendinopathy
B. Hip arthritis
C. L2 root lesion
D. Total hip arthroplasty with reduced offset
E. Post-operative superior gluteal nerve palsy

HIP II STRUCTURED SBA ANSWERS

1. Answer D. **Type IV**
   Type IV hypersensitivity is responsible for the hypersensitivity response to metallic orthopaedic implants. Type IV sensitivity is cell mediated opposed to antibody mediated, helper T cells activate cytotoxic cells and macrophages. Types I, II, III and V hypersensitivity are all antibody mediated. Currently, there are no guidelines for addressing suspected or known metal allergy preoperatively and there is no evidence-based support for either preoperative testing or routine use of hypoallergenic implants.

   Eftekhary N et al. Metal hypersensitivity in total joint arthroplasty. *JBJS Rev.* 2018;**6**:e1.

2. Answer C. **Neurofibromatosis**
   Protrusio is not commonly associated with neurofibromatosis. Focal skeletal abnormalities associated with neurofibromatosis include scoliosis, congenital bowing of the tibia (anterior lateral) and forearm, pseudoarthrosis and limb hypertrophy. The other four systemic conditions are all associated with protrusio acetabuli.

3. Answer E. **Simvastatin**
   The radiograph demonstrates osteonecrosis (see Figure 4.1 in the Questions section). Simvastatin is not a cause of osteonecrosis and has been postulated to be protective against osteonecrosis. Glucocerebrosidase is the gene underlying Gaucher's disease, which is a recognised cause of osteonecrosis. HbSS is the genotype of sickle cell disease, a recognised cause of osteonecrosis, and protein S deficiency is a clotting abnormality resulting in a hypercoagulable state. Immunological conditions such as SLE, Sjogren's syndrome, dermatomyositis, rheumatoid arthritis and scleroderma have been associated with increased risk of osteonecrosis. These associations may be mediated by use of corticosteroids or other immunosuppressive drugs or may be related to the specific disease activity itself.

   Yang Z et al. The efficacy of statins in preventing glucocorticoid-related osteonecrosis in animal models: a meta-analysis. *Bone Joint Res.* 2016;**5**:393–402.

4. Answer D. **25° flexion, 5° adduction, 5° external rotation**
   Optimal position of flexion is a compromise between ease of standing and sitting. Any abduction of the hip results in coronal imbalance when standing, and therefore a few degrees of adduction is preferred to position the ankle joint beneath the centre of mass of the torso. External rotation is generally matched to the contralateral side. In a review article, Beaulé et al. (2002) recommended flexion of 20–30°, adduction 5° and external rotation 5–10°.

   Beaulé PE, Matta JM, Mast JW. Hip arthrodesis: current indications and techniques. *J Am Acad Orth Surg.* 2002;**10**:249–258.

5. Answer C. **Reducing offset**
   Reducing hip offset increases the force required by the abductors muscles to maintain a single leg stance. Medialisation of the cup reduces the moment arm of the body mass and therefore reduces the force required by the abductors to maintain a single leg stance. Walking with a stick in the contralateral hand reduces the abductor force. Trunk leaning to the ipsilateral side shifts the centre of mass over the hip joint which reduces the force required by the abductors to maintain single leg stance. Carrying a bag of shopping in the ipsilateral arm helps to balance the centre of mass and therefore reduces the force required by the abductors to maintain a single leg stance.

6. Answer B. **1, 2, 6 and 7**
   In a seminal orthopaedic paper, Gruen et al. (1979) described both zones of failure of a cemented femoral total hip arthroplasty stem and five different modes of failure. Zone 1 describes the proximal lateral bone–cement–implant interface, zone 4 the tip and zone 7 the proximal medial aspect of the femur. The classical mechanism by which femoral stems fracture is due to loss of proximal support with a stem that is well fixed distally. The proximal medial and lateral cement breaks up, resulting in lucency in Gruen zones 1, 2, 6 and 7. This mode of failure is termed cantilever bending.

   Gruen TA, McNeice GM, Amstutz HC. 'Modes of failure' of cemented stem-type femoral components: a radiographic analysis of loosening. *Clin Orth Rel Res.* 1979;**141**:17–27.

7. Answer B. **MARS MRI**
Metal artefact reduction sequence MRI or ultrasound are recommended by the Medicines and Healthcare products Regulatory Agency (MHRA) for imaging of metal-on-metal hip replacements. Ultrasonography is a good screening tool, is cheap and has no radiation hazard; however, the detection of small or deep lesions with ultrasound is difficult. Soft tissue inflammatory reactions to metal debris are a recognised complication of metal-on-metal resurfacing. These reactions are grouped under the umbrella term 'adverse reactions to metal debris' (ARMD). The spectrum of ARMD is extensive and ranges from small asymptomatic cysts to large soft tissue masses (pseudotumours). Inflammatory pseudotumour is the clinical term given to an aseptic mass in the periprosthetic tissues that is either solid or cystic and is associated with clinical, radiological or histopathological signs of inflammation. An aseptic-lymphocytic vasculitis-associated lesion (ALVAL) is a histological diagnosis that describes the unique cellular changes that occur periprosthetically in response to metal particles.

Drummond J, Tran P, Fary C. Metal-on-metal hip arthroplasty: a review of adverse reactions and patient management. *J Funct Biomaterials* 2015;**6**:486–499.

8. Answer C. **Revise to a metal-lined ceramic head with change of polyethylene liner**
Ceramic head fracture is rare, especially with modern ceramics. The safest of the given options is to revise to a metal-lined ceramic head with a change of polyethylene. Metal-bearing surfaces should be avoided due to their reduced scratch resistance (hardness) compared with ceramic-bearing surfaces. Revision of all implants is unnecessary, provided all implants are in a satisfactory position and there has not been significant damage to the acetabular shell liner locking mechanism and the stem trunnion. Completed synovectomy is recommended during revision to remove as much of the ceramic debris as possible which can lead to accelerated third body wear.

9. Answer B. **Boundary**
Boundary lubrication is the predominant mechanism by which lubrication occurs in prosthetic joints. Elastohydrodynamic, squeeze film, weeping and boosted lubrication occur in native synovial cartilaginous joints but not prosthetic joints. Boundary lubrication also occurs in native synovial cartilaginous joints.

10. Answer C. **Failure of the repair of the short external rotators**
The short external rotators consist of piriformis, superior gemellus, obturator internus, inferior gemellus and quadratus femoris. The short external rotators are divided during the posterior approach to the hip. Repair of the short external rotators has been shown to reduce the risk of dislocation and so has become common practice. Failure of repair of the short external rotators can result in the foot turning inwards with walking. Excessive retroversion of the femoral stem may result in hip instability or an externally rotated lower leg. Weakness of the gluteus maximus results in weakness of hip extension. Excessive cup anteversion is most likely to result in anterior hip instability. Palsy of gluteus medius and minimus would result in weakness of hip abduction and a Trendelenburg gait.

11. Answer A. **External iliac**
With profuse bleeding, it is likely that a major vessel has been injured. Of the major vessels (femoral, internal and external iliac), the most commonly injured is the external iliac artery. The anterior superior quadrant of the acetabulum is known as the 'zone of death', as a screw or a drill that penetrates too far risks laceration of the external artery or vein. If a major vessel is injured during screw placement, the hip wound should be packed tightly. An anterior incision should be performed before closing the hip wound in order to gain proximal control of the bleeding artery (Figure 4.2).

Shoenfeld NA, Stuchin SA, Pearl R, Haveson S. The management of vascular injuries associated with total hip arthroplasty. *J Vasc Surg.* 1990;**11**:549–555.

12. Answer D. **Hypotensive anaesthesia**
Hypotensive anaesthesia has been shown to reduce blood loss in primary and revision THA. In a case series of 100 patients who were Jehovah's Witnesses undergoing THA, hypotensive anaesthesia was performed in 89 of them. Sixty-five

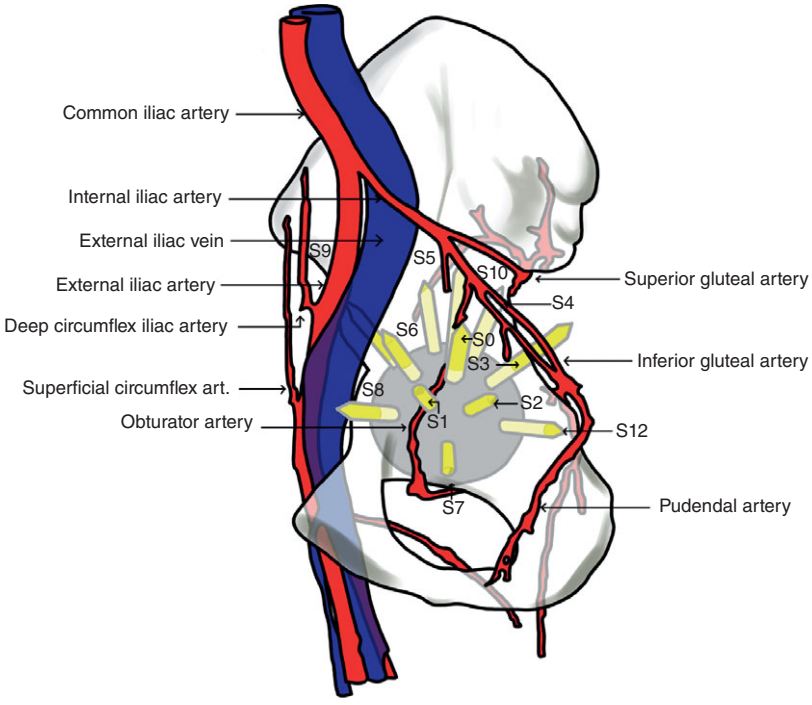


Figure 4.2 Acetabular screw position and risk of vascular injury

patients underwent primary THA with an average of 450ml of blood loss; this was 43% less than a control group. Twenty-four patients who had had previous ipsilateral hip surgery underwent revision hip arthroplasty under hypotensive analgesia and sustained an average intraoperative blood loss of 680ml, which was 30% less than that of similar matched controls. The final 11 Jehovah's Witnesses undergoing hip arthroplasty were not candidates for hypotensive anaesthesia. Other blood management techniques in patients who are Jehovah's Witnesses include erythropoietin therapy, meticulous haemostasis, haemodilution and intraoperative blood salvage.

Nelson CL, Bowen WS. Total hip arthroplasty in Jehovah's Witnesses without blood transfusion. *J Bone Joint Surg Am.* 1986;**68**:350–353.

Nelson CL, Stewart JG. Primary and revision total hip replacement in patients who are Jehovah's Witnesses. *Clin. Ortho Rel Res.* 1999;**369**:251–261.

13. Answer A. **Antibiotic loaded bone cement**
The Medical Research Council (MRC) trial published by Lidwell et al. (1982) showed that antibiotic loaded cemented was the greatest factor in reducing prosthetic joint infection. In decreasing order of effect, the other factors assessed were systemic antibiotics, ultraclean air, plastic isolators and body exhaust suits.

Lidwell OM et al. Effect of ultraclean air in operating rooms on deep sepsis in the joint after total hip or knee replacement: a randomised study. *BMJ (Clinical Res Ed.)* 1982;**285**:10–14.

14. Answer B. **Nerve to obturator internus**
From superior to inferior, the short external rotators consist of piriformis supplied by the nerve to piriformis, superior gemellus and obturator internus, which are both supplied by the nerve to obturator internus, inferior gemellus and quadratus femoris, which are both supplied by the nerve to quadratus femoris and obturator externus, which is supplied by the posterior branch of the obturator nerve (Figure 4.3). Particular attention should be paid to the nerve supply of the gemelli, as they are innervated by two different nerves, which are named after and also innervate the short external rotators immediately inferior to them.

15. Answer B. **Nerve to quadratus femoris**
The nerve to quadratus femoris exits the greater sciatic foramen but does not re-enter the lesser

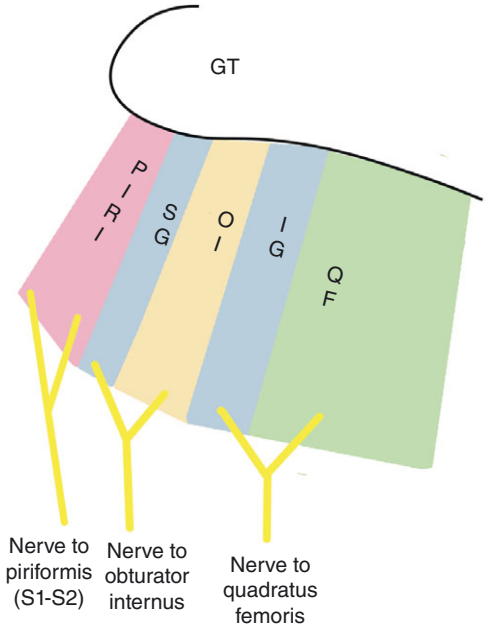


Figure 4.3 Anatomy of the short external rotators. GT = greater trochanter, PIRI = piriformis, SG = superior gemellus, OI = obturator internus, IG = inferior gemellus and QF = quadratus femoris

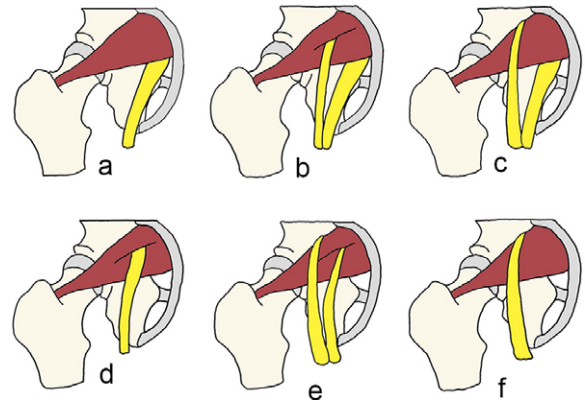


Figure 4.4 Sciatic nerve variations:

a. Sciatic nerve exits beneath piriformis (84.2%)
b. Peroneal nerve exits through piriformis and tibial nerve exits beneath piriformis (11.7%)
c. Peroneal nerve exits above piriformis and tibial nerve exits beneath piriformis (3.3%)
d. Sciatic nerve exits through piriformis (0.8%)
e. Common peroneal exits above piriformis and tibial nerve exits through piriformis (hypothetical)
f. Sciatic nerve exits above piriformis (hypothetical)

sciatic foramen. Obturator internus exits the lesser sciatic foramen, not the greater sciatic foramen. The pudendal nerve and the nerve to obturator internus both exit the greater sciatic foramen and re-enter the lesser sciatic foramen. Obturator externus does not pass through either the lesser or greater sciatic foramen. Obturator externus originates from ischiopubic ramus and the obturator membrane which spans the obturator foramen.

16. Answer D. **Obturator internus**
Obturator internus exits rather than enters the pelvis via the lesser sciatic foramen. The pudendal nerve, internal pudendal vessels (artery and vein) and the nerve to obturator internus all enter the pelvis via the lesser sciatic foramen having first exited the pelvis via the greater sciatic foramen.

17. Answer C. **Common peroneal division passing through piriformis and tibial nerve division exiting beneath piriformis**
Beaton and Anson performed a cadaveric study of the anatomical variants of the relationship of the sciatic nerve to the piriformis muscle. The most prevalent relationship is the sciatic nerve exiting the greater sciatic nerve beneath the piriformis muscle and occurs in about 84% of the population. The next most common variation is the sciatic nerve dividing in the pelvis with the common peroneal division passing through piriformis and the tibial division exiting beneath piriformis; this variant occurs in approximately 12% of the population (Figure 4.4).

Beaton LE, Anson BJ. The relation of the sciatic nerve and of its subdivisions to the piriformis muscle. *Anatom Rec.* 1937;**70**:1–5.

18. Answer D. **Short head of biceps femoris**
Weakness of ankle dorsiflexion and foot eversion represent a palsy of the superficial peroneal nerve. Intact ankle plantar flexion would suggest the tibial nerve is spared. The short head of biceps is the most proximal muscle to be supplied by the common peroneal nerve and therefore should be the first to be re-innervated. The long head of biceps is supplied by the tibial nerve. Two other muscles in the leg also have dual nerve supply: adductor magnus and pectineus. The adductor part of adductor magnus is supplied by the posterior division of the obturator nerve, whereas the hamstrings portion is supplied by the tibial nerve. The anterior fibres of the pectineus are supplied by the femoral

nerve, whereas the posterior fibres are supplied by the anterior division of the obturator nerve. Peroneus longus is supplied by the superficial branch of the peroneal nerve, tibialis posterior and popliteus by the tibialis nerve.

19. Answer A. **Bone scintigraphy**
Three-phase bone scintigraphy is the most sensitive imaging modality for early detection of heterotopic ossification. Plain film radiographs might not show heterotopic ossification until 1–4 weeks after it is visible on bone scintigraphy. Single-photon emission computed tomography (SPECT) improves the sensitivity and specificity of planar bone scintigraphy due to more accurate localisation of activity.

Ghanem MA, Dannoon S, Elgazzar AH. The added value of SPECT-CT in the detection of heterotopic ossification on bone scintigraphy. *Skeletal Radiol.* 2020;**49**:291–298.

20. Answer B. **Cotyloid fossa, superior aspect of the obturator foramen and the cortical surface of the true pelvis**
The pelvic teardrop is a radiographic landmark seen in the anteroposterior view of the pelvis. The teardrop is formed by a continuous U-shaped surface of bone, the lateral border of which is made up of the cortical surface of the cotyloid fossa (true floor of the acetabulum). This surface of bone continues through the acetabular notch and curves inferior medially beneath the transverse acetabular ligament through the superior margin of the obturator foramen. This forms the inferior bend of the U of the teardrop. The medial aspect of the teardrop is made of the cortical surface in the true pelvis. The bony structures that form the pelvic teardrop were confirmed in a radiographic study in which a strip of lead foil was applied to the true floor of the acetabulum, through the obturator foramen and onto the cortical surface of the true pelvis. The teardrop is a frequently used landmark in total hip arthroplasty. When templating for a THA, the inferior part of the cup should be level with the bottom of the teardrop.

Vare VB, Jr. The anatomy of the pelvic tear figure. *J Bone Joint Surg Am.* 1952;**34-A:**167–169.

21. Answer A. **Ankylosing spondylitis**
Ankylosing spondylitis is associated with increased acetabular anteversion. Slipped upper femoral epiphysis (SUFE), Legg–Calvé–Perthes disease and pincer femoral acetabular impingement (FAI) are characteristically associated with acetabular retroversion. Rheumatoid arthritis is associated with acetabular protrusion. The increased acetabular anteversion associated with ankylosing spondylitis predisposes patients with ankylosing spondylitis who are undergoing total hip arthroplasty to anterior dislocation. Patients with ankylosing spondylitis compensate for fixed kyphosis of the spine with pelvic extension, which leads to increased acetabular anteversion. Pelvic extension and knee flexion allow a patient with fixed kyphosis of the spine (positive sagittal balance) to bring the head back over the pelvis. Addressing spinal deformity in patients with ankylosing spondylitis prior to total hip arthroplasty has been advocated.

Direito-Santos B et al. Acetabular retroversion: diagnosis and treatment. *I Open Rev.* 2018;**3**:595–603.

22. Answer D. **Femoral head medial to ilioischial line**
The definition of protrusion is the femoral head protruding medial to the ilioischial line. The iliopectineal line is medial to the ilioischial line, so if the femoral head protrudes medial to the iliopectineal line there will be acetabular protrusion. However, this is not the defining threshold of protrusion. An acetabular fossa medial to the ilioischial line defines coxa profunda (deep acetabular socket). Other definitions for acetabular protrusion have been proposed:
- Centre-edge angle greater than 40°and medialisation of the medial wall of the acetabulum protruding past the ilioischial line.
- Acetabular fossa greater than 3mm beyond the ilioischial line in men and greater than 6mm in women.

23. Answer E. **Superior lateral femoral neck stress fracture involving 25% of neck width**
All tension side (superior femoral neck) stress fractures require internal fixation. Compression (inferior femoral neck) stress fractures involving more than 50% width of the femoral neck also need internal fixation. The mainstay of treatment for piriformis syndrome and iliotibial band

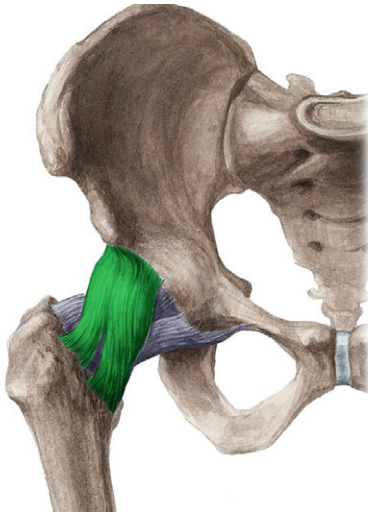


Figure 4.5
Iliofemoral ligament

syndrome is physical therapy. Symptomatic cam lesions may be amenable to surgical intervention when conservative measures have been exhausted.

24. Answer D. **Material that exhibits linear stress strain relationship until the point of failure**
This describes a material that is brittle. Ceramic bearing surfaces fracture because they are brittle and have low toughness and poor fracture resistance. The area under the stress–strain curve describes a material's toughness. Ductile materials exhibit non-linear change in length (plastic deformation) beyond the elastic limit on a stress–strain curve. Failure at a point below the ultimate tensile strength secondary to repetitive loading is termed 'fatigue failure'. Progressive deformation in response to a constant force over a prolonged period of time is the definition of 'creep'.

25. Answer A. **Early prosthetic loosening**
Early prosthetic loosening is associated with sickle cell disease; the mechanism is extended bone infarct disease. Psoriasis is associated with higher periprosthetic infection rate. Paget's disease is associated with increased blood loss, and ankylosing spondylitis is associated with a higher risk of heterotopic ossification.

Kenanidis E, Kapriniotis K, Anagnostis P, Potoupnis M, Christofilopoulos P, Tsiridis E. Total hip arthroplasty in sickle cell disease: a systematic review. *EFORT Open Rev.* 2020 Mar 2;5(3):180–188.

26. Answer A. **Iliofemoral**
The iliofemoral ligament, also known as the Y-ligament of Bigelow, is the strongest ligament in the body. It originates from the anterior inferior iliac spine and then fans out in an inverted Y shape to attach along the anterior intertrochanteric line of the femur (Figure 4.5). The ligament is a static stabiliser and checks hip extension. Because the ligament limits hip extension, it allows maintenance of an upright posture with slight hip extension. With reduced need for muscle contractions, the ligament is therefore energy conserving.

27. Answer B. **Cup inclination 40°, cup anteversion 15°, femoral stem anteversion 15°**
In a classic paper, Lewinnek et al. (1978) proposed a relative 'safety zone' for the acetabular cup position of 40±10° inclination and 15±10° anteversion. The study has a number of limitations; it was a case series of 300 total hip arthroplasties but there were only 9 dislocations and there was no mention of femoral stem anteversion. Cup version cannot be considered in isolation; the relationship between cup and stem version is described by the term 'combined anteversion'. While all surgeons accept the importance of implant orientation, there are numerous other factors that are important for hip stability, which are commonly grouped into surgical factors (implant position, surgical approach, surgeon experience/volume), implant factors (head size, head–neck ratio, type of cup/acetabular liner) and patient factors (muscle weakness, soft tissue quality).

Lewinnek GE, Lewis JL, Tarr R, Compere CL, Zimmerman JR. Dislocations after total hip-replacement arthroplasties. *J Bone Joint Surg Am.* 1978;**60**:217–220.

28. Answer C. **35°**
The combined anteversion is the sum total of acetabular version and femoral anteversion. Combined anteversion can be assessed on the operating table once components have been implanted and before the joint is closed by internally rotating the femur with the knee flexed until the cup and base of the femoral head are coplanar; the angle made between the lower leg and the floor is the combined anteversion. The optimal combined version is debated. Dorr et al. (2009) believe there is a wide safe zone and recommended aiming for 25–45° with a mean of 35°.

Dorr LD, Malik A, Dastane M, Zhinian W. Combined anteversion technique for total hip arthroplasty. *Clin Orthop Rel Res.* 2009;**467**:119–127.

29. Answer C. **Gluteus medius and minimus deficiency**

A constrained polyethylene liner should be reserved for recurrent desolators with soft tissue dysfunction. A constrained liner encircles the femoral head and mechanically prevents the head from displacing out of the socket. Constrained liners increase the stress at the bone–implant interface, which increases the risk of early loosening. In all of the other options listed, suboptimal implant position or design could be corrected with revision of implants.

30. Answer D. **5cm**

Numerous sources report that the superior gluteal nerve may be damaged if the gluteus medius is split more than 5cm proximal to the greater trochanter. However, it may lie even closer. In a cadaveric study of 44 hips, the superior gluteal nerve was found to be a mean of 4.8cm (range 2–9cm) from the greater trochanter. Ramesh et al. (1996) reported 11% risk of superior gluteal nerve denervation following a series of Hardinge approaches in which the gluteus medius was not splint more than 4cm from the greater trochanter.

Khan T, Knowles D. Damage to the superior gluteal nerve during the direct lateral approach to the hip: a cadaveric study. *J Arthroplasty* 2007;**22**:1198–1200.

Ramesh M et al. Damage to the superior gluteal nerve after the Hardinge approach to the hip. *J Bone Surg Br.* 1996;**78**:903–906.

31. Answer B. **Lateral to the primary compressive trabeculae and medial to the secondary compressive trabeculae**

Ward's triangle is a space formed near the centre of the femoral neck by the intersection of three trabecular bundles, namely, the principal compressive, the secondary compressive and the tensile trabecular (Figure 4.6). This central region, containing some thin and loosely arranged trabeculae, defines a neutral axis where tensile and compressive forces balance each other. The three boundaries of Ward's triangle are medially the primary compressive trabeculae, laterally the secondary compressive trabeculae and superiorly the primary tensile trabeculae. Ward's triangle itself is not a sign of osteoporosis; however, expansion of Ward's triangle, which can be visualised on a plain film AP hip radiograph, is due to loss of trabeculae.

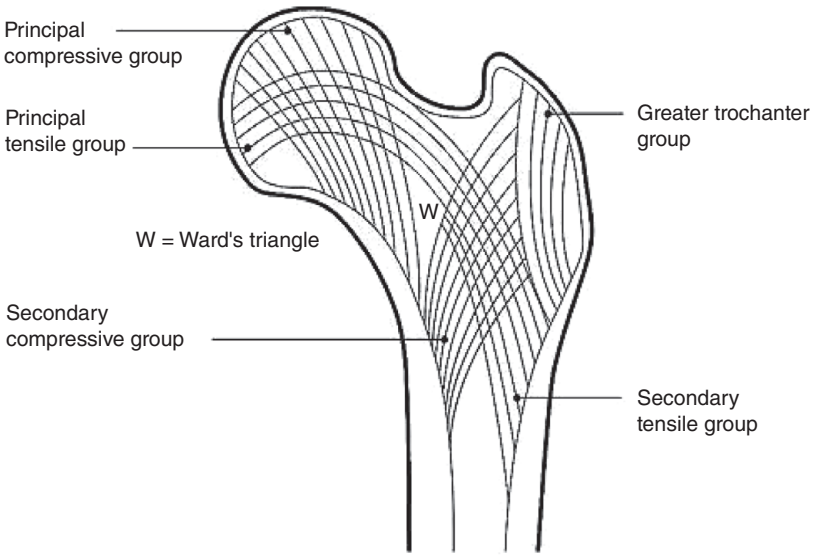


Figure 4.6 Ward's triangle

32. Answer A. **Ascending branch of the lateral femoral circumflex artery**
The ascending branch of the lateral femoral circumflex artery crosses the interval proximally between sartorius (femoral nerve) and tensor fascia lata (superior gluteal nerve). The ascending branch of the lateral femoral circumflex artery should be identified and ligated to prevent excessive bleeding. In 1919 Smith-Petersen first described a direct anterior approach (DAA) to the hip for reducing congenital hip dislocations. Smith-Petersen is also credited with the first DAA for hip arthroplasty in 1949. Over the subsequent decades, several modifications to his technique have occurred, along with the development of new instruments to make it less invasive and easier to perform for THA.

33. Answer B. **0.5μm**
Particulates in the range of 0.1–1.0μm (submicron) are biologically active, with those in the range of 0.1–0.5μm are thought to be the most biologically active and responsible for osteolysis. Macrophages phagocytose polyethylene particles, as they are a similar size to bacteria. Activated macrophages release cytokines, which stimulate osteoblasts to release RANK ligand. This in turn leads to activation of osteoclasts, which resorb bone. The cytokines released by activated macrophages are TNFα, IL-1, IL-6, PGE2 and PDGF. Activated macrophages also directly absorb bone via the release of matrix metalloproteinases (MMPs) and upregulate osteoclast differentiation via macrophage-colony stimulating factor (MCSF) (Figure 4.7).

34. Answer E. **Total hip arthroplasty**
A subchondral lucent line describes the crescent sign. The crescent sign features in both the modified Ficat and Steinberg staging systems for adult hip osteonecrosis. Presence of the crescent sign indicates imminent femoral head collapse. Joint preserving procedures such as core decompression, osteotomy and vascularised bone grafting are limited to pre-collapse femoral heads, whereas joint replacement procedures are indicated in the presence of femoral head collapse.

35. Answer C. **Osteoprotegerin**
Osteoprotegerin is a decoy receptor of the receptor activator of nuclear factor kappa-B ligand (RANKL). Osteoprotegerin binds RANKL to limit its activity. Platelet-derived growth factor, interleukin-1 and interleukin-6 are involved in signalling from macrophages to activate osteoclasts to resorb bone. Osteoclasts are activated indirectly via osteoblasts and the RANKL pathway.

36. Answer D. **Uncemented, fully porous coated titanium stem**
A number of factors contribute to stress shielding: stem fixation; cemented composite

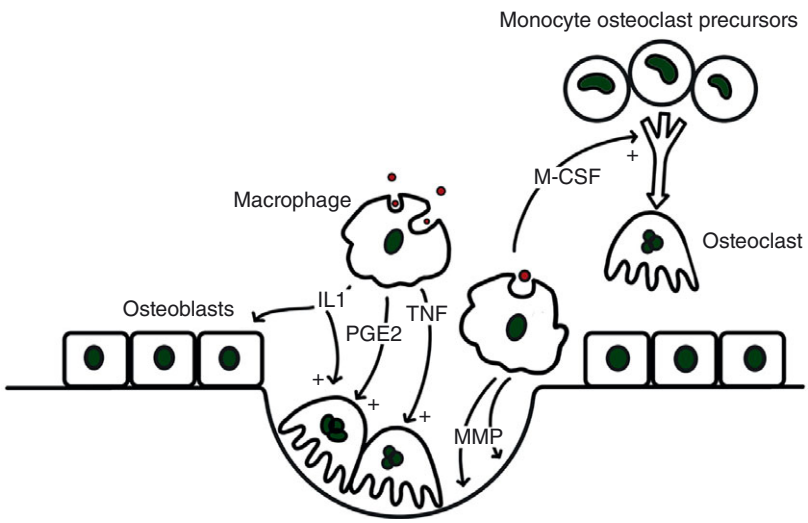


Figure 4.7 A series of proinflammatory factors, including IL-1, IL-6, PGE2, TNF-α, can be produced by wear particle-activated macrophages. These cytokines can induce the expression of RANKL, which activates osteoclasts. Macrophages also release matrix metalloproteinases (MMPs) and downregulate production of tissue inhibitors of metal metalloproteinases (TIMPs)

beam versus taper slip, uncemented fully porous coated versus proximally porous coated, Young's modulus of the cement stem and radius of the stem (Figure 4.8). With taper slip stem design, viscoelastic properties of bone cement allow slip of the stem in the cement mantle as it is loaded axially. Axial forces are converted into hoop stresses throughout the length of the taper; therefore, provided the cement mantle is not excessively thick, bone is loaded along the length of the implant. Composite beam cemented stem designs are so named because the stem, cement and bone behave as one (a composite) construct. With composite beam stem designs, forces are concentrated at the distal tip of the stem opposed to throughout the proximal femur with taper slip designs. Composite beam designs therefore lead to more proximal bone loss than do taper slip designs. Calcar flanges were added to composite beam designs in an attempt to load the bony calcar and prevent proximal stress shielding. The loading of the femur is similar in uncemented stems to composite beam cemented stems. Proximal stress shielding is reduced in proximally porous coated stems opposed to fully porous coated stems. Increasing stem radius increases the stiffness and therefore increases stress shielding. The following commonly used metals for femoral stems are listed in decreasing order of stiffness: cobalt-chrome, stainless steel and titanium. Answer D is correct as it combines the greatest number of factors which contribute to stress shielding.

Figure 4.8 Anteroposterior (AP) radiograph of right reverse hybrid THA, uncemented fully porous coated stem, with significant proximal femur bone loss secondary to stress shielding and osteolysis

37. Answer C. **Adductor longus and gracilis**
There is no internervous plane for the medial approach to the hip. The superficial intermuscular plane is between adductor longus and gracilis, both of which are innervated by the anterior division of the obturator nerve. The deep intermuscular plane is between adductor brevis supplied by the anterior division of the obturator nerve and adductor magnus, which has dual innervation. The adductor portion is supplied by the posterior division of the obturator nerve, and the hamstrings portion is supplied by the tibial portion of the sciatic nerve.

38. Answer A. **Adductor brevis – posterior division of obturator nerve**
Gracilis is supplied by the anterior division of the obturator nerve. Two muscles around the hip and one muscle in the thigh have dual innervation: adductor magnus, pectineus and biceps femoris. Adductor magnus is supplied by the posterior division of the obturator nerve and the tibial nerve. Pectineus is supplied by the femoral and the obturator nerve. Biceps femoris is supplied by the tibial nerve (long head) and peroneal nerve (short head). Adductor longus is supplied by the anterior division of the obturator nerve.

39. Answer B. **Iliopsoas**
The medial and lateral circumflex arteries are named according to their relationship to the iliopsoas tendon (Figure 4.9). The medial

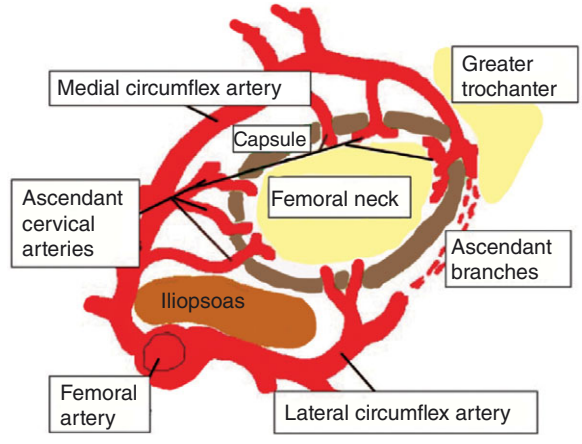


Figure 4.9 Femoral neck blood supply

femoral circumflex artery (MFCA) is a branch of the profundal femoris; it winds around the medial side of the femur, passing between pectineus and iliopsoas (medial to it). The femoral head receives its blood supply primarily from the deep branch of the MFCA. The medial and lateral femoral circumflex arteries contribute to an extracapsular arterial ring at the base of the femoral neck. The extracapsular arterial ring gives rise to the retinacular vessels, which run superiorly along the femoral neck until they reach the cartilaginous border of the femoral head, at which point they penetrate the femoral head. The lateral femoral circumflex artery is also usually a branch of the profundal femoris artery and passes lateral to the iliopsoas tendon. The calcar femorale refers to the vertical plate of dense cancellous bone that develops in the posterior femoral neck separated from the lesser trochanter. It is not to be confused with the calcar, which is the lowermost and thickest point of the cortex constituting the medial wall of the femoral neck.

Hammer A. The calcar femorale: a new perspective. *J Orthop Surg (Hong Kong)* 2019;**27**:2309499019848778.

40. Answer B. **Flexible femoral stem**
Flexible femoral stems are not optimal for stem fixation, as they place increased stress on the cement mantle; hence, most femoral stems are made from stainless steel (316L) or cobalt-chrome. A cement mantle >2mm reduces the risk of cement mantle fracture. Stem centralisation using a plastic tip centraliser aims to produce an even cement mantle around the femoral stem, which decreases stress on the cement mantle and improves fixation. The centraliser is hollow to allow the stem to subside by leaving a space for the tip of the stem to subside into. Prior to the use of hollow stem centralisers, 'punch out' fractures were observed in the distal portion of the cement mantle. Highly polished femoral stems reduce shear stresses at the cement–stem interface and allow subsidence, which converts axial load into radial hoop stresses. Matt finish taper slip stems are thought to have failed early due to abrasive wear at the cement–stem interface. Vacuum preparation of cement is a feature of third generation cementation and reduces the porosity of the cement, which reduces stress points in the cement and increases the strength of stem fixation.

41. Answer B. **The capsule attaches more distally on the neck posteriorly compared with anteriorly**
The capsule attaches more distally on the femoral neck anteriorly compared with posteriorly. Posteriorly, the capsule attaches more proximally. Hence, when performing arthroplasty for subcapital femoral neck fracture, there are often fragments of the head attached to the capsule posteriorly once the head has been removed. The gluteus minimus inserts into the anterior capsule and greater trochanter. The reflected head of the rectus femoris originates from the anterior hip joint capsule, whereas the direct head originates from the anterior inferior iliac spine. The ischiofemoral ligament forms the posterior hip joint capsule and is divided when performing the Southern–Moore (posterior) approach to the hip joint. The iliofemoral ligament forms the anterior hip joint capsule and is divided when entering the hip joint using the Smith-Petersen (anterior) approach. The iliofemoral ligament and the direct head of the rectus femoris tendon share an attachment to the ilium just superior to the acetabulum.

42. Answer B. **L2**
Radicular pain from nerve roots L1 and L2 may mimic referred hip pain in the groin. L2 radiculopathy may mimic referred hip pain in the thigh. Impingement of the lateral cutaneous nerve of the thigh causes numbness and burning pain over the lateral aspect of the thigh, the condition known as meralgia paresthetica. Causes of compression include tight belts or irritation from seat belts worn during prolonged driving, pregnancy and obesity. The posterior cutaneous nerve of the thigh is rarely a cause of complaint due to impingement. It arises from the S1 to S3 nerve roots, so sensation may be diminished as part of cauda equina syndrome. The obturator nerve supplies sensation to the medial thigh and groin. The femoral nerve supplies sensation to the anterior medial thigh extending distal to the area supplied by the obturator nerve.

43. Answer A. **Anterior intrasubstance labral tear and a posterior acetabular cartilage lesion**

A pincer-type lesion is due to overcoverage of the acetabulum and is common in middle-aged females. This results in abnormal contact between the acetabular rim and the femoral head–neck junction. The anterior superior femoral head–neck junction is levered against the acetabular rim and a contrecoup cartilage lesion may occur on the posterior inferior acetabulum. Protrusio and acetabular retroversion are causes of acetabular overcoverage. Acetabular retroversion may be seen on a plain film AP radiograph of the pelvis; the anterior wall may be seen crossing lateral to the posterior wall. This is called the crossover sign. The other common pattern of femoral acetabular impingement is termed cam impingement. Cam impingement is most common in young males and is caused by a non-spherical femoral head and decreased head–neck offset. In hip flexion the aspherical head engages with acetabular cartilage, causing a shearing force that results in delamination of the anterior acetabular cartilage and avulsion of the anterior labrum. The radiographic appearance of a non-spherical femoral head that may cause cam-type impingement is described as a 'pistol grip deformity'.

Imam S, Khanduja V. Current concepts in the diagnosis and management of femoroacetabular impingement. *Int Orthop.* 2011;**35**:1427–1435.

44. Answer B. **2.3mm, 3.3mm**
If the femoral neck angle is 125° this amounts to a 35° angle from the horizontal. Therefore, any further increase in the neck length will result in a smaller increase in the leg length compared with offset. When considering the addition of a 'plus 4mm' head, answer E (4.0mm, 0mm) is incorrect, as this change in leg length to offset could only be achieved with a neck angle of 180°. Likewise, answer A is incorrect (0mm, 4.0mm), as this change in leg length to offset could only be achieved with a neck angle of 90°. Answer D (3.3, 2.3mm) is incorrect, as this leg length to offset change would be the result of a neck angle of 145°. Answer C (2.8, 2.8mm) is incorrect, as an equal increase in leg length and offset could only be achieved if a neck angle of 135° (45° to the horizontal) is used. The key to answering this question correctly is not a thorough understanding of trigonometry but rather a knowledge that if the neck angle is 135°, increasing neck length will increase leg length and offset in an equal ratio, and that if the neck length is less than 135°, increasing neck length will increase leg length less relative to offset.

45. Answer B. **Calcar pivot**
In a seminal orthopaedic paper, Gruen described both zones of failure of a cemented femoral total hip replacement stem and five different modes of failure. Zone 1 describes the proximal lateral bone–cement–implant interface, zone 4 the tip and zone 7 the proximal medial aspect of the femur. With calcar pivot mechanism of failure, the stem pivots on the calcar and toggles (windscreen wiper effect). Although Gruen's original paper described loosening of cemented femoral stems, the calcar pivot mechanism is more common with uncemented stems with a large collar like the uncemented Austin Moore prosthesis.

Gruen TA, McNeice GM, Amstutz HC. 'Modes of failure' of cemented stem-type femoral components: a radiographic analysis of loosening. *Clin Orthop Rel Res.* 1979;**141**:17–27.

46. Answer E. **Pistoning: Stem within cement**
A distal cement fracture and a radiolucent line between the stem and cement mantle in Gruen zones 1 and 2 are classical of pistoning of the stem within the cement (mode Ia). Mode Ib pistoning: stem within bone results in radiolucency in all Gruen zones.

Gruen TA, McNeice GM, Amstutz HC. 'Modes of failure' of cemented stem-type femoral components: a radiographic analysis of loosening. *Clin Orthop Rel Res.* 1979;**141**:17–27.

47. Answer D. **Poor distal cement fixation**
Cemented femoral stem fracture is a rare complication. Poor proximal stem fixation or a low neck cut reduces the support for the stem proximally. If the stem remains well fixed distally, the increased moment arm due to loss of proximal medial support can result in catastrophic stem fatigue failure. This was described by Gruen as mode IV cantilever bending with lucency around the proximal zones (1, 2, 6 and 7). Increased body mass, elongated femoral heads and smaller stem sizes are all risk factors associated with stem fracture.

Gruen TA, McNeice GM, Amstutz HC. 'Modes of failure' of cemented stem-type femoral components: a radiographic analysis of loosening. *Clin Orthop Rel Res.* 1979;**141**:17–27.

48. Answer A. **Direct anterior approach**
The direct anterior approach (DAA) has been shown to have a lower dislocation rate following total hip arthroplasty. Elevated BMI increases the risk of dislocation. Neurological disorders including Parkinson's disease increase the risk of dislocation. There is an increased risk of dislocation following total hip arthroplasty for hip fracture. Proposed theories for this include predisposition to falls, capsular laxity compared with osteoarthritis and the technical challenge of restoring leg length and offset in the context of hip fracture. A history of lumbar spine fusion has been shown to increase the risk of hip dislocation.

Kunutsor SK et al. Risk factors for dislocation after primary total hip replacement: meta-analysis of 125 studies involving approximately five million hip replacements. *Lancet Rheum.* 2019;**1**:e111–e121.

Buckland AJ et al. Dislocation of a primary total hip arthroplasty is more common in patients with a lumbar spinal fusion. *Bone Joint J.* 2017;**99-B**:585–591.

49. Answer B. **Removal of all metalwork and cemented total hip arthroplasty bypassing the most distal screw hole by at least 2.5 femoral diameters**
The cemented stem must pass well below the distal screw hole to reduce the risk of periprosthetic fracture due to a stress riser. In a biomechanical study, Panjabi et al. (1985) showed that normal stress patterns return at a distance of two times the cylinder (femur) diameter away from the stress riser.

Panjabi MM, Trumble T, Hult JE, Southwick WO. Effect of femoral stem length on stress raisers associated with revision hip arthroplasty. *J Orthop Res.* 1985;**3**:447–455.

50. Answer A. **Increased fracture toughness**
Highly cross-linked polyethylene (HXLPE) has a lower fracture toughness, decreased tensile strength and decreased fatigue strength compared with standard cross-linked polyethylene. HXLPE has the theoretical advantage when used in total hip arthroplasty of increased wear resistance. In total knee arthroplasty, fracture and fatigue resistance are also important, and so the benefits of HXPLE are not thought to apply to total knee arthroplasty.

51. Answer B. **4cm**
Leg lengthening of more than 4cm is generally accepted to significantly increase the risk of sciatic nerve injury. Edwards et al. (1987) were the first to report the increased risk of sciatic nerve injury associated with leg lengthening of more than 4cm. In a case series of 23 sciatic and peroneal nerve injury palsies, they showed sciatic nerve palsy occurred following mean lengthening of 4.4cm (range 4–5.1cm, n=3) and peroneal palsy occurred with a mean lengthening of 2.7cm (range 1.9–3.7cm, n=12).

Edwards BN, Tullos HS, Noble PC. Contributory factors and etiology of sciatic nerve palsy in total hip arthroplasty. *Clin Orthop Rel Res.* 1987;**218**:136–141.

52. Answer D. **Plain film imaging**
If the sciatic nerve has not been identified during the operation, then surgical exploration is mandated, as it could have been injured or accidentally tethered with a suture. Plain film imaging of the hip is sensible before surgical exploration to assess for leg lengthening, retained cement in the vicinity of the nerve or a prominent acetabular screw in the posterior inferior quadrant of the acetabulum. If the sciatic nerve was identified, protected throughout surgery and checked before closing the fascia lata, then the surgeon may wish to perform three-dimensional imaging to rule out a haematoma or cement compressing the sciatic nerve. If imaging is negative for occlusive pathology, one may wish still to explore the sciatic nerve or observe the palsy for improvement.

53. Answer E. **Larger femoral head**
The primary arc range is the range of motion which components allow between the two extremes of impingement before the head begins to lever out of the cup. The range of motion allowed before the hip dislocates is termed the lever range. The jump distance or excursion

distance is the distance the femoral head must translate out of the cup in order to dislocate. In a hemispherical cup, the excursion distance is approximately equal to the radius of the femoral head. Impingement occurs between the acetabular cup and the femoral neck and is dependent upon cup geometry, head size and neck size. The larger the head size is compared with the neck (head–neck ratio), the greater the primary arc range and stability will be. Increased offset and increased femoral neck length have no effect on the primary arc range. Extended lipped liners and constrained liners reduce primary arc range. When performing total hip arthroplasty, one should aim to centre the primary arc range within the patient's functional hip range.

54. Answer B. **Adhesive wear**
Adhesive bearing wear is the most important process that generates submicron-sized polyethylene (PE) particles. Adhesive wear occurs when the anatomical forces between two opposing surfaces are stronger than the inherent strength of either material. In a metal-on-PE THA bearing surface, adhesive wear results in small portions of the PE surface adhering and transferring to the opposing metal femoral head. This leads to wear particle generation and the creation of pits and voids in the PE. Abrasive wear occurs when a soft material comes into contact with a hard material and the microscopic counter-face asperities of the harder material surface plough into the soft surface. Corrosive wear is defined as the unwanted dissolution of a metal in a solution. Four modes of wear have been described (Table 4.1). In mode 1, the two bearing surfaces are in contact with each other in the manner intended by the designer. In modes 2, 3 and 4, unintended surfaces are in contact with each other, representing malfunctioning of the prosthesis. In mode 2 wear, a bearing surface is wearing against a non-bearing surface, e.g. when the femoral head wears completely through the PE liner and contacts the metal shell or cement. In mode 3 wear, the primary bearing surfaces are still articulating with each other but with the addition of an interposed third body, e.g. cement, bone, metal or ceramic fragments. In mode 4 wear, two non-bearing surfaces are moving against each other, e.g. femoral neck and socket or 'backside' wear between an acetabular liner and shell or fretting between the metal stem and the surrounding bone or cement mantle.

Table 4.1 Mathematical analogues of the four wear modes

Surfaces in contact	Mathematical analogue	Mode number
Primary vs. primary	1 × 1 =1	1
Primary vs. secondary	1 × 2 = 2	2
Primary vs. primary vs. third bodies	1 × 1 × 3 = 3	3
Secondary vs. secondary	2 × 2 = 4	4

In Table 4.1, a primary bearing surface is assigned the number l; a secondary, non-bearing surface is assigned a 2, and third body particles are assigned a 3. Multiplication is the mathematical analogue for two or more surfaces in moving contact to cause wear.

McKellop HA. The lexicon of polyethylene wear in artificial joints. *Biomaterials* 2007;**28**:5049–5057.

55. Answer C. **Insert screws into cup**
The incidence of periprosthetic acetabular fractures recognised intraoperatively is approximately 0.4%. Occult fractures occur more frequently. A study which reviewed CT scans performed as a part of a study to review component position reported an 8.4% incidence of periprosthetic acetabular fractures (Hasegawa et al. 2017).

Most periprosthetic acetabular fractures occur during cup insertion and involve the superior wall. Periprosthetic acetabular fractures have been classified by Paprosky (Table 4.2). If the fracture is undisplaced and the cup is stable no further action is required. In reality, assessing cup stability intraoperatively can be challenging so use of supplemental screws through an uncemented cup is advised (Chitre et al. 2013); if the cup is unstable and the fracture is displaced then the fracture needs to be stabilised. Once the fracture has been stabilised an assessment must be made as to whether the bone stock is sufficient to allow a component to be implanted. If there is insufficient bone, bone grafting or the use of trabecular metal augments should be considered.

The best method of treating a periprosthetic fracture is to prevent it from occurring. This

Table 4.2 Paprosky classification of periprosthetic acetabular fractures

1. Intraoperative during component insertion	A. Recognised, stable component, undisplaced fracture B. Recognised, displaced fracture, cup unstable C. Not recognised intraoperatively
2. Intraoperative during removal	A. Less than 50% bone stock loss B. Greater than 50% bone stock loss
3. Traumatic	A. Component stable B. Component unstable
4. Spontaneous	A. Less than 50% bone stock loss B. Greater than 50% bone stock loss
5. Pelvic discontinuity	A. Less than 50% bone stock loss B. Greater than 50% bone stock loss C. Associated with pelvic radiation

involves being aware of high-risk cases and considering the use of cemented acetabular fixation in elderly osteoporotic patients (Chitre et al. 2013). NHS England's 'Best Practice Tariff' (BPT) directive now requires 80% of total hip arthroplasty (THA) be cemented or hybrid, for those patients aged 70 years or over, with financial penalties if this is not achieved. A more recent update from GIRFT has advised BPT should even 'go further' advising 80% of THA to be fully cemented for patients aged 70 years or over. Registry data shows only marginally superior implant survivorship for patients aged greater than 74 years with a fully cemented prosthesis but the cost savings are significant (Ben-Shlomo 2021).

Ben-Shlomo Y et al. *The National Joint Registry 18th Annual Report 2021*. 2021; National Joint Registry.

Chitre A, Wynn Jones H, Shah N, Clayson A. Complications of total hip arthroplasty: periprosthetic fractures of the acetabulum. *Curr Rev Musculoskeletal Med.* 2013;**6**:357–363.

Hasegawa K, Kabata T, Kajino Y, Inoue D, Tsuchiya H. Periprosthetic occult fractures of the acetabulum occur frequently during primary THA. *Clin Orthop Rel Res.* 2017;**475**:484–494.

56. Answer B. **65-year-old male who mobilises with a single walking stick**

Deciding which patients might benefit from total hip arthroplasty for intra-capsular hip fracture remains a contentious topic lacking in robust evidence to guide decision making. Bearing this in mind arguments could be made for all or indeed none of the above patients to receive a THA. The perceived advantages of THA for hip fracture are better mobility, less pain and reduced risk of acetabular erosion (Burgers et al. 2012; Lewis et al. 2019). The disadvantages of THA are longer anaesthetic, increased intraoperative blood loss, increased risk of dislocation and reoperation, increased cost compared with hemiarthroplasty and difficulties with service provision (Gill et al. 2021; Miller et al. 2014; Reed and Haddad 2016).

Since 2011 the National Institute for Health and Care Excellence (NICE) has recommended offering THA for displaced intracapsular hip fracture for patients who walk with no more than one stick, who are not cognitively impaired and are fit to undergo anaesthesia and the procedure (National Clinical Guidance Centre 2011). In the UK the proportion of eligible patients that receive a THA is approximately 30%.

THA versus hemiarthroplasty for the treatment of displaced intracapsular hip fracture is an area of continuing debate in the orthopaedic literature. A systematic review and meta-analysis reported THA to be superior to hemiarthroplasty in terms of risk of reoperation, hip function and quality of life (Lewis et al. 2019). The largest RCT to date to attempt to shed some light on this topic was performed by the HEALTH investigators. The HEALTH investigators reported no difference in secondary procedures, similar mortality and modest but not significantly superior function following THA compared with hemiarthroplasty (Bhandari et al. 2019). One criticism of this trial is the average age of patients recruited was 80 years. It is possible younger patients with a greater life expectancy and higher functional demands may benefit more from a THA compared with hemiarthroplasty.

Rheumatoid arthritis is considered a soft indication for THA for fear of increased acetabular erosion caused by hemiarthroplasty. Degenerative neurological conditions such as Parkinson's disease are considered a relative contraindication for THA to treat hip fractures because of reduced mobility (reducing the benefit of THA) and increased falls risk (increasing the risk of dislocation) (Awadallah et al. 2022). Mobilising with a frame is a contraindication to THA for hip fracture for most hip surgeons. A patient with lung cancer and a suspected pathological fracture would need investigation to stage the disease. If lung cancer was a new diagnosis and it was an isolated metastasis to the proximal femur curative treatment might still be possible and so treatment decisions should be guided by an MDT. In general, hemiarthroplasty is indicated for most patients who suffer a femoral neck fracture with lung cancer and bone metastases due to reduced life expectancy.

Awadallah M et al. Is there a higher risk of dislocation of hip hemiarthroplasty in patients with neuromuscular conditions? A clinical study of 3827 patients. *Injury* 2022;**53**:631–633.

Bhandari M et al., HEALTH Investigators. Total hip arthroplasty or hemiarthroplasty for hip fracture. *New Engl J Med* 2019;**381**:2199–2208.

Burgers PT et al. Total hip arthroplasty versus hemiarthroplasty for displaced femoral neck fractures in the healthy elderly: a meta-analysis and systematic review of randomized trials. *Int Orthop.* 2012;**36**:1549–1560.

Gill JR, Pathan A, Parsons SJ, Wronka K. Total hip arthroplasty for hip fracture: clinical results and mid-term survivorship. *Cureus* 2021;**13**:e20492.

Lewis DP, Wæver D, Thorninger R, Donnelly WJ. Hemiarthroplasty vs total hip arthroplasty for the management of displaced neck of femur fractures: a systematic review and meta-analysis. *J Arthroplasty* 2019;**34**:1837–1843.e2.

Miller CP, Buerba RA, Leslie MP. Preoperative factors and early complications associated with hemiarthroplasty and total hip arthroplasty for displaced femoral neck fractures. *Geriatr Orthop Surg Rehab.* 2014;**5**:73–81.

National Clinical Guideline Centre (UK). *The Management of Hip Fracture in Adults*. Royal College of Physicians (UK); 2011.

Reed M, Haddad FS. Randomised trials of total hip arthroplasty for fracture: is our failure to deliver symptomatic of a wider scrutiny? *Bone Joint J.* 2016;**98-B**:1425–1426.

57. Answer D. **Snapping iliotibial band**

Coxa saltans (coxa = hip, saltans = to dance or jump) refers to snapping hip and encompasses three main causes, extra-articular (either external or internal) or intra-articular. The most common form of coxa saltans is the external (coxa saltans externa) extra-articular variety which involves the iliotibial band flicking over the greater trochanter during hip flexion and extension or internal and external rotation. Coxa saltans externa can manifest as a snapping, but often is described as a sensation that the hip dislocates (Yen et al. 2015).

Coxa saltans interna is caused by snapping of the iliopsoas tendon over the iliopectinal eminence or the femoral head. The iliopsoas tendon can also snap over the acetabular component of a total hip arthroplasty (THA).

Intra-articular causes include labral tears, ligamentum teres tears, loose bodies and even subtle instability of the joint. Intra-articular causes often cause a clicking or catching sensation. Hip microinstability can present as a subjective feeling of instability. The most common causes of native hip microinstability are iatrogenic following non-arthroplasty hip surgery and in patients with connective tissue disorders (Cohen et al. 2022).

Cohen D et al. Hip microinstability diagnosis and management: a systematic review. *Knee Surg Sports Trauma Arthroscopy* 2023;**31**:16–32.

Yen YM, Lewis CL, Kim YJ. Understanding and treating the snapping hip. *Sports medicine and arthroscopy review*, 2015;**23**:194–199.

58. Answer E. **Resorption of bone**

It is not the necrosis itself but rather the repair process and in particular the resorptive component that results in loss of structural integrity and subchondral fracture. Osteocyte necrosis occurs within a few hours of anoxia (Shah et al. 2015). Reactive hyperaemia (visible on MRI) and capillary revascularisation occur in the periphery of the necrotic zone and with the entry of blood vessels, a repair process begins consisting of both bone resorption and production that

incompletely replaces dead and living bone. New living bone is laminated on dead trabeculae, this process is known as creeping substitution. Bone resorption exceeds formation leading to the net removal of bone and loss of structural integrity. There is a race between the ability of the body to repair the necrotic bone and mechanical collapse of the bone. Decreased blood flow is the final common pathway which results in osteocyte necrosis. Fat cell hypertrophy is thought to be one of the mechanisms by which corticosteroids and alcohol cause osteonecrosis. Fat cell hypertrophy results in compromised blood supply by extraosseous compression.

Shah KN, Racine J, Jones LC, Aaron RK. Pathophysiology and risk factors for osteonecrosis. *Curr Rev Musculoskeletal Med.* 2015;**8**:201–209.

59. Answer B. **Gaucher's disease – intravascular coagulation**

Gaucher's disease is an autosomal recessive lysosomal storage disease. Gaucher's disease has been implicated in the development of osteonecrosis of the femoral head due to its role in decreasing capillary blood flow, possibly by increasing the pressures in the intraosseous extravascular space. Due to the deficiency of beta-glucocerebrosidase, patients with Gaucher's disease accumulate large amounts of glucocerebrosides in the lysosomes of their histiocytes, aptly named Gaucher cells. There are three main pathogenic mechanisms by which the blood supply to bone can be interrupted (Figure 4.8):

I. **Mechanical vascular interruption (traumatic causes)**
Interruption of vessels feeding bone due to fracture or dislocation. Hip haemarthrosis has been proposed as a potential cause of extraosseous compression of the ascending retinacular vessels by tamponade, however this theory lacks strong support.

II. **Intravascular occlusion**
Vascular occlusion due to thrombus (sickle cell disease, thrombophilias and systemic lupus erythematosus), clot, fat (corticosteroids and alcohol) or nitrogen embolus (Caisson's disease).

III. **Extravascular compression**
Occlusion can occur due to extravascular pressure on vessels for example by fat cell hypertrophy (corticosteroids and alcohol) and Gaucher cells.

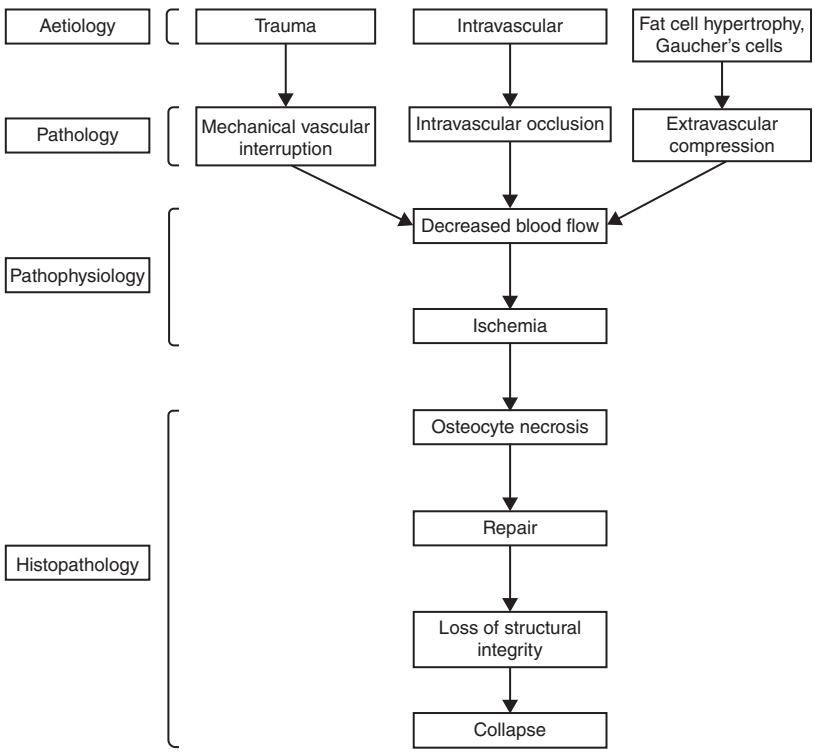


Figure 4.10 Pathophysiology of osteonecrosis (Aaron 2015, Reprinted with permission from Wolters Kluwer)

Aaron RK. Osteonecrosis: etiology, pathophysiology, and diagnosis. In Callaghan JJ, Rosenberg AG, Rubash HE, eds. *The Adult Hip*. Philadelphia, PA: Wolters Kluwer; 2015.

60. Answer A. **Creeping substitution**
Creeping substitution is a form of appositional bone formation as new bone is laminated on dead trabeculae. The dead trabeculae that are not resorbed by osteoclasts serve as scaffolds for deposition of new living bone Creeping substitution is the process by which bone repair occurs in osteonecrosis as well as the incorporation of cancellous bone allograft.

In 1930 Phemister coined the term, 'creeping substitution' to describe the repair of necrotic bone: 'By the process of creeping substitution, the old bone is gradually absorbed and replaced by new bone, so that in the course of months or occasionally years the necrotic area is more or less completely transformed into living bone ... the amount of new bone formed ... depends largely on the extent of the living bone with which it (the dead bone) is in contact.'

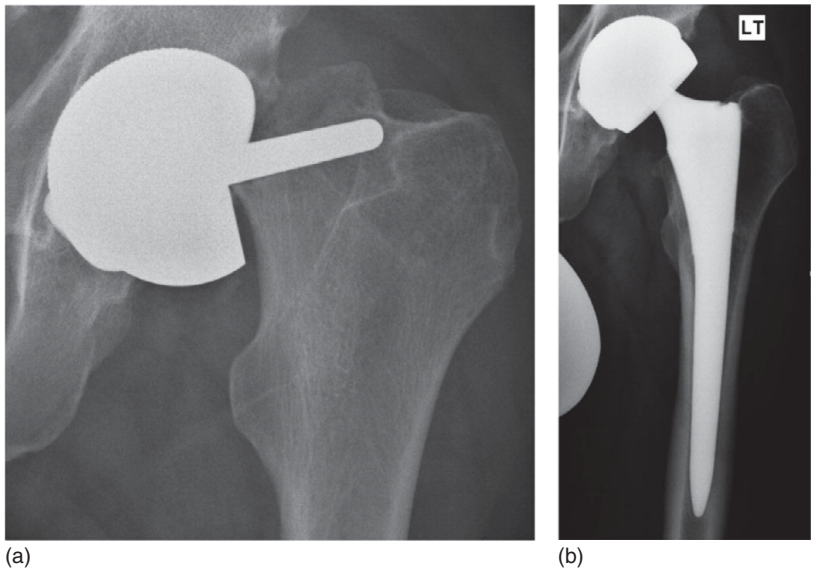
Enchondral ossification is the process by which long bones are formed in the embryo, longitudinal bone growth (physeal) and secondary bone healing by fracture callus. In enchondral ossification bone replaces a cartilage model.

Intramembranous ossification is the mechanism of embryonic flat bone formation and bone formation during distraction osteogenesis. In intramembranous ossification, aggregates of undifferentiated mesenchymal cells differentiate into osteoblasts which form bone. Primary bone healing is bone healing without callus. Absolute stability (<2% strain) is required for primary bone healing. Secondary bone healing is healing via callus in the presence of relative stability (enchondral ossification). Appositional ossification is the mechanism of periosteal bone enlargement (diameter) and the bone formation phase of remodelling. In appositional ossification osteoblasts lay down new bone on existing bone so creeping substitution is a form of appositional ossification.

Core decompression is thought to relieve the pain and to allow creeping substitution to the necrotic area by bringing the blood supply through the drill channels.

Phemister DB. Repair of bone in the presence of aseptic necrosis resulting from fractures, transplantations, and vascular obstruction. *J Bone Joint Surg Am.* 1930;**12**:769–787.

61. Answer A. **Femoral neck fracture**
The incidence of femoral neck fracture after hip resurfacing is approximately 1–2% (Matharu et al. 2020) (Figure 4.11). Most femoral neck fractures after hip resurfacing occur in the early



(a) (b)

Figure 4.11 (a) Left hip resurfacing fracture. (b) Conversion to MoM hip arthroplasty

post-operative period, however they can occur at any stage (Matharu et al. 2013). Risk factors for femoral neck fracture are notching of the superior aspect of the femoral neck and varus placement of the femoral component relative to the pre-operative neck shaft angle (Shimmin and Back 2005). Femoral and sciatic nerve injuries present with sensory and motor weakness with or without pain. The incidence of sciatic nerve palsy following THA is approximately 1.5% (Hasija et al. 2018). The sciatic nerve is at greatest risk during the posterior approach whereas the femoral nerve is at greater risk during the anterior approach (Hasija et al. 2018).

Iliopsoas impingement does not tend to present until later when patients are more mobile. The most common cause is the iliopsoas tendon impinging on a prominent anterior rim of the acetabular cup. Patients with iliopsoas impingement tend to complain of pain in the groin during activities which require active hip flexion, such as walking up stairs and lifting the leg in and out of a car. Provocative clinical examination manoeuvres that will reproduce the pain of iliopsoas impingement are resisted seated hip flexion or a straight leg raise. The incidence of iliopsoas impingement after THA is about 4% (Dora et al. 2007). Haematomas do not tend to cause severe pain unless they compress other structures such as nerves, in which case they are an important reversible cause of nerve palsy.

Dora C, Houweling M, Koch P, Sierra RJ. Iliopsoas impingement after total hip replacement: the results of non-operative management, tenotomy or acetabular revision. *J Bone Joint Surg Br.* 2007;**89**:1031–1035.

Hasija R. et al. Nerve injuries associated with total hip arthroplasty. *J Clin Orthop Trauma* 2018;**9**:81–86.

Matharu GS et al. The effect of surgical approach on outcomes following total hip arthroplasty performed for displaced intracapsular hip fractures: an analysis from the National Joint Registry for England, Wales, Northern Ireland and the Isle of Man. *J Bone Joint Surg Am.* 2020;**102**:21–28.

Matharu GS, McBryde CW, Revell MP, Pynsent PB. Femoral neck fracture after Birmingham Hip Resurfacing Arthroplasty: prevalence, time to fracture, and outcome after revision. *J Arthroplasty* 2013;**28**:147–153.

Shimmin AJ, Back D. Femoral neck fractures following Birmingham hip resurfacing. *J Bone Joint Surg Br.* 2005;**87-B**:463–464.

62. Answer C. **Proximal hamstring avulsion**
Water-skiing accidents are a classic mechanism for proximal hamstring insertion injuries (Sallay et al. 1996). This either occurs due to forceful hip flexion and knee extension while attempting to start from a submerged position or as a result of a fall at speed (Figure 4.12). Interest in surgical repair of proximal hamstring avulsions is increasing due to reports of promising results (Wood et al. 2020). Rectus femoris avulsions occur in adolescents (apophyseal injury) taking part in sports involving kicking and sprinting. Rectus femoris is a biarticular muscle, this predisposes it to injury due to resultant greater

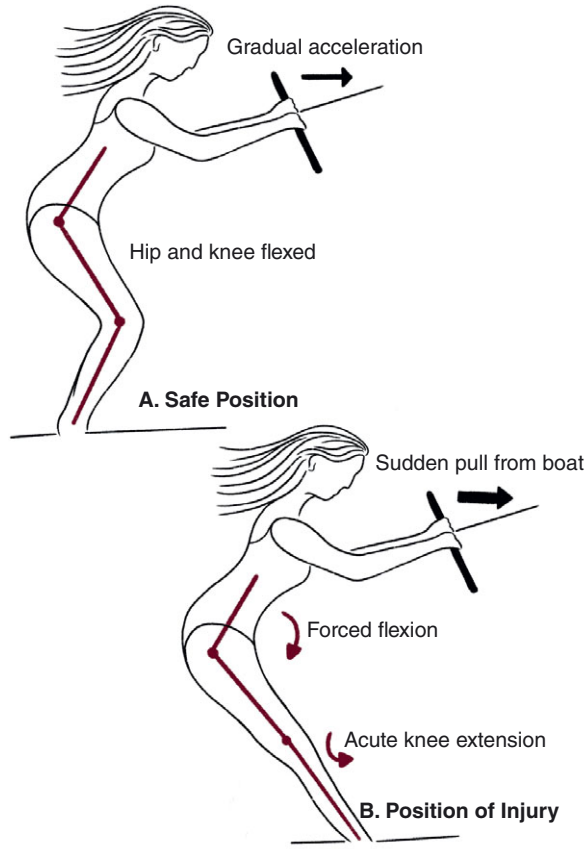


Figure 4.12 Hip is flexed while the knee is extended, causing eccentric contraction of the hamstrings when suddenly pulled by the boat (Chakravarthy et al. 2005)

length change and strain compared with monoarticular muscles. Gluteus maximus avulsion injuries are rare. Isolated greater trochanter fractures occur most commonly in elderly patients with osteoporotic bone. It is important to differentiate an isolated greater trochanter fracture from one that has intertrochanteric extension.

Transversus process fractures are common in high energy trauma as a result of psoas and fascial avulsions occurring in extension and lateral flexion.

Chakravarthy J, Ramisetty N, Pimpalnerkar A, Mohtadi N. Surgical repair of complete proximal hamstring tendon ruptures in water skiers and bull riders: a report of four cases and review of the literature. *Br J Sports Med* 2005;**39**:569–572.

Sallay PI, Friedman RL, Coogan PG, Garrett WE. Hamstring muscle injuries among water skiers: functional outcome and prevention. *Am J Sports Med.* 1996;**24**:130–136.

Wood D, French SR, Munir S, Kaila R. The surgical repair of proximal hamstring avulsions. *Bone Joint J.* 2020;**102-B**:1419–1427.

63. Answer A. **Crowe IV dysplastic hip (superior subluxation) – positive Galeazzi test, asymmetrical Bryant's triangle, Thomas test negative**
The Galeazzi test is used to assess discrepancy in femur or tibia length by assessing knee position with the patient supine, knees at 90° and feet planted at the same position. Any disparity in knee height indicates a positive test and either a difference in femur or tibia length or both.

In a superior hip dislocation the Galeazzi test will be positive because the femur will appear shortened due to the superior centre of rotation of the hip joint. Figure 4.13 is a diagram of Bryant's triangle. Bryant's triangle is a hypothetical triangle of lines drawn on the body to determine upward displacement of the trochanter (originally described as a method to diagnose hip fracture). The Thomas test is used to detect a hip fixed flexion deformity. Crowe type IV hip dysplasia causes an asymmetrical Bryant's triangle. Hip arthrodesis is typically performed with ~30° hip flexion and so would result in a positive Thomas test. Hip arthrodesis would also likely result in shortening of the femur and so a positive Galeazzi test. A previous femoral physeal

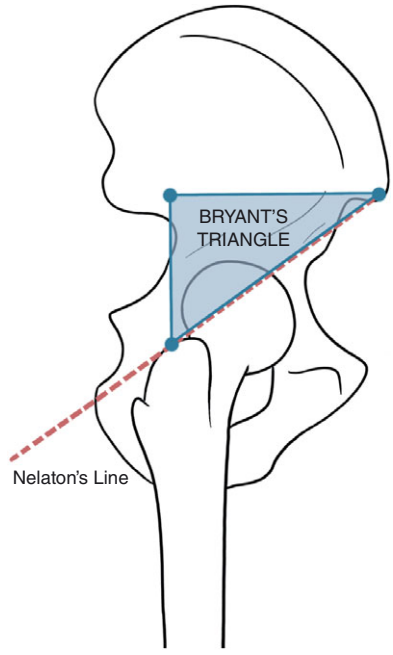


Figure 4.13 A triangle formed by the tip of the greater trochanter and anterior superior iliac spine and the vertical and horizontal lines that intersect

injury would likely result in femoral shortening and thus a positive Galeazzi test. A previous tibial fracture malunion should have symmetrical Bryant's triangles.

The aetiology of leg length discrepancy (LLD) can be classified as true or apparent. A true LLD is defined as the anatomical difference between the lengths of one or more of the segments of the lower extremity (femur or tibia). An LLD that refers to discrepancies that are not true differences in anatomic segment lengths are termed apparent or a postural discrepancy (e.g. knee flexion contracture or a dislocated hip). A functional LLD is the sum of the true and apparent LLD and is the most important in treatment decisions.

Clinical methods for measuring LLD include measuring tape and blocks. Using a tape measure, true leg length is measured from the medial malleolus to the anterior superior iliac spine. However, this method for measuring true LLD is slightly flawed as this method would wrongly attribute a hip dislocation to be a true LLD whereas by definition it is an apparent LLD.

Apparent leg length is measured by measuring from the medial malleolus to a bony reference point in the midline such as the xiphisternum. A discrepancy of apparent leg

length measurement can occur due to pelvic obliquity (scoliosis), pelvic deformity, hip or knee fixed flexion deformity or a true LLD. Placing blocks of known height beneath the heel of the short leg to level the pelvis allows an 'indirect' measurement of leg length discrepancy. This method is slightly more reliable and accurate than using a tape measure.

Radiographic methods such as plain radiography, CT scanogram or EOS are useful for quantifying LLD more accurately. Finally, a long-standing LLD can cause a compensatory hip and knee fixed flexion deformity of the contralateral limb which can further complicate the clinical picture.

64. Answer C. **L2 root lesion**

The Trendelenburg test is a clinical test used to assess hip pathology. During a normal test when performing single leg stance, the pelvis rises slightly on the contralateral side. Four basic elements are required for a normal test. Functioning fulcrum (hip joint), normal lever arm (offset), functioning hip abductor muscle (gluteus medius and minimus) and intact nerve supply to hip abductors. The hip abductors are supplied by the superior gluteal nerve which has a root level of L5 and not L2. Hip abductor tendinopathy or tendon avulsions are a common cause of a positive Trendelenburg sign. Abductor tendinopathy also causes a Trendelenburg gait. The resultant hip adduction increases the tension of the iliotibial band and increases compression of the trochanteric bursa and will eventually lead to trochanteric bursitis which can cause significant lateral hip pain.

Osteoarthritis is known to induce periarticular muscle atrophy so hip arthritis causes hip abductor atrophy and weakness.

A total hip arthroplasty with a reduced offset compared with the native hip means the hip abductors would not be correctly tensioned to function optimally. To put it another way a reduced offset results in a reduced hip abductor lever arm and so can result in a positive Trendelenburg sign.

The hip abductors are supplied by the superior gluteal nerve. The superior gluteal nerve is at risk during the Hardinge approach when gluteus medius is split too proximal from the trochanter.

Chapter 5

Hip III Structured SBA

Nicholas Wei and Paul Banaszkiewicz

HIP III STRUCTURED SBA QUESTIONS

1. An 80-year-old female patient attends the arthroplasty follow-up clinic complaining of non-specific left hip pain.
   The appearance of the left uncemented femoral stem calcar (Figure 5.1) would have been minimised by using

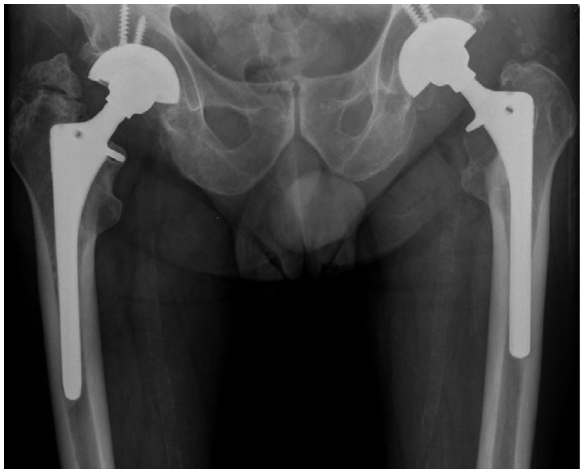


Figure 5.1 Radiograph left calcar

   A. A round stem
   B. A tapered stem
   C. A titanium alloy
   D. Avoiding flutes
   E. Using a cemented stem

2. Post-operative radiographic femoral offset measurements of a patient following THA suggest an excessive femoral offset.
   Consequences of an excessive femoral offset include?
   A. Abductor weakness
   B. Increased likelihood of using a walking aid
   C. Increased hip joint reaction forces
   D. Instability
   E. Trochanteric pain

3. A 72-year-old female attends the arthroplasty follow-up clinic. Her anteroposterior (AP) radiograph is shown in Figure 5.2. She has lower back pain and non-specific right hip pain.
   The appearance will
   A. Affect implant survival
   B. Depend on stem stiffness
   C. Lead to increased rates of osteolysis
   D. Lead to mid-thigh pain
   E. Result in loosening of the implant

Figure 5.2 Anteroposterior (AP) radiograph hip

4. An 85-year-old female attends clinic complaining of a 2-week history of hip pain on weight bearing, groin tenderness on rotation. No history of injury. Her radiographs are shown in Figure 5.3.
   The most likely diagnosis would be
   A. Age-related thinning

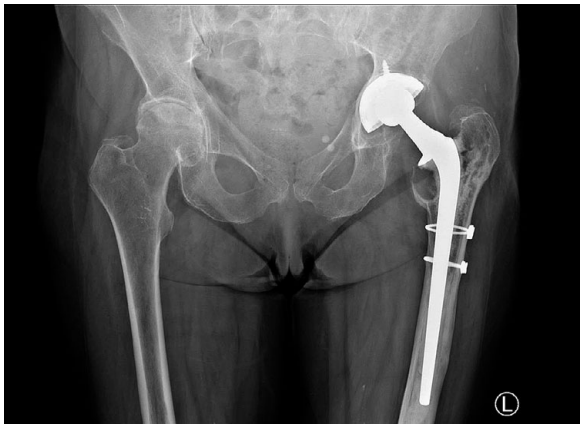


Figure 5.3 Radiograph of 85-year-old female

B. Osteolysis
C. Osteomyelitis
D. Stress shielding
E. Tumour

5. An 85-year-old female attends clinic complaining of a 2-week history of hip pain on weight bearing, groin tenderness on rotation. No history of injury. Her radiographs are shown in Figure 5.3.
The most appropriate plan of action would be
A. Bone scan
B. CT scan
C. Curettage and bone grafting to left hip
D. Observation with yearly follow-up clinic review
E. Revision femoral stem

6. A 67-year-old male attends follow-up arthroplasty clinic. Three weeks prior he had a minor fall and attended the ED. Radiographs were taken in clinic today and his right anteroposterior (AP) hip radiograph is shown in Figure 5.4.

Figure 5.4 Anteroposterior (AP) radiograph right hip

The acetabular cup demonstrates the following features
A. Absent medial stress shielding (osteopenia)
B. Absent superolateral sclerosis (buttress)
C. Continuous radiolucent line around cup
D. No evidence of inferomedial buttress
E. Remodelling of radial trabeculae pattern

7. A 43-year-old woman presents to clinic with groin pain. She had undergone a right MoM hip resurfacing 3 years previously
Concerning her MRI scans (Figure 5.5).

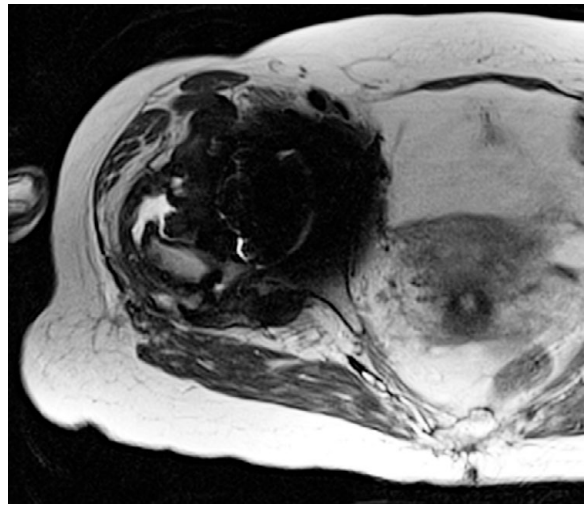


Figure 5.5 MRI pelvis axial T2

A. Appearance would be consistent with her painful symptoms and lack of function
B. Biopsy is indicated
C. Diagnosis is made by histological diagnosis
D. Is specific for an adverse reaction to metal debris
E. Pathogenesis involves a delayed hypersensitive (type IV) response to Co-Cr particles

8. A 76-year-old male attends the arthroplasty follow-up clinic. He had a cemented total hip arthroplasty performed 10 years previously using a lateral Hardinge type approach. He complains of anterior thigh and knee pain with walking. Clinical examination reveals an antalgic gait with abductor lurch.
The most likely diagnosis would be
A. Abductor muscle atrophy with partial gluteal detachment
B. Infection
C. Loose femoral component

D. Thoracolumbar discogenic pain
E. Vastus lateralis muscle herniation

9. A 69-year-old woman is seen as an emergency add on to the orthopaedic clinic. She underwent cemented THA 10 days previously. Her wound has been persistently draining since she was discharged from hospital. She is well within herself, apyrexia with minimal hip pain.
The next most appropriate course of action is to
A. Aspirate the hip
B. DAIR hip
C. Discontinue anticoagulation treatment
D. Start oral antibiotics
E. Swab the wound

10. A 52-year-old male attends clinic with a fused hip. Fusion was performed 30 years previously following an RTA with an acetabular fracture and secondary development of osteonecrosis. He complains of severe low back pain and ipsilateral knee pain. Radiographs show a cobra head plate in place with some concern about his abductor muscle mass.
The most appropriate assessment would be:
A. Electromyography
B. Inspection and palpation abductor muscle mass
C. MRI scan to assess abductor status
D. Trendelenburg test
E. US scan abductor muscle

11. A 24-year-old male presents to the orthopaedic clinic with a 2-year history of progressively worsening osteoarthritic hip pain. Pain limits his walking distance to around 1/2 mile with almost continuous pain and causes sleep disturbance at night. He is struggling to climb ladders at work as a scaffolder and can no longer play football.
The most appropriate course of action would be to
A. Advise he is too young to undergo THA and he should continue with conservative management of his hip arthritis
B. List for an uncemented ceramic on HXLPE THA
C. List for hip fusion
D. List for steroid local anaesthetic injection hip so he can restart playing football
E. Refer on to hip surgeon who performs MoM resurfacing

12. A 78-year-old female is seen in the outpatient clinic with severe bilateral end stage arthritis. She asks that both hips be operated on at the same time as it would 'get them both out of the way in one sitting and save time'.
Compared with a 2-stage bilateral THA procedure a simultaneous bilateral total hip arthroplasty (SBTHA) has
A. Increased cardiovascular complications
B. Increased dislocation rate
C. Increased DVT risk
D. Increased risk of death
E. Increased transfusion requirements

13. You have been on call for the acute trauma take during the last 24 hours. At the trauma meeting before theatre radiographs of a 51-year-old female who drinks 1 bottle of wine a day are shown (Figure 5.6). She had a low velocity fall onto her right hip. She is otherwise fit and well.
The most appropriate choice of management would be
A. Cannulated screw fixation
B. Cemented bipolar hemiarthroplasty
C. Cemented total hip arthroplasty
D. Two-hole dynamic hip screw (DHS) with supplementary screw fixation
E. Uncemented total hip arthroplasty

Figure 5.6 Anteroposterior (AP) radiographs femur

14. You have been on call for the acute trauma take during the last 24 hours. At the trauma meeting before theatre the radiographs of a 38-year-old female with known excessive alcohol intake are shown (Figure 5.7). She has had a low velocity

fall onto her right hip. The anaesthetist is concerned about her anaesthetic risk for surgery. She has mildly deranged clotting and LFTS results.

The most appropriate choice of management would be

A. Bipolar cemented hemiarthroplasty hip
B. Cannulated screw fixation
C. Cemented total hip arthroplasty
D. Monopolar cemented hemiarthroplasty
E. Two-hole dynamic hip screw (DHS)

Figure 5.7 Anteroposterior (AP) radiographs femur

15. You see and list a 76-year-old female for a left total hip arthroplasty. She has moderate Parkinson's disease.

The most appropriate option to reduce her dislocation risk would be

A. 20° lipped liner
B. Captive cup
C. Change from a normal posterior approach to the hip to an anterolateral Hardinge approach
D. Dual mobility cup
E. Use of a large femoral head (36mm if possible)

16. You are performing a hybrid hip replacement in a 62-year-old patient with mild cognitive impairment. There is some concern about compliance with post-operative instructions. The bone quality appears poor at surgery. The definitive cup is a press fit design but is loose when impacted.

The most appropriate action is to

A. Add supplementary screw fixation
B. Change to a hydroxyapatite cup with screw fixation
C. Convert to using a cement cup
D. Insert the next sized larger cup into the acetabulum
E. Upsize and insert an uncemented TM revision cup

17. A patient with a large BMI ($\geq$40) has been referred to your clinic for a second opinion regarding the need for THA. The first surgeon who she met in clinic turned her down for THA mentioning that risks of complications were too significant with her large BMI.

With an increased BMI over 40 there is

A. Higher risk of revision for aseptic loosening
B. Higher risk of revision for mechanical failure of the implant
C. Increased risk of mortality
D. Poorer functional outcome compared with non-obese patients
E. Reduced improvement in pain scores compared with non-obese patients

18. A 69-year-old male presents to ED complaining of sudden onset of severe leg and hip pain. His radiographs are shown in Figure 5.8.

The following statement is true

A. Calcar pivot is the most common mode of failure
B. Mode 3 failure involves medial migration of the proximal stem coupled with lateral migration of the distal stem tip

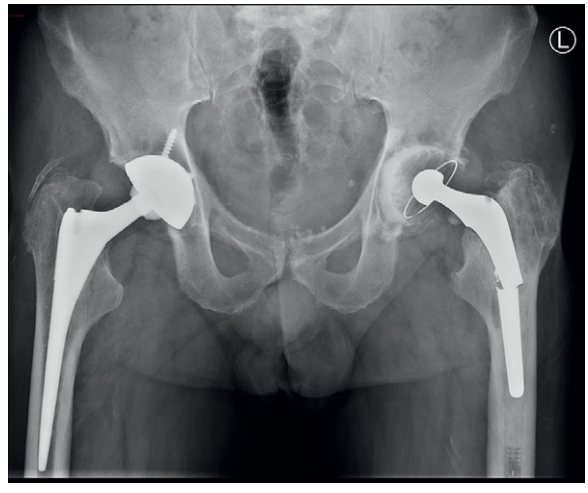


Figure 5.8 Anteroposterior (AP) radiographs pelvis

C. Mode 4 failure can be recognised early by radiolucencies developing along the proximal lateral cortex (convex) surface of the stem
D. The least common mode of failure is bending cantilever failure
E. This radiograph demonstrates Gruen mode 2 failure

19. The most common mode of femoral stem fracture is
A. Bending cantilever (fatigue)
B. Calcar pivot
C. Medial midstem
D. Type 1b pistoning
E. Type 1a pistoning

20. In theatre performing a cemented total hip arthroplasty. The scrub nurse mixing the cement mentions that they had recently been on a 'cement training day' organised by one of the implant companies. She was unsure about the difference between third- and fourth-generation cementing techniques.
You mention
A. Fourth-generation cementing involves late insertion of an implant into viscous cement
B. Fourth-generation cementing involves using high pressure pulsed lavage
C. Fourth-generation involves using distal and proximal centralisers to ensure an even cement mantle
D. Fourth-generation techniques involve improved stem designs
E. Third- and fourth-generation cementing techniques are essentially the same procedure

21. A 72-year-old man returns to arthroplasty follow-up clinic 1 year following cemented THA. His AP radiograph is shown in Figure 5.9.
Concerning the X-ray appearance
A. Early removal is advisable in order to reduce the risk of dislocation
B. It is a rare occurrence (<5%) after THA
C. Pathophysiology is an inappropriate differentiation of pluripotent mesenchymal stem cells
D. Risk factors includes posterior approach
E. Very likely to result in lower Harris hip scores

Figure 5.9 Anteroposterior (AP) radiograph pelvis

22. Concerning heterotopic ossification (HO) after total hip arthroplasty (THA), this is most likely to occur in the following situation:
A. Ankylosing spondylitis
B. Head injury
C. Male sex
D. Ankylosed hip
E. Cementless prosthesis

23. Regarding Gruen's mode of cemented femoral stem failure
A. An initial mode Ia failure may progress into mode II failure
B. Mode Ia is the most common cause of failure
C. Mode IV (bending cantilever) is rarely seen
D. Modes 1b, II and III are each seen in about equal numbers
E. The modes of failure were based on a taper slip femoral prosthesis

24. A 76-year-old female dislocates her THA 1 day post-operatively in bed the next morning following surgery. The THA was performed by a trainee orthopaedic surgeon although closely supervised by their consultant.
The most likely reason for the dislocation occurring would be
A. Component malalignment
B. Failure to remove osteophytes
C. Large, retained piece of cement in the hip joint

D. Non-compliance with post-operative hip precautions
E. Using a posterior approach to the hip and failing to adequately repair the soft tissues

25. An 81-year-old man is admitted from the ED with a dislocated left THA. He underwent the surgery 3 weeks previously.
The strongest independent patient predictor of early THA dislocation (within 40 days) is
A. Dementia
B. Depression
C. Lung disease
D. Parkinson's disease
E. Spinal fusion

26. Regarding MoM resurfacing biomechanics.
Contact Patch to Rim Distance (CPRD) is most influenced by
A. Arc of cover
B. Cup inclination angle
C. Cup version angle
D. Femoral head diameter
E. Head-cup clearance

27. In the team brief before surgery the lead surgeon is concerned about the dislocation risk in a patient with cognitive impairment. The plan is to use a large 36mm femoral head. The rationale being that a larger femoral head will increase jump distance.
Factors known to increase the jump distance include
A. Decreased femoral head offset
B. Increase in cup anteversion angle
C. Increased abduction angle
D. Polyethylene liners with an offset
E. Smaller acetabular hemisphere

28. A 39-year-old male presents to the orthopaedic clinic with severe acute onset of right hip pain of 8 weeks' duration. You suspect osteonecrosis. A medical student in clinic has heard this condition is due to a vascular disturbance in the femoral head blood supply like a compartment syndrome of bone.
The most likely vascular disturbance attributed to a compartment syndrome of bone would be
A. Extraosseous arterial factors
B. Extraosseous extravascular (capsular) factors
C. Intraosseous arterial factors
D. Intraosseous extravascular factors
E. Intraosseous venous factors

29. A 43-year-old male presents to the orthopaedic clinic with an 8-week history of severe left hip pain. His radiographs are shown in Figure 5.10.
The most appropriate treatment would be
A. Bisphosphonates
B. Core decompression
C. Hip resurfacing
D. Total hip arthroplasty
E. Vascularised fibular graft

Figure 5.10 Anteroposterior (AP) radiographs pelvis

30. During a total hip arthroplasty the senior surgeon asks the implant rep if his company's HXLPE is first- or second-generation. The implant rep says he thinks it is second-generation and mumbles that it has been processed by 5 Mrad
The main difference between first- and second-generation HXLPE
A. First-generation annealed HXLPE contains no residual free radicals
B. First-generation remelted HXLPE contains elevated residual free radicals
C. Second-generation HXLPE involves a single irradiation and remelting with addition of vitamin E
D. Second-generation HXLPE involves sequential irradiation and annealing
E. Second-generation HXLPE involves sequential irradiation and remelting

31. A 78-year-old female who underwent right THA via a posterior approach is seen the next morning with a dense painful foot drop.
The most appropriate initial management is
A. MRI scan
B. Nerve conduction studies
C. Physiotherapy and foot drop splint
D. Radiographs hip
E. Re-exploration of the hip

32. A 40-year-old man has been referred to the orthopaedic clinic with a 6-week history of (right) hip pain. The pain was unrelated to trauma and was a severe, deep aching groin pain worse at night. The patient has a limp with pain on weight bearing and a positive Trendelenburg sign. Radiographs of his hips are normal. An MRI scan of his pelvis is shown (Figure 5.11).

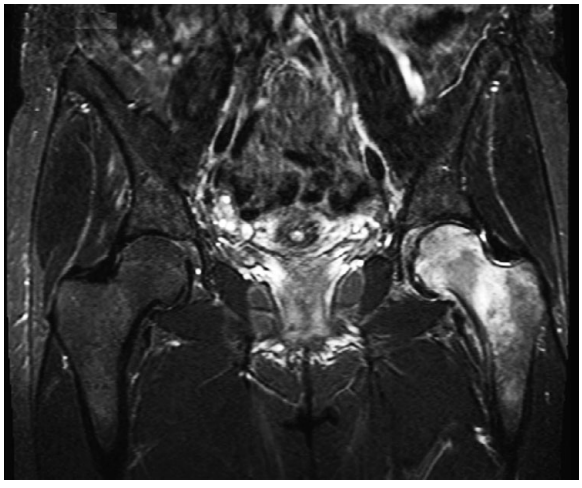


Figure 5.11 T2 sagittal MRI pelvis

The most likely diagnosis is?
A. Bone marrow oedema syndrome
B. Infection (septic arthritis)
C. Osteochondromatosis
D. Osteonecrosis
E. Reflex sympathetic dystrophy

33. Surgical care practitioner is reviewing an AP radiograph of a cemented THA in the arthroplasty follow-up clinic. The patient is doing well but her radiographs suggest cup loosening. There is no suggestion of infection. The cup has been in 10 years and they are concerned about the PE used.
Compared with standard UHMWPE HCLPE has
A. Decreased ductility
B. Increased fatigue strength
C. Increased fracture toughness
D. Increased tensile strength
E. Larger PE particles generated

34. A 48-year-old male with established severe osteoarthritis of the right hip is being listed for THA in clinic. His neighbour has recommended using a ceramic-on-ceramic hip replacement.
You mention that CoC bearing surfaces have fallen out of popularity due to
A. Incidence of squeaking is now regarded as being too high
B. Limited number of head and cup implant options
C. Risk of catastrophic failure has not improved with the fourth-generation Biolox delta
D. There are equivalent clinical results with a ceramic and HCPLE bearing surface combination
E. With limited healthcare budgets, the increased cost for use has now become prohibitive

35. You have performed an uncomplicated uncemented CoP THA on a 55-year-old male. The patient was discharged at 2 days progressing well. Medical staff shortages meant that his radiographs were not reviewed before discharge. You review his post-operative radiographs after discharge (Figure 5.12).
The most important next step is
A. Arrange for a duty of candour
B. Arrange for urgent clinic follow up
C. Ask the patient to attend the ED so that the orthopaedic team on call can review the patient
D. Discuss the case at the next weekly MDT
E. Put protocols in place to make sure that all radiographs are reviewed by the medical team before patient discharge

36. A patient with an excessively anteverted uncemented cup returns early to clinic because of concerns about the dislocation risk. His radiographs are shown in Figure 5.12. He is progressing well. You haven't had a chance to discuss the case at the next MDT due to the holiday period.

Figure 5.12 Anteroposterior (AP) pelvic radiographs

You recommend

A. Adopting a watch and wait policy for the hip
B. Ultrasound scan to look for iliopsoas impingement
C. Prophylactic hip brace for 3 months
D. Making sure his physiotherapy is face to face rather than just a telephone review
E. Revision to a dual motion cup liner

37. A 62-year-old male with known rheumatoid arthritis is seen in clinic. He has severe end stage co-existing right hip and knee arthritic pain with a similar pain and functional disability level. He asks that you proceed first with a TKA for him as he thinks he is likely to recover more quickly from the TKA.

The most appropriate management option is:

A. To arrange for a local anaesthestic/steroid injection to be given to the knee to see how he responds to the injection and therefore how likely a TKA will relieve his knee pain
B. To arrange for a local anaesthestic/steroid injection to hip to gauge how severe his hip pain is
C. To arrange for a rheumatology review so that his DMIARs medication can be reviewed and changed if needed
D. To recommend that THA should be performed before TKA
E. To take the patient's wishes into account and list for a TKA (Shared care process)

38. A 54-year-old female with known rheumatoid arthritis has severe end stage co-existing right hip and knee arthritic pain with a similar pain and functional disability level. She has been listed for THA but on the day of surgery asks whether going ahead first with a TKA rather than THA would be best.

All the following reasons are valid arguments for proceeding with THA first EXCEPT

A. Adequate arc of hip motion is required for deep knee flexion, which is often required for successful TKA procedures
B. In patients with brittle rheumatoid arthritis hip surgery is likely to be more straightforward than knee surgery and a patient's confidence will be gained with performing relatively easy surgery
C. It is best to resolve any knee pain that is referred from the hip. At times even a TKA can be delayed because of the pain relief gained by replacing the hip
D. It is easier for a patient to exercise a hip above a painful arthritic knee whereas it is difficult to exercise a knee below a painful stiff arthritic hip
E. It makes sense to avoid twisting and torquing a well-balanced TKA while dislocating and exposing a stiff hip for THA

39. You are performing THA in a 76-year-old male and are keen to increase the femoral offset of the implant to improve a weakened abductor function.

The options available to increase femoral offset include

A. Decreasing the neck shaft angle
B. Decreasing the femoral neck length
C. Lateralising the femoral neck while concomitantly decreasing the femoral neck length

D. Use of a dual motion implant
E. Use of medialised acetabular liners

40. A 19-year-old ballet dancer presents with a snapping sensation in the groin region.
On clinical examination, which of the following manoeuvres will be most helpful in confirming the diagnosis?
A. With the patient in the lateral position the hip is flexed to 45° and the knee to 90°. The pelvis is stabilised, and the flexed hip is adducted
B. With the patient in the lateral position, the hip is brought from flexion and adduction into extension and abduction
C. With the patient supine, the hip is brought from a position of flexion, abduction and external rotation into extension, adduction and internal rotation
D. With the patient supine, the hip is flexed to 90°, then adducted and internally rotated
E. With the patient supine, the ipsilateral knee is flexed to 90° and the hip is then extended, adducted and externally rotated

41. **When investigating the causative organism in an infected THA which would be your preferred method?**
A. Intraoperative frozen section
B. Intraoperative Gram stain
C. Percutaneous aspiration and culture
D. Polymerase chain reaction
E. Tissue culture of intraoperative biopsies

42. A 75-year-old patient presents with multiple episodes of dislocation following primary hip arthroplasty performed through a Hardinge approach.
Which of the following is the most appropriate indication for use of a constrained acetabular liner?
A. Excessive anteversion of acetabular component
B. Excessive anteversion of femoral stem
C. Femoral neck impingement
D. Gluteal muscle (abductor) deficiency
E. Revision hip surgery

43. **Which of the following factors will result in the greatest chance of an elective primary hip arthroplasty dislocating?**
A. Use of a collarless femoral prosthesis
B. Use of a long posterior wall acetabular component
C. Use of a monoblock femoral prosthesis
D. Use of a small femoral head
E. Use of hybrid components

44. An 80-year-old lady is being planned for a revision hip replacement for aseptic acetabular component loosening (Figure 5.13). You are planning to revise the acetabular component to an uncemented porous coated shell.
Which of the following statements is correct regarding safe zones of the acetabulum?
A. Anterior-inferior quadrant has good bone stock compared with posterior-superior quadrant
B. Anterior-superior quadrant is generally considered a safe zone for placement of acetabular screws
C. Risk of external iliac vessel injury is high with posterior-inferior quadrant
D. Risk of injury to inferior gluteal and pudendal vessels is high with posterior-inferior quadrant
E. Risk to superior gluteal vessels is high with anterior superior quadrant

Figure 5.13 Anteroposterior (AP) pelvis demonstrating loose acetabular cup

45. A 59-year-old man is referred to the arthroplasty clinic as a second opinion. He had Perthes disease as a child and had an uncemented THA performed 2 years previously. He is complaining of a clicking sensation around the hip,

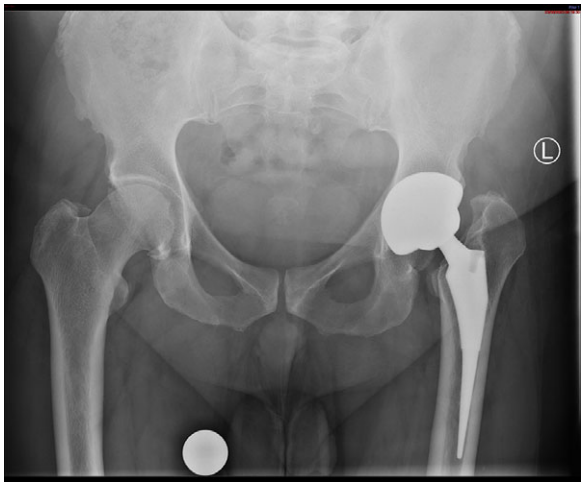


Figure 5.14 Anteroposterior (AP) pelvis demonstrating left I THA

trochanteric discomfort, has a Trendelenburg gait and hip pain with movements. His radiographs are shown in Figure 5.14.

The most likely cause for his pain is

A. Failure of osteointegration of the femoral stem
B. Leg length discrepancy
C. Proximal/distal femoral stem mismatch
D. Reduced femoral offset
E. Residue pain from Perthes disease

HIP III STRUCTURED SBA ANSWERS

1. Answer E. **Using a cemented stem**
An SBA to revise principles of stress shielding. There is calcar reabsorption.

The radiograph is an example of subtle stress shielding. This is the phenomenon of proximal femoral bone density loss observed over time in the presence of a solidly fixed implant. Biomechanically, there is a decrease in the physiological stress to bone caused by the stiffer structure that shares its load.

Stem stiffness is the primary factor causing stress shielding. The extent of porous coating has some effect on stress shielding but is less important than stem stiffness.

The archetypal scenario of stress shielding in THA is a large diameter stem that is made of Co-Cr alloy, has a round cylindrical shaft and has an extensive porous coating.

Factors affecting stem stiffness include (1) stem size, (2) metal choice and (3) stem geometry.

Stiffness increases in proportion to the fourth power of the stem radius.

A stiffer material also increases stem stiffness. Co-Cr has a higher modulus of elasticity than titanium and is therefore stiffer.

Stems that are solid and round are stiffer.

Stem geometries that are less stiff include hollow or tapered stems and stems that have slots and flutes.

2. Answer E. **Trochanteric pain**
The simplest and most frequently used measurement of femoral offset is the perpendicular distance between the centre of the femoral head and a line drawn down the centre of the femoral shaft.

For the purpose of understanding the force alterations that occur with alterations in offset, the perpendicular distance from the line of action of the abductor muscles to the centre of the femoral head is the most effective variable.

Femoral component offset depends on both the length of the femoral neck and the neck-shaft angle of the prosthesis.

Femoral offset is important because it controls the tension and moment arm of the abductor muscles, tension of the soft tissues, wear of the acetabular component and the load imposed on both the acetabular and femoral implants. Excessive femoral offset has the potential to overload the femoral implant, to generate micromotion at the implant-bone interface and to cause pain in the abductor muscles and the region of the greater trochanter.

Failure to restore the femoral offset may lead to excessive wear, fatigue, limping and/or hip instability and an increased need for use of a walking aid.

Charles MN et al. Soft tissue balancing of the hip: the role of femoral offset restoration. *J Bone Joint Surg.* 2004;**86**:1078–1088.

3. Answer B. **Depend on stem stiffness**
Although a well-fixed stem with stress shielding does not affect implant survival it is prone to fracture and revision of a stem with significant stress shielding is difficult. Femoral cortical bone is thin and more prone to damage during extraction.

The stiffness of the material in a femoral stem and the extent of porous coating covering the component have been shown to contribute to stress-shielding.

There is no increase in femoral osteolysis seen in patients with stress shielding.

Risk factors for stress shielding include bone quality, stem size, extent of porous coating, gender and age.

Figure 5.15 Anteroposterior (AP) radiograph right hip demonstrating stress shielding

Clinical problems directly attributable to proximal femoral stress-related bone resorption have not been reported to any significant degree in the literature.

Engh Jr CA, Young AM, Engh Sr CA, Hopper Jr RH. Clinical consequences of stress shielding after porous-coated total hip arthroplasty. *Clin. Orthop.* 2003;**417**:157–163.

4. Answer B. **Osteolysis**

The patient's radiographs demonstrate focal osteolysis around the lesser trochanter. The major differential diagnosis of focal osteolysis is generalised loosening, stress shielding, infection and tumour. If there is rapid osteolysis or bone disintegration, then be suspicious of infection. It may be necessary to culture joint aspirations. In infections, progression of bone loss is related to the aggressiveness of the source organism. Tumour will also show more aggressive destruction.

Osteolysis distal to the implant articulation is explained as being due to direct access of joint fluid and wear particles to the endosteal bone via the bone-cement interface. In its most destructive form, this pattern of focal endosteal osteolysis has been labelled as an 'aggressive granulomatous lesion'.

Focal osteolysis can be defined as a discrete region of bone loss that occurs at the bone–prosthesis or bone–cement interface and does not conform to the prosthesis shape.

Osteolysis was defined as a localised or scalloped periprosthetic bone loss in order to distinguish it from loosening – which shows a linear or more evenly extensively distributed bone loss around the implant. Schmalzried et al. (1992) studied hips with linear (diffuse) or lytic (localised) areas of periprosthetic bone loss. Although the gross radiographic appearances of bone loss were different, the histological appearance of active bone resorption was similar. They suggested that the radiological difference in bone loss may be related to the local concentration of particulate wear debris and the preferential flow within the effective joint.

Several authors have demonstrated the potential for a passage to form at the stem–cement interface. Joint fluid and particles are driven along the interface by the high intra-articular pressures generated during normal gait and reach the cement–bone interface via defects in the cement mantle. The resulting biological reaction can lead to focal osteolysis in the presence of a well-fixed cemented stem.

Cemented stems are considered definitely loose when the component has migrated, a new radiolucency at the cement–metal interface has developed, the stem is fractured, or when the cement mantle is fractured.

Many proposed mechanisms for focal femoral osteolysis around cemented femoral components have been put forward. These include stem micromotion (Charnley 1975), allergy to metal (Evans et al. 1974), a tissue response to wear particles such as polymethylmethacrylate (Horowitz et al. 1993), high density polyethylene (Jiranek et al. 1993) or metal debris (Haynes 1993), a response to cytokines produced in the hip capsule and transported in synovial fluid (Nivbrant 1999) or as a tissue response to fluid under pressure (van der Vis 1997).

Charnley J. Fracture of femoral prosthesis in THR. *Clin Orthop.* 1975;**111**:105–120.

Evans E, Freeman M, Miller A, Vernon-Roberts B. Metal sensitivity as a cause of bone necrosis and loosening of the prosthesis in TJR. *J Bone Joint Surg.* 1974; **56-B**:626–642.

Haynes D, Rogers S, Hay S, Pearsy M, Howie D. The differences in toxicity and release of bone resorbing mediators induced by titanium and Co-Cr -alloy wear particles. *J Bone Joint Surg.* 1993;**75-A**:825–834.

Horowitz S, Doty S, Lane J, Burnstein A. Studies of the mechanism by which the mechanical failure of PMMA leads to bone resorption. *J Bone Joint Surg.* 1993;**75A**:802–813.

Jiranek W, Machado M, Jasty M. Production of cytokines around loosened cemented acetabular components. *J Bone Joint Surg.* 1993;**75-A**:863–879.

Nivbrant B, Karlsson K, Karrholm J. Cytokine levels in synovial fluid from hips with well functioning or loose prostheses. *J Bone Joint Surg.* 1999;**81-B**:163–166.

Park JS et al. Focal osteolysis in total hip replacement: CT findings. *Skeletal Radiol.* 2004;**33**:632–640.

Schmalzried TP, Jasty M, Harris WH. Periprosthetic bone loss in total hip arthroplasty: polyethylene wear debris and the concept of the effective joint space. *J Bone Joint Surg Am.* 1992;**74**:849–863.

Van Der Vis H, Marti R, Tigchelaar W, Schuller H, Van Noorden C. Benign cellular responses in rats to different wear particles in intra-articular and intramedullary environments. *J Bone Joint Surg.* 1997;**79B**:837–843.

5. **Answer B. CT scan**

The patient's hip symptoms are non-specific, not disabling and short term. The lucency around the proximal femoral component is a long-standing feature and comparison should be made of previous radiographs if available to see progression of the disease. In view of her advanced age and lack of specific hip symptoms the best course of action would be for a CT scan which would be useful for the prediction and assessment of the nature and extent of focal osteolysis.

The lesion is best managed conservatively with yearly clinic review and serial radiographs to see if the lesion is expanding and threatening a periprosthetic fracture. However it would be a brave decision based purely on plain radiographic appearance to review the patient in a year without any further investigations. Option D is a realistic distractor with some debate as to whether to schedule follow up at 6 months rather than 1 yearly.

Ordering a bone scan is a reasonable option but not essential as radiographs do suggest only a localised osteolysis and no widespread femoral stem loosening. More generally a bone scan would identify whether an area of osteolysis was more widespread than anticipated or if the stem was loose. It is likely her focal osteolysis is asymptomatic and very slowly progressive.

Any revision surgery would be a large undertaking in this elderly patient. A full revision may be necessary as leaving the cup *in situ* may limit the head size that can be used and so increasing the risk for dislocation. If needed a full revision with a dual motion acetabular component would be a reasonable option.

Bone biopsy for suspected focal osteolysis would show a foreign body reaction with multinucleated giant cells and monocyte macrophages. Plain radiography is the cornerstone of evaluation and has been used to determine the extent and nature of focal osteolysis.

Beck RT, Illingworth KD, Saleh KJ. Review of periprosthetic osteolysis in total joint arthroplasty: an emphasis on host factors and future directions. *J Orthop Res.* 2012;**30**:541–546.

Park JS et al. Focal osteolysis in total hip replacement: CT findings. *Skeletal Radiol.* 2004;**33**:632–640.

6. Answer E. **Remodelling of radial trabeculae pattern**

The fall should alert the reader to look for any associated periprosthetic fracture or any other pelvic fracture such as a pubic rami or sacral fracture. The patient has had a hybrid hip replacement performed with the cup being uncemented. The SBA is testing the reader if they are aware of radiographic signs of a stable acetabular uncemented cup fixation.

Moore et al. (2006) compared radiographic appearances of bone ingrowth acetabular components with findings at revision surgery (Figure 5.18). They found five signs useful in determining stable uncemented acetabular fixation that are:

- Absence of radiolucent lines.
- Presence of a superolateral buttress (Figure 5.19).
- Medial bone stress-shielding (Figure 5.20).
- Radial trabeculae (Figure 5.21).
- Inferomedial buttress.

Ninety-seven per cent of cups with three or more of these signs were stable at the time of revision surgery whereas 83% of the cups with two or fewer signs were loose.

In osseointegrated uncemented cups, redistribution of load to the periphery of the bone–cup interface results in the development of superolateral and inferomedial bone densities called buttresses. An osseointegrated uncemented cup exerts tensile forces at the inferior region of the acetabulum, producing bone hypertrophy at that region. Implantation of a device stiffer than the subchondral plate results in redistribution of forces to the periphery of the ilium and away from the central cancellous bone.

The decreased loading on the medial subchondral or retroacetabular bone becomes evident as medial stress-shielding. This is secondary to a decrease in the loading of the apical region of the acetabulum when osseointegration has been successful superolaterally and inferomedially.

Abnormal shear and peak contact forces are produced in an arthritic hip, resulting in medial subchondral sclerosis. After an uncemented cup is implanted, this sclerosis resolves and a trabecular

Figure 5.16 Normal bone ingrowth acetabular component. This acetabular component shows signs of osseointegration with no lucent lines present, developing superolateral sclerosis, medial osteopenia (stress shielding), and remodelling of trabeculae (arrow).

pattern usually begins to develop. As the abnormal contact forces associated with an arthritic hip are replaced by the predominantly direct, compressive force associated with an osseointegrated cup, the trabeculae reorient in line with that force and radial trabeculae are seen radiographically.

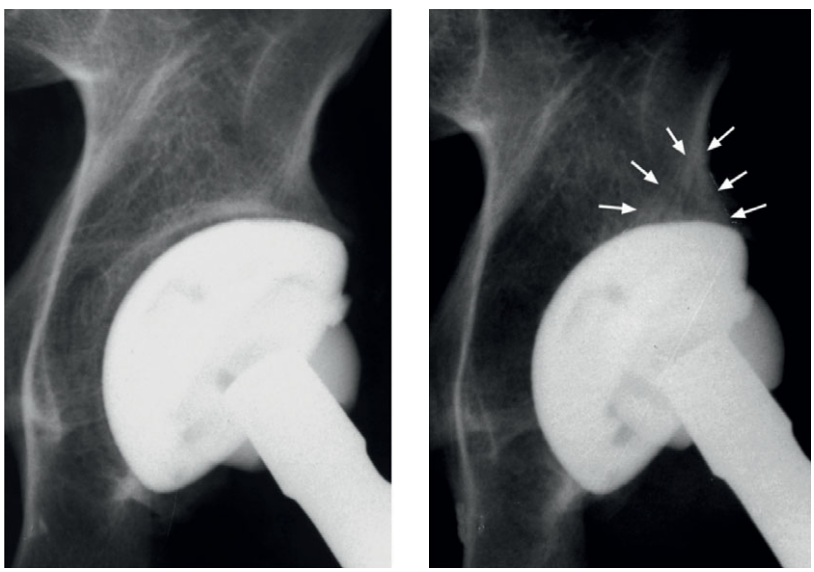
Moore MS, McAuley JP, Young AM, Engh Sr CA. Radiographic signs of osseointegration in porous-coated acetabular components. *Clin Orthop Relat Res.* 2006;**444**:176–183.

Chang CY, Huang AJ, Palmer WE. Radiographic evaluation of hip implants. *Semin Musculoskeletal Radiol.* 2015;**19**:12–20.

7. **Answer E. Pathogenesis involves a delayed hypersensitive (type IV) response to Co-Cr particles**

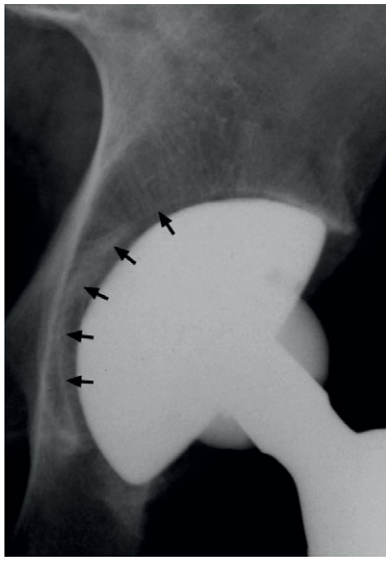
The lesion seen on the MRI scan is highly suggestive of a pseudotumour. A pseudotumour is a cystic lesion in the periarticular region that is neither infective nor neoplastic. It develops in the vicinity of a THA and has a direct communication with the joint. It is best diagnosed using Metal Artefact Reducing Sequence (MARS) MRI.

Biopsy is generally not performed on a pseudotumour. FNA biopsy may occasionally be indicated if infection or malignancy is suspected. ALVAL is a histological diagnosis made from tissue sampling at the time of revision surgery identifying an abundance of lymphocytes in the local pericapsular tissue. There is a spectrum of

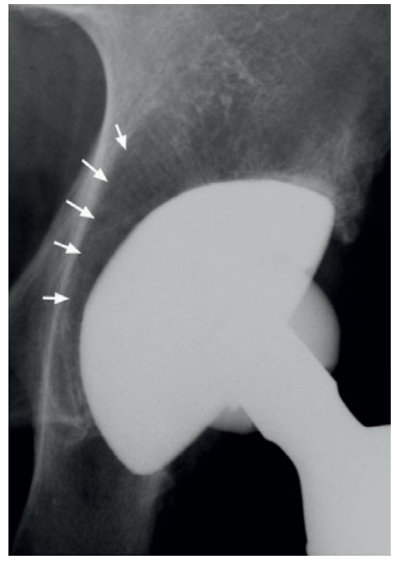


(a) (b)

Figure 5.17 (a) A post-operative radiograph showing an absence of a superolateral buttress, and the (b) pre-revision radiograph shows a superolateral buttress (white arrows).

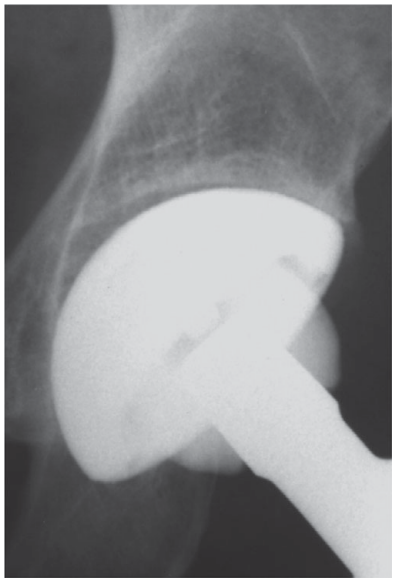


(a)

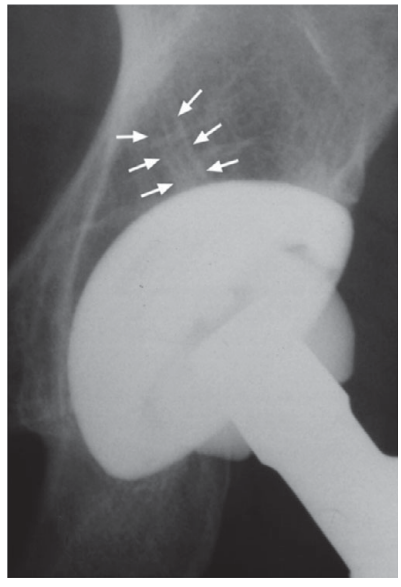


(b)

Figure 5.18 (a) A post-operative radiograph shows the presence of subchondral sclerosis (black arrows), and the (b) pre-revision radiograph demonstrating that the subchondral sclerosis has resolved and medial stress **shielding** has occurred (white arrows).



(a)



(b)

Figure 5.19 (a) A post-operative radiograph demonstrating a radial trabecular pattern. (b) The radial trabecular pattern is more evident in the pre-revision radiograph (white arrows).

necrotic and inflammatory changes in response to deposition of cobalt chromium wear particles.

A pseudotumour can present in different ways. Common presentations include gradually worsening groin pain, hip pain with or without groin pain, or a palpable swelling. More often, it is asymptomatic.

The patient's hip symptoms may be due to a variety of both intra- and extra-articular reasons and may not necessarily be specific to an adverse reaction to metal debris (ARMD).

The pathogenesis of a pseudotumour is uncertain but it may involve both a delayed hypersensitivity (type IV) response to Co-Cr particles and

cytotoxicity. Option E is partially correct but the best option of the available five to choose.

Mahendra G et al. Necrotic and inflammatory changes in metal-on-metal resurfacing hip arthroplasties. *Acta Orthop*. 2009;**80**:653–659.

8. Answer C. **Loose femoral component**
Diagnosis of a loose femoral component can be difficult. It is important to exclude extrinsic and other causes of intrinsic hip pain.

Whilst thoracolumbar discogenic pain may present in a non-specific manner patients would usually complain of both low back pain and neurogenic pain.

The giveaway for a loose femoral component is the antalgic gait with abductor lurch. The antalgic gait is caused by motion of the stem within the femoral canal. With significant stem subsidence an abductor lurch is often seen as the abductors have shortened and are at a biomechanical disadvantage.

Vastus lateralis muscle herniation through a defect in the fascia lata is an unusual and rare cause of thigh pain. This usually presents weeks to months following surgery as a patient increases their activity levels.

Abductor muscle atrophy with partial detachment would definitely be in the differential diagnosis but these patients typically have long-standing difficulties and the diagnosis would have been apparent within a year or so of surgery. These patients can slowly progress in time until symptoms become quite disabling but this should be well documented in the clinic follow-up letters.

Infection following THA must always be ruled out. At 10 years the cause is most likely to be haematogenous. Patients would typically present with rest pain and night pain. It is important to try and identify a source for the infection so ask about any recent dental procedure, chest or urinary infection. With persistent hip pain following THA ask about any history of a leaking wound post-operatively or a return to theatre for hip washout or DAIR.

Comparison of serial radiographs is the most useful method for making the diagnosis of a loose femoral stem. Other differentials for thigh pain include mismatch in the modulus of elasticity between an implant and host bone (mostly an issue for uncemented stems), stress fractures and oncological lesions.

Moucha CS. I have a patient with start-up thigh. In *Curbside Consultation in Hip Arthroplasty: 49 Clinical Questions*. SLACK Incorporated, 2008:81.

9. Answer A. **Aspirate the hip**
The use of oral antibiotics is generally discouraged until a definite diagnosis is made as the indiscriminate use of antibiotics will cloud the clinical picture.

Early discontinuation of anticoagulation treatment following arthroplasty surgery is a balance between reducing the risk of thromboembolism and preventing excessive bleeding. The decision must be individualised for each patient, weighing up the risks and benefits of stopping prophylaxis. Discontinued anticoagulation use at 2 or 3 days due to a leaky wound is a reasonable option especially if there is a suggestion of over anticoagulation (low BMI, reduced renal function, advanced age) but at 10 days the preferrable option is to aspirate the hip.

DAIR would be used for a patient that has a proven hip infection.

Persistent wound drainage (PWD) following arthroplasty surgery and appropriate wound management strategies have been shown to reduce the risk of surgical site infection and development of deep joint infection. We do not currently have UK agreed definitions of PWD or an agreed way of managing wounds that are persistently draining to prevent development of infection. The UKPJI group are working to try and develop a UK consensus in the definition, identification and management of PWD and appropriate dressing selection to reduce development of infection.

10. Answer B. **Inspection and palpation abductor muscle mass**
Cobra head plating involves release of the abductors from the iliac crest to accommodate a cobra-shaped plate. This invariably causes damage to the abductors and can be problematic if at a later date conversion to a THA is needed. Weak or destroyed abductors are considered by some surgeons to be a contraindication to conversion to a THA.

Although CT, MRI and US scan may be used to assess abductor status the most important information about the state of the abductors is obtained by clinical examination. Inspection and palpation of the abductor mass for active contraction, bulk and defects.

Electromyography is thought to be useful to access the gluteus medius and minimus muscles for evidence of denervation but this is generally not performed.

The patient would be asked to attempt abduction in the arthrodesed hip and the degree of contraction assessed.

A Trendelenburg test (TT) will give you a false negative result as the pelvis will not move despite probable abductor muscle compromise. In general if a hip is fused a TT should not be performed as this suggests a candidate doesn't fully understand the biomechanical principles behind the test.

An option that we removed was 'CT scan to assess abductor status'.

A CT is useful in the assessment of the bone stock and identifying if a pseudarthrosis is present but not abductor status. Trendelenburg test (TT) was a much better plausible distractor.

11. Answer E. **Refer on to hip surgeon who performs MoM resurfacing**

This is a difficult clinical situation. The patient despite his young age has advanced hip OA and although continuing on with conservative management is an option, he is unlikely to accept this. A steroid local anaesthetic injection is best used if there is any diagnostic uncertainty as to the source of pain and would be unlikely to provide any long-term therapeutic value.

A hip fusion remains an option in a young male patient with advanced osteoarthritis but it is unlikely that he would agree to it given the excellent outcomes following THA.

THA is likely to result in early failure in a young active patient and whilst certainly an option would be ideally managed with a second opinion from an experienced hip surgeon.

Referral on to a hip surgeon who performs MoM hips is a good option as the patient can explore the possibility of a MoM hip which still has a role albeit in a very narrow defined group of patients. Young males either with a heavy manual job or those still wanting to play sports such as football. Even if a MoM hip is not performed the patient has a further opinion regarding his hip arthritis and whether to proceed or not with a more conventional THA.

MoM hips are a good option in manual workers or in an occupation that places the hip at a risk for dislocation (e.g. carpenter, steel worker).

This is an ideal test SBA as we have not included a radiograph to better guide a candidate and also made the clinical situation suitably vague. It is very similar to a real SBA seen in the exam. SBA exam questions may have incomplete clinical information on purpose so that you have to apply higher order thinking to the situation to come up with the most appropriate clinical choice.

12. Answer E. **Increased transfusion requirements**

The literature regarding 2-stage bilateral THA versus simultaneous bilateral total hip arthroplasty (SBTHA) is controversial and contradictory. Not good terms to come across when constructing SBAs!

This is a good SBA to test for higher order thinking and having to make assumptions.

The benefits of SBTHA include patients needing only one anaesthesia, only one hospital stay, a reduced overall hospital length of stay (LOS), cost reduction and similar outcomes.

Some studies advocate SBTHA as they have demonstrated that the rates of perioperative complications are similar to staged bilateral THA (Stavrakis et al. 2015).

Huang et al. (2019) suggested the safety and reliability of simultaneous bilateral THA (SBTHA) in low-risk patients showing a reduction of LOS, a shorter anaesthesia and surgery time, faster rehabilitation and better cost-effectiveness.

Opposing studies have found that SBTHA poses greater risks to patients, with increased transfusions, greater adverse events and suboptimal functional outcomes.

A meta-analysis by Shao et al. (2017) reported SBTHA had a lower risk of major systemic complications, less DVTs, and shorter operative time compared with 2-stage bilateral THA. There were no significant differences in death, pulmonary embolism, cardiovascular complication, infections, minor complications, and other surgical complications between procedures. Interestingly this study did not encourage performing simultaneous over 2-stage bilateral THA as the paper concluded that higher evidence level studies were needed before firm recommendations could be given.

Allogenic blood transfusion is a known risk factor for post-operative infection, venous thromboembolism and acute lung injury in TJA. Although there are differences in studies, the transfusion rate after SBTHA is reported to be as high as 50%.

For the average day one fellowship trained consultant hip surgeon in a DGH, whilst SBTHA may have a role in patients with AS or those with significant bilateral flexion deformities, the surgery would need careful planning. SBTHA is a demanding procedure and ultimately may best be performed in high volume centres by more experienced surgeons.

Several studies have been conducted to determine which is the best way to address a patient requiring bilateral hip surgery. Unfortunately, there are few definitive conclusions. There is a lack of control groups with few prospective studies. Most of the literature often compares SBTHA with unilateral THA.

Recent interest has focused on bilateral DAA-THA as it offers an opportunity to consider a simultaneous bilateral procedure under one anaesthetic and without repositioning. Disadvantages include a steep learning curve and a possible increased risk of intraoperative femoral fracture.

Ramezani et al. (2022) in a systematic review and meta-analysis demonstrated that simultaneous and staged THA have similar 90-day mortality, dislocation and PJI rates. A statistically significant risk reduction was identified in DVT, pulmonary, systemic and local complications in the SBTHA group. Reduced length of hospital stay and total surgery cost are considered essential advantages of SBTHA compared with 2-stage THA (Ramezaniet et al. 2022).

In summary SBTHA comprise about 1% of THA. They are more commonly performed in males, younger patients, those with private insurance, higher volume hospitals and lower risk patients (ASA 1, 2). There may be a role for SBTHA surgery in selected individuals especially considering the cost savings involved.

Shao H et al. Bilateral total hip arthroplasty: 1-stage or 2-stage? A meta-analysis. *J Arthroplasty* 2017;**32**:689–695.

Stavrakis AI, SooHoo NF, Lieberman JR. Bilateral total hip arthroplasty has similar complication rates to unilateral total hip arthroplasty. *J Arthroplasty* 2015;**30**:1211–1214.

Ramezani A et al. Simultaneous versus staged bilateral total hip arthroplasty: a systematic review and meta-analysis. *J Orthop Surg Res.* 2022;**17**:392.

Huang L et al. Comparison of mortality and complications between bilateral simultaneous and staged total hip arthroplasty: a systematic review and meta-analysis. *Medicine (Balt.)* 2019;**98**:e16774.

13. Answer C. **Cemented total hip arthroplasty**

This patient is borderline alcoholic with probable osteoporosis so there is a high chance that internal fixation with either cannulated screws or a DHS would fail. The surgery most likely to get the patient back to walking again as quickly as possible would be a cemented THA, provided she met NICE guidelines for this.

An uncemented THA is not a good option in someone likely to be osteoporotic. In particular, in this situation an uncemented femoral stem could sink down into the femur with failure of osteointegration, LLD and a risk of dislocation.

In general aim to perform a cemented femoral stem in every fracture patient. Very occasionally a cementless femoral stem may be indicated but be confident about the bone quality, young age of patient, no inflammatory arthritis etc.

In general, it is best to avoid a cemented monopolar arthroplasty in someone this young. An Exeter bipolar hemiarthroplasty is a reasonable option if the patient is considered too high risk for a THA. This patient is relatively young at 51 so she would need to have a number of additional co-morbidity factors before opting for a bipolar prosthesis over THA.

The fracture pattern is intracapsular and if undisplaced and she was younger with no significant co-morbidity issues there would be merit in discussing fixation options with her with the warning that if ORIF failed a THA would be required at a later date.

A hybrid THA would be our preferred method as it is likely a larger femoral head could be used reducing the dislocation risk. Supplementary acetabular cup screws should be used to reduce any excessive cup motion and help with osseointergration. This choice wasn't given in the options.

14. Answer A. **Bipolar cemented hemiarthroplasty hip**

The fractured NOF occurring in various age groups, with different fracture patterns and different co-morbidities is fair game for at least 1 or 2 SBA questions in each Part 1 exam sitting.

An alcoholic patient with osteoporosis.

Compared with question 13 the patient is younger but with a presumed higher alcohol intake and inference that she is probably alcoholic arising from the concern regarding fitness for surgery. It is preferable to again avoid internal fixation as bone quality would be poor and the fracture unlikely to heal.

The choice lies between a THA or bipolar hip. A THA is a high-risk procedure with concerns regarding post-operative physiotherapy compliance (dislocation risk), increased blood loss, wound healing issues and deep infection.

A bipolar arthroplasty is a safer option, less of a surgical insult, less operating time, less blood loss, a more stable prosthesis and can be converted at a later date to THA if acetabular erosion develops.

The design of the bipolar implant allows for inter-prosthetic movement between the inner and outer head. This theoretical mechanical advantage results in minimal acetabular erosion without risking dislocation, ideal for younger and more active patients than a monopolar prosthesis. A monopolar hemiarthroplasty should be avoided in a 38-year-old female even if alcoholic.

15. Answer D. **Dual mobility cup**

Many patients with Parkinson's disease (PD) have severe hip osteoarthritis that warrants THA. The muscular rigidity and diminished bone quality encountered in these patients presents important challenges to the orthopaedic surgeon. Disease symptoms, such as tremor, shuffling gait and instability, can potentially make performing THA riskier. The unsteadiness in PD patients makes them more likely to fall, resulting in post-operative prosthesis dislocation and periprosthetic fracture. Because of these concerns, PD has historically been considered a relative contraindication to THA.

All listed options will decrease the risk of dislocation.

Recent studies indicate that short-term results of THA using cementless dual mobility implant in patients with PD reduces the dislocation rate without an increased risk of loosening (Lazennec et al. 2018). This is a good management option to deal with the increased risks of dislocation in this population group.

A captive cup is generally viewed as a last 'get out of jail' option for a recurrent hip dislocator. It is best avoided in a primary arthroplasty setting. Inserting an uncemented captive cup risks the shell pulling out of the bony acetabulum in the early post-operative period before osseointegration has occurred. The use of acetabular screws reduces but does not eliminate this risk. A lipped liner will decrease the risk of dislocation but at the expense of reducing hip range of movement.

Use of a 36mm head reduces dislocation risk but this is not as effective as using a dual motion implant. A large femoral head may increase the risk of trunnionosis.

Many experienced hip surgeons believe that there is little evidence to support the view that the Hardinge anterolateral approach reduces the risk of a dislocation and that there are significant disadvantages using a Hardinge approach (abductor muscle damage).

Lazennec JY, Kim Y, Pour AE. Total hip arthroplasty in patients with Parkinson disease: improved outcomes with dual mobility implants and cementless fixation. *J Arthroplasty* 2018;**33**:1455–1461.

Silverberg A, Parvataneni HK, Pulido L, Prieto H. The current role of dual mobility articulations in total hip arthroplasty. *J Hip Surgery* 2018;**2**(:194–204.

16. Answer C. **Convert to using a cement cup**

If the surgeon finds the bone quality to be poor when reaming the acetabulum and is concerned about achieving either a good press fit or osteointegration they should consider changing plan and using a cemented component instead. This may mean trading off an increased dislocation risk using a smaller head size against eliminating the concern of failure to osseointegrate when using an uncemented cup. Partial weight bearing for several weeks is an option if the initial press fit is suboptimal but it is unlikely the patient would comply with this.

Theoretically, a press-fit method does not require additional screw fixation since sufficient primary fixation can be achieved.

Whilst additional screw fixation can be used in certain situations if press-fit fixation alone is not satisfactory the giveaway in the SBA is that the bone quality is poor. In this situation despite the use of screws a surgeon may still be unsure about the chances of successful osteointegration. The other subtle clue is mild cognitive impairment with the inference that the risk for revision

surgery for this patient should be minimised. The question does not elaborate on dislocation risk.

Inserting a TM revision shell may provide a better surface for bone ingrowth but is difficult to justify on the basis of high cost and its need in a primary arthroplasty case.

Hydroxyapatite is an adjunct coating and aids bidirectional closure of gaps and shortens osseointegration. However, if the cup is loose and the bone stock also poor, substituting the cup for one that is HA coated is unlikely to result in a successful outcome. It is a good distractor option for the weaker candidate to choose.

Inserting the next sized larger cup into the acetabulum may be successful but with the added concern of poor bone stock is best avoided in this situation. This would usually require additional acetabular reaming which in some situations is undesirable. The acetabulum may end up being over-reamed predisposing to an acetabular fracture +/− possible dissociation. Again, the surgeon should avoid taking any unnecessary risks that may end up resulting in needing revision surgery.

In order to obtain long-term osseointegration, a press-fit acetabular cup must gain initial rigid stability with limited micromotion. In addition, the implant surface must promote ingrowth and maintain contact with viable bone.

17. Answer C. **Increased risk of mortality**
Some studies report higher perioperative complications, longer hospital stays, poorer wound healing and more anaesthetic complications in obese patients undergoing THA. Furthermore, obesity is associated with poor short-term outcomes after undergoing THA, with reported complications of increased rates of periprosthetic infections, dislocations and instability. Other studies report no difference in short-term outcomes in obese patients after THA.

A recent systematic study reported a revision rate of 7.99% in the morbidly obese versus 2.75% in non-obese patients at medium-term follow up (Barrett et al. 2018).

It is thought that even though a higher BMI is associated with increased loading of the hip prostheses, the lack of a large difference in aseptic wear rates may arise from a more sedentary lifestyle in morbidly obese patients, resulting in reduced mobility and less prosthetic wear (Halawi et al. 2019).

Data from the Swedish Hip Registry reported an increasing risk of reoperation at 2 years and revision at 5 years mainly due to increased risk of infection. Uncemented and reversed hybrid fixations and surgical approaches other than posterior were all associated with increased risk. Obesity class III ($\geq$40), male sex and increasing ASA class were associated with increased 90-day mortality (Sayed-Noor et al. 2019).

There appears to be no difference in patient-reported outcome measurements.

Barrett M et al. Total hip arthroplasty outcomes in morbidly obese patients: a systematic review. *EFORT Open Rev*. 2018;**3**:507–512.

Halawi MJ, Gronbeck C, Savoy L, Cote MP. Effect of morbid obesity on patient-reported outcomes in total joint arthroplasty: a minimum of 1-year follow-up. *Arthroplasty Today* 2019;**5**:493–496.

Sayed-Noor AS, Mukka S, Mohaddes M, Kärrholm J, Rolfson O. Body mass index is associated with risk of reoperation and revision after primary total hip arthroplasty: a study of the Swedish Hip Arthroplasty Register including 83,146 patients. *Acta Orthopaedica* 2019;**90**:220–225.

18. Answer C. **Mode 4 failure can be recognised early by radiolucencies developing along the proximal lateral cortex (convex) surface of the stem**
In the original paper by Gruen mode Ib is the most common cause of failure in 5.1% of cases. Modes 1a, II and IV were each seen in 3% of cases (Gruen et al. 1979). Mode III (calcar pivot) was seen only in 3 hips (0.7%).

The radiograph is showing mode IV failure bending cantilever (fatigue) with femoral stem fracture. Bending cantilever failure is by far the most common cause of femoral stem fracture.

The stem is of the composite beam variety and is most probably a Charnley type stem. Distally the stem appears to be well fixed but proximally it is loose within the cement mantle with lucent lines particularly in Gruen zones 6 and 7 suggesting mode IV failure bending cantilever fatigue with femoral stem fracture.

The four modes of femoral stem failure are described in detail:

- Mode Ia is stem pistoning within the cement, occurs secondary to an incomplete cement

mantle or loss of proximal medial cement support.

- Mode Ib consists of stem/cement subsidence within bone. This mode of failure is most familiar to orthopaedic surgeons evaluating radiographs of loose total hip replacements.
- Mode II is medial midstem pivot, characterised by medial migration proximal stem coupled with lateral migration distal stem tip. It is caused by weak proximal/medial (calcar) support and lack of distal cement support.
- Mode III failure consists of medial-lateral toggle distal stem due to lack of distal stem support. This is the windshield type of loosening.
- Mode IV failure is cantilever fatigue failure characterised by **partial or complete loss** of **proximal support** with subsequent **medial migration of the proximal stem** whilst the distal end remains rigidly fixed in cement. This mode of failure can be recognised early by **radiolucencies** developing along the **proximal lateral cortex** (convex) surface of the stem.

Comment: We have rewritten and recycled this SBA a couple of times changing either the correct answer or a distractor. This is similar to what occurs in the an exam setting when preparing a paper. This SBA is important as it tests basic science knowledge of femoral stem failure which is core knowledge for surgeons and essential for hip arthroplasty practice.

Gruen TA, McNeice GM, Amstutz HC. 'Modes of failure' of cemented stem-type femoral components: a radiographic analysis of loosening. *Clin Orthop Relat Res.* 1979;**141**:17–27.

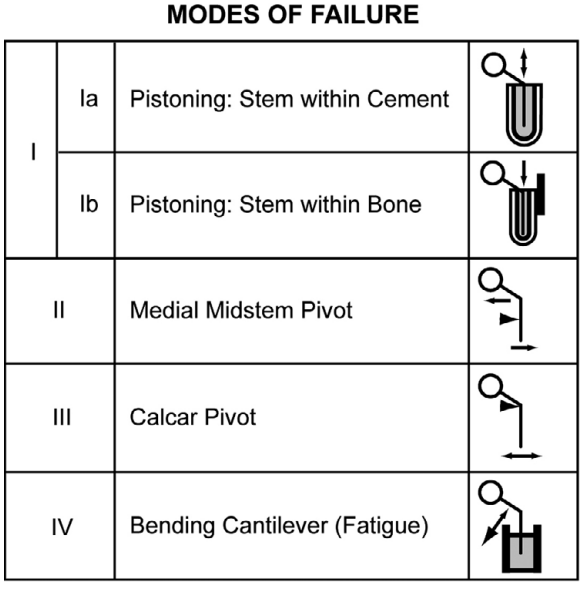


Figure 5.20 Gruen modes of cemented femoral stem failure. Copyright 2014 Springer-Verlag London

19. Answer A. **Bending cantilever (fatigue)**
When writing SBAs what should be a level 2 SBA sometimes ends up being level 1 and tests factorial knowledge.

A contributing factor to a femoral stem fracture could be poor femoral stem design – sub-optimal stem geometry, manufacture (metallurgic defects) and sub-optimal stem material as the loosening is not dramatic.

Bending cantilever (fatigue) is Gruen mode IV: the distal cement holds well, but proximal cement fixation is lost which can lead to fatigue fracture of the implant.

The SBA is testing the same core knowledge as in the previous SBA but the twist in the question is femoral stem fracture. In the original paper by Gruen Mode Ib is the most common cause of failure in 5.1% of cases.

When there is some doubt as to the correct answer go back to the original paper. Gruen et al. reported that among the 7 femoral components requiring revision were 2 fractured femoral components both of which had failed in mode IV.

20. Answer C. **Fourth generation involves using distal and proximal centralisers to ensure an even cement mantle**
The specific technical details of what exactly each generation of cementing technique entails is often unclear and mixed up between various textbooks.

Our understanding is that fourth generation involves both proximal and distal cement centralisers. The proximal centraliser may also be used to enhance pressurisation after insertion of the stem.

The importance of a complete cement mantle is recognised and led to the development of both

distal and proximal centralisers. These centralisers facilitate the ability to reproducibly create an adequate cement mantle by placing the stem in the centre of the cavity.

Fourth generation cementing also includes refinements of stem design and advances in material science. In a number of books only three generations of cementing techniques are mentioned, the third being known as contemporary. As such option E is correct but less correct than option C.

Late insertion of an implant into viscous cement is widely practiced and considered part of third-generation cementing technique.

'First-generation', cementing techniques did not involve bone preparation (i.e. washing or drying) before cement insertion. In addition, the cement was inserted antegrade by hand with no attempt at pressurisation beyond finger packing. An intramedullary plug was not used. These techniques caused the potential for cement lamination, inclusion of blood or voids within the cement, inadequate cement mantles, and poor penetration of the cement into the interstices of the cancellous bone. Despite these limitations there are many reports of good long-term survivorship of prostheses inserted using this technique.

'**Second-generation**' techniques involve the bone being (thoroughly) cleaned before cement insertion, using an intramedullary plug, and the cement inserted retrograde to reduce blood laminations and cement voids (gun and restrictor).

'Third-generation' cementation techniques introduced the concept of maintaining pressurisation of the cement before and during insertion of the femoral stem. This was achieved by placing a rubber seal around the nozzle of the cement gun, which effectively sealed the proximal end of the femoral canal. After retrograde insertion of the cement, further cement was delivered through the seal. The medullary canal was thus sealed distally and proximally. As more cement was inserted, the pressure increased, and the cement was forced into the interstices of the surrounding bone.

Third generation includes serial pulsed lavage, vacuum mixing of cement, obtaining a thoroughly dried femoral canal to improve bone cement penetration.

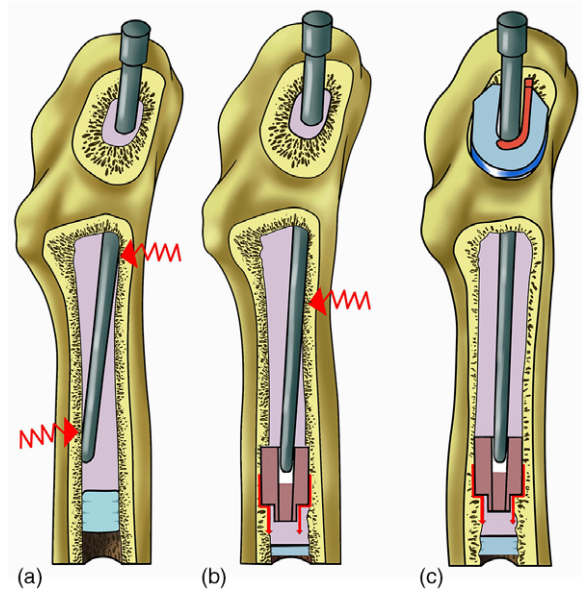


Figure 5.21 Fourth generation involves using distal and proximal centralisers to ensure an even cement mantle. (a) no centralisers, (b) distal centraliser and (c) proximal and distal centralisers. Copyright Springer.

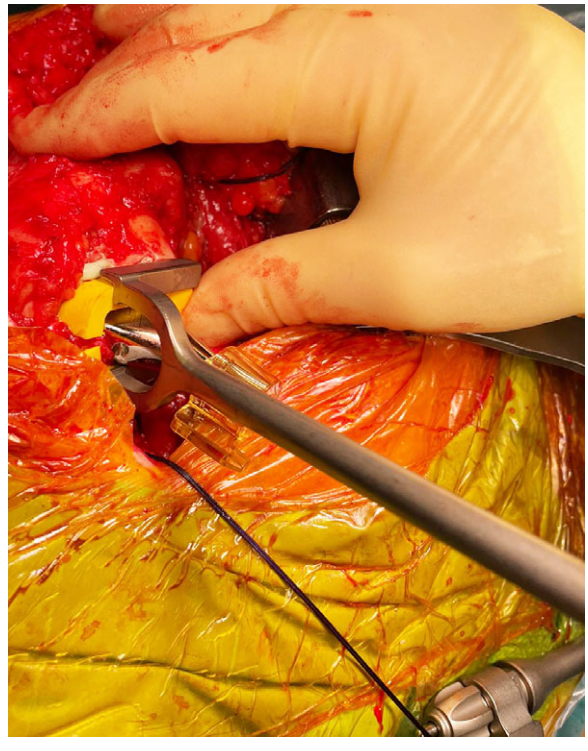


Figure 5.22 Proximal centraliser used intraoperatively

Pulsed lavage appears to jump between second and third generations of cement depending on what textbook is read. However, pulsed lavage is probably best thought of as third-generation cementing. Vacuum mixing results in porosity reduction of the cement.

Surface modifications of the implant include the avoidance of sharp edges and a broader lateral surface.

Learmonth ID. The evolution of contemporary cementation techniques. *Orthopaedics* 2005;**28**:S831–S832.

21. Answer C. **Pathophysiology is an inappropriate differentiation of pluripotent mesenchymal stem cells**

The radiograph demonstrates heterotopic ossification (HO). The osteoblastic cell responsible for HO is believed to result from inappropriate differentiation of pluripotent mesenchymal stem cells.

Typically HO is asymptomatic, but higher Brooker grades can result in impairment of hip arthroplasty function due to pain, impingement, instability, decreased ROM, trochanteric bursitis and nerve irritation.

The overall incidence of HO originally reported in Brooker's paper (21%) is substantially lower than that accepted these days. A systematic review by Vavken et al. (2009) has reported an incidence of 43% and that of severe HO (Brooker grades III/IV) of 9%.

Risk factors include

- Intraoperative muscle ischaemia.
- Direct lateral approach.
- Extent of soft-tissue dissection.
- Bone trauma.
- Persistence of bone debris (reamings, marrow within the surgical field).

HO can be a serious complication after THA particularly when the amount of bone interferes with hip motion or produces pain.

Instability is a potential complication of HO after THA if the periarticular mass of bone contributes to impingement with limitation of hip excursion and initiation of dislocation.

There is a need to ensure the HO is mature prior to excision (1 year to 18 months) otherwise bleeding and reoccurrence can occur. Surgery is not normally recommended.

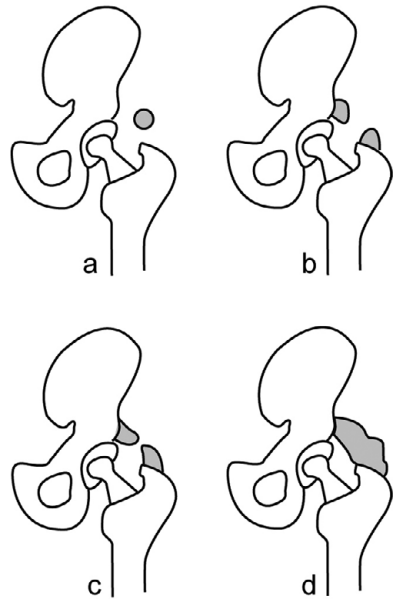


Figure 5.23 Brooker classification of heterotopic ossification. (a) Islands of bone in the soft tissues. (b) Bone spurs arising from the proximal femur/pelvis with ≥1cm joint space between ends. (c) Bone spurs arising from the proximal femur/pelvis with <1cm joint space between ends. (d) Apparent bony ankylosis

Vavken P, Castellani L, Sculco TP. Prophylaxis of heterotopic ossification of the hip: systematic review and meta-analysis. *Clin Orthop Rel Res*. 2009;**467**:3283–3289.

22. Answer D. **Ankylosed hip**

Heterotopic ossification is the abnormal formation of mature lamellar bone in soft tissues. All the options provided, except for cementless prosthesis, are valid risk factors. In a meta-analysis by Zhu et al. (2015) reviewing the risk factors for HO following THA, they identified male sex, ankylosing spondylitis, cemented prosthesis, bilateral hip joint arthroplasty and hip joint ankylosis as significant risks. Hip ankylosis had the strongest association (odds ratio = 9.85).

Regarding the cemented prosthesis, it was suggested that contamination of the surgical field and activation of osteoprogenitor cells during preparation of the femoral canal increased the risk of HO. This is less likely to occur in preparing the femur for an uncemented prosthesis as the endosteal bone is compacted.

Surgical approach, prosthesis type, and use of trochanteric or femoral osteotomy also appear to affect the risk of HO formation. Anterolateral

and lateral approaches to hip arthroplasty have been shown to increase the risk of HO formation in retrospective studies.

HO formation is a common complication following operative repair of acetabular fractures, particularly those treated with posterior, combined and extensile approaches.

Rheumatoid arthritis is said to be protective against HO, which may be partly due to the NSAIDs these patients take for pain relief.

Pavlou G et al. Risk factors for heterotopic ossification in primary total hip arthroplasty. *Hip Int.* 2012;**22**:50–55.

Zhu Y et al. Incidence and risk factors for heterotopic ossification after total hip arthroplasty: a meta-analysis. *Arch Orthop Trauma Surg*. 2015;**135**:1307–1314.

23. Answer A. **An initial mode Ia failure may progress into mode II failure**

Gruen's (1979) original paper reported that three cases of Mode 1a failure progressed into mode II failure. The cemented femoral component initially loosened into mode la failure and the subsequent distal punch-out fracture rendered inadequate distal acrylic support. Together with poor proximal medial cement support, these cases progressed into mode I1 failure.

The modes of failure were based on a Charnley prosthesis.

Gruen's seminal paper is regarded as a classic in orthopaedics. It introduced the concept of Gruen femoral zones dividing the femur into 7 regions for detailed review of anteroposterior (AP) radiographs of cemented femoral components for signs of loosening. In addition, it presents a detailed analysis of the modes of failure of cemented femoral stems (Banaszkiewicz 2014).

Gruen TA, McNeice GM, Amstutz HC. "Modes of failure" of cemented stem-type femoral components: a radiographic analysis of loosening. *Clin Orthop Relat Res.* 1979;**141**:17–27.

Banaszkiewicz PA. "Modes of failure" of cemented stem-type femoral components: a radiographic analysis of loosening. In *Classic Papers in Orthopaedics*, 35–38. London: Springer; 2014.

24. Answer A. **Component malalignment**

Early dislocation following THA is usually either due to component malalignment or failure to comply with post-operative instructions. The giveaway in the stem is the relative inexperience of the surgeon and the fact it is day 1 post-operatively with the patient not yet having been mobilised. The dislocation rate is double for surgeons who have performed less than 30 hip replacements when compared with surgeons who have performed more than 30. Whilst close trainee supervision by a consultant will likely lessen the chance of dislocation this does not prevent it occurring. Sources of impingement such as cement or osteophytes may cause dislocation in the early post-operative period but are very rare causes.

The occurrence of dislocation after THA is variable. Surgeons usually advise patients of a 1–3% dislocation risk (Meek et al. 2006). However, data from an arthroplasty registry in the UK suggest a higher rate of 5% at 5 years post-operatively (Fender et al. 1999). Several studies have suggested THA dislocation is related to the experience of the surgeon including the volume of surgery performed. Hedlundh et al. (1996) reported that surgeons who perform less than 10 THAs a year have three times the risk of dislocation in the THA recipient. However, the rate did not decrease once the surgeon reached a volume of more than 30 THAs per year.

Meek RM, Allan DB, McPhillips G, Kerr L, Howie CR. Epidemiology of dislocation after total hip arthroplasty. *Clin Orthop Rel Res*. 2006;**447**:9–18.

Fender D, Harper WM, Gregg PJ. Outcome of Charnley total hip replacement across a single health region in England: the results at five years from a regional hip register. *J Bone Joint Surg Br.* 1999;**81**:577–581.

Hedlundh U, Ahnfelt L, Hybbinette CH, Weckstrom J, Fredin H. Surgical experience related to dislocations after total hip arthroplasty. *J Bone Joint Surg Br.* 1996;**78**:206–209.

25. Answer E. **Spinal fusion**

Both patient-related factors and surgeon-controlled factors influence the likelihood of dislocation after THA. A number of technical modifications were developed in the 2000s to address THA instability, including increasing the femoral head diameter, use of posterior lip acetabular

liners and the introduction of the dual mobility bearing. These adaptions have been associated with a declining rate of dislocation.

A recent study by Gausden et al. (2018) reviewed a Nationwide Readmission Database. A total of 207,285 THAs were identified between 2012 and 2014. Of the total, 2842 dislocation-associated readmissions (1.4%) were identified, at a median of 40 days post-THA. A history of spinal fusion was the strongest independent predictor of dislocation. Parkinson's disease was also significantly associated with dislocation, as well as dementia, depression and chronic lung disease.

Gausden EB, Parhar HS, Popper JE, Sculco PK, Rush BN. Risk factors for early dislocation following primary elective total hip arthroplasty. *J Arthroplasty* 2018;**33**:1567–1571.

26. Answer B. **Cup inclination angle**

This SBA is fairly small point as it deals with the contact patch area of a MoM hip. We think it is useful to include as it introduces biomechanical concepts worth knowing about if you are going for the gold medal.

The contact patch is the area of the femoral head articular surface that makes contact with the acetabular component during any and all functions (Yoon et al. 2013).

The 'contact patch to rim' (CPCR) distance describes the distance from the edge of the contact area to the acetabular rim (Underwood et al. 2012).

Edge loading occurs when the contact area between the head and cup intersects the rim of the cup. It is thought that CPCR can determine the susceptibility of a MOM to edge loading and is likely to correlate with component wear and blood metal ion levels.

In order of decreasing effect on CPCR the variables were: cup inclination angle, cup version angle, arc of cover, femoral diameter and clearance (Matthies et al. 2014).

The Articular Surface Replacement (ASR; DePuy Orthopaedics) was more susceptible to suboptimal cup position. In addition, its reduced arc of cover was also associated with increased wear rates and higher ion levels.

An understanding of the design features of the ASR implant that led to its failure and recall from market is useful.

Design features such as the reduced 'arc of cover' (the angle subtended by the articular surface of the cup) and head-cup clearance are thought to have increased the likelihood of edge loading and high wear.

Suboptimal component position and design are thought to lead to edge wear and raised blood metal ion levels in metal-on-metal hips.

It is thought that edge loading leads to increased contact pressures and disruption of the lubrication regime.

Matthies AK et al. Predicting wear and blood metal ion levels in metal-on-metal hip resurfacing. *J Orthop Res.* 2014;**32**:167–174.

Underwood RJ, Zografos A, Sayles RS, Hart A, Cann P. Edge loading in metal-on-metal hips: low clearance is a new risk factor. *Proc Inst Mech Eng H.* 2012;**226**:217–226.

Yoon JP et al. Contact patch to rim distance predicts metal ion levels in hip resurfacing. *Clin Orthop Relat Res.* 2013;**471**:1615–1621.

27. Answer A. **Decreased femoral head offset**

In general terms when the femoral neck impinges on the acetabular cup, it begins to lever out of the socket. The range of motion allowed before the hip dislocates is termed the lever range. The excursion distance is the distance the head must travel to dislocate. In effect this excursion distance is equal to half the diameter of the femoral head. Most textbooks regard excursion distance and jump distance (JD) as similar equivalent terms but this is an approximation and not strictly true.

The JD is the degree of lateral translation of the femoral head centre required before dislocation occurs.

Sariali et al. (2009) evaluated jump distance and its variation according to implant characteristics. They found that JD varies according to (1) cup abduction angle, (2) cup anteversion angle, (3) femoral head diameter and (4) cup centre offset.

It is only partly true that JD increases with femoral head diameter. JD depends not only on femoral head size, but also on orientation of the implanted cup and on cup offset. The position of the implanted cup has two variables that affect JD: (1) abduction angle and (2) anteversion angle.

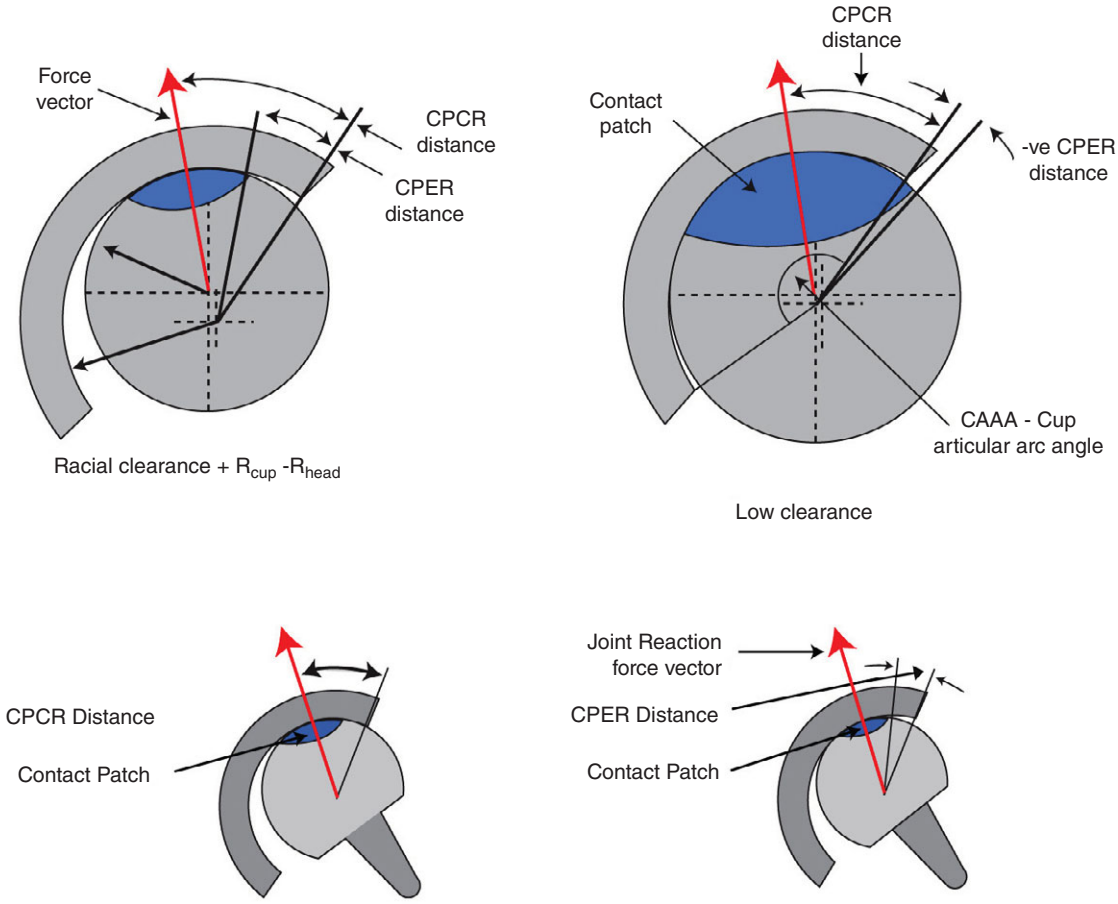


Figure 5.24 Contact patch centre to rim (CPCR) distance describes the distance from the centre of the contact area to the acetabular rim. Contact patch edge to rim (CPER) distance. When the contact patch between head and cup extends over the cup rim this leads to a large increase in local contact pressure, disruption to the lubrication mechanism and increases wear rate at the cup rim occurs.

- JD decreases as the abduction angle increases.
- JD increases as the acetabular anteversion increases but this variation is much lower than the variation according to abduction angle.

With regard to the femoral head

- JD was found to decrease as the femoral head offset increases.
- JD increases as the femoral head diameter increases.

Femoral head offset is the shortest distance from the centre of the head to the opening plane of the cup. The offset is positive when the head centre lies outside the opening plane of the cup, which is the case when the cup is not a full hemisphere or when the acetabular liner is offset to increase the amount of material medially in the polyethylene liner. The offset is negative (and is called an inset) when the head centre lies inside the opening plane of the cup. Increasing the offset causes the centre of rotation to lay outside the opening plane of the cup, thereby making the cup shallower and increasing susceptibility to dislocation.

The net gain obtained by increasing the femoral head diameter is counterbalanced by the increase in femoral head offset.

A final point to consider is that dislocation after THA is nevertheless a multifactorial

phenomenon and cannot be analysed with only the jump distance as a predictive parameter.

Sariali E, Lazennec JY, Khiami F, Catonné Y. Mathematical evaluation of jumping distance in total hip arthroplasty: influence of abduction angle, femoral head offset, and head diameter. *Acta Orthopaedica* 2009;**80**:277–282.

Table 5.1 Factors affecting the jump distance

Factors that decrease jump distance
Increase in femoral head offset
Smaller acetabular hemisphere
Polyethylene liners with an offset
Increased abduction angle
Factors that increase jump distance
Decreased femoral head offset
Increased anteversion
Larger acetabular hemisphere

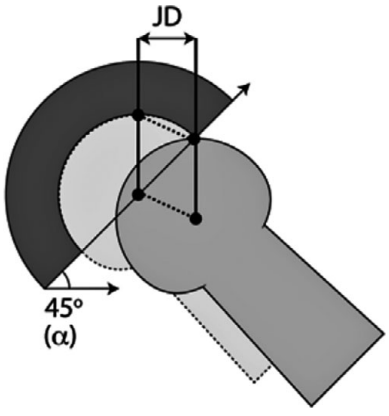


Figure 5.25 Jump distance is the femoral head centre translation distance required for a head to dislocate from a socket

28. Answer D. **Intraosseous extravascular factors**
This SBA neatly summarises possible vascular causes for ON otherwise aetiological factors can end up becoming a random list of causes that candidates may find difficult to structure to aid recall.[1]

Extraosseous arterial factors.

The femoral head is at increased risk because blood supply is an end-organ system with poor collateral development. Blood supply can be interrupted by trauma, vasculitis (Raynaud's disease) or vasospasm.

Intraosseous arterial factors.

May block the microcirculation of the femoral head through circulating microemboli. Possible causes include sickle cell disease (SCD), fat embolisation or air embolisation from dysbaric phenomena.

Intraosseous venous factors

Reduce venous blood flow causing stasis. Causes include Caisson disease, SCD or enlargement of intramedullary fat cells.

Intraosseous extravascular factors

Increased pressure in the femoral head that results in a femoral head compartment syndrome. Causes include fat cells hypertrophy after steroid administration or lipid deposit in the marrow. Cytotoxic factors (alcoholism, steroid use) have a direct toxic metabolic effect on osteogenic cells.

Extraosseus extravascular (capsular) factors

This involves tamponade of the lateral epiphyseal vessels resulting in ON.

29. Answer D. **Total hip arthroplasty**
The patient's radiographs demonstrate Ficat grade III ON. There is ill-defined mixed sclerotic and lytic lesion of the left femoral head. Additional cortical collapse of the superior aspect of the femoral head is noted with a linear area of

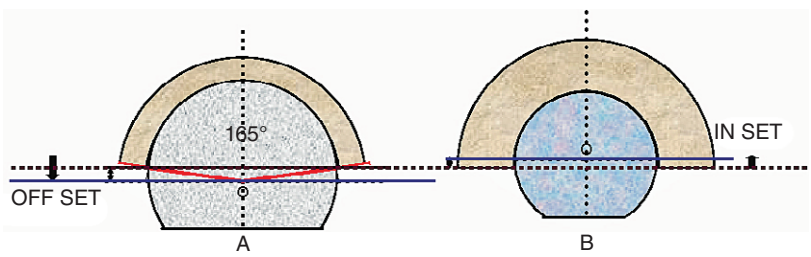


Figure 5.26 The femoral head offset is the distance from the centre of the head (O) to the opening plane of the cup (red line). (a) If the head centre is outside the cup, the offset is positive (A); (b) otherwise, it is negative and is called inset (B). The use of large heads above 38 mm in diameter generally imposes the use of an offset because the cup is usually a truncated hemisphere of 165° for the large heads

lucency below it (crescent sign). Evidence of secondary degenerative change.

Surgical management can be broadly divided into joint preserving or joint replacing procedures. The ON is too far advanced for a joint preserving procedure and the best choice would be for total hip arthroplasty. Although hip resurfacing has been used in the past it has fallen out of favour in recent years because of the risks of ARMD.

30. Answer D. **Second-generation HXLPE involves sequential irradiation and annealing**

First generation HXLPE involves either annealing or remelting PE. The annealing method involved a single thermal treatment below the crystalline melt transition in polyethylene to preserve crystallinity and mechanical properties, but also results in a material containing residual free radicals with the potential to oxidise *in vivo*.

The remelting method involved thermal treatment above the melt transition. This resulted in a material with undetectable free radicals but at the expense of reduced crystallinity and lower material properties.

Second-generation annealed HXLPE was developed to further improve on first-generation annealed HXLPE to achieve oxidative resistance, and to maintain low wear and mechanical strength. Cross-linking is achieved using a sequential irradiating and annealing process, which increases the amount of cross-linking. Sequential annealing mops up most free radicals.

Second-generation methods were aimed at quenching free radicals effectively without remelting HXLPE and the related loss of crystallinity/mechanical properties.

Vitamin E-infused HXLPE is a second-generation HXLPE that stabilises free radicals without the need for sequential annealing or melting.

Vitamin-E stabilised HXLPE was introduced to provide enhanced oxidation resistance without compromising the fatigue strength. Vitamin E improves oxidation resistance by stabilising free radicals induced by irradiation, and avoids the need for post-irradiation melting.

In summary

- **Crystalline phase** – provides mechanical properties to PE.
- **Amorphous phase** – only amorphous area can cross-link.
- Post irradiation melting eliminates all free radicals but reduces mechanical properties.
  - Cross-linking of free radicals occurs during melting which prevents recrystallisation.
  - This results in lower crystallinity with lowered mechanical properties.
- Annealing eliminates some but not all free radicals.
  - During annealing, crystalline areas do not unravel and eliminate free radicals.
  - Crystalline areas do not cross-link, so free radicals remain leading to oxidation risk.
- Increased crystallinity – chain scissor oxidation and wear. Mechanical properties good but wear properties poor.
- Decreased crystallinity – decreased mechanical properties but wear characteristics good.

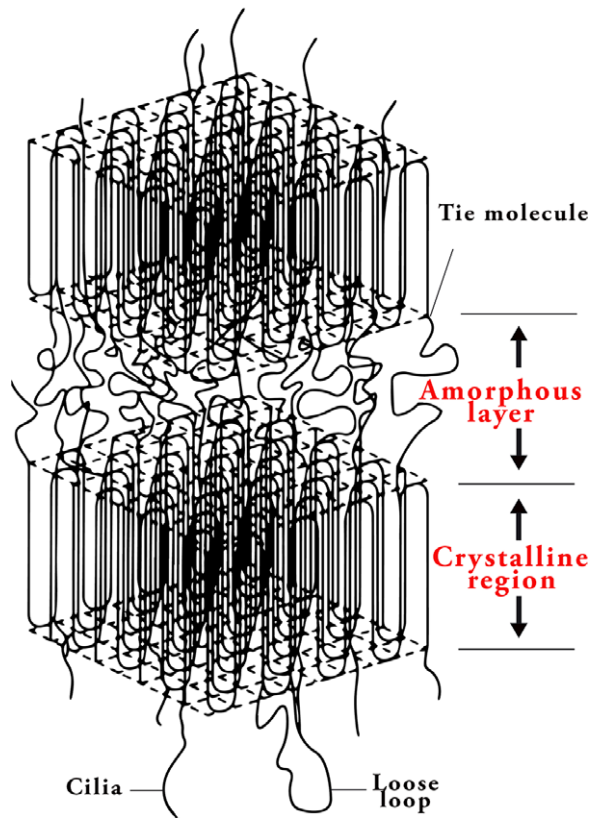


Figure 5.27 Structure of HXLPE

For the gold medallist

Loose loop – polymer chains will often decide they want to come back into the lamella after wandering around outside for a while.

Cilia – sometimes a polymer chain is indecisive with part of it in the crystalline lamella and part of it staying outside the lamella in the amorphous region.

Tie molecule – some chains start in one lamella, cross the amorphous region, and then join another lamella. These chains are called tie molecules. They provide a unique property of tying the lamellae to each other. In a sense, they act like cross-links and strengthen the solid polymer, giving it better mechanical properties.

31. Answer D. **Radiographs hip**

Most likely the surgeon would go in and re-explore the hip looking for any bruising, haematoma or discontinuity of the sciatic nerve. The key words are dense and painful which alerts for a major concern with the state of the nerve. Most surgeons routinely check the sciatic nerve to see if it is free from any suture entrapment or compression after repairing the short external muscles and before moving on to close the fascia lata but this is not mentioned in the stem.

MRI could potentially locate a large haematoma around the sciatic nerve pushing a surgeon towards re-exploration but a radiograph would be the most useful all-round management to see if the leg has been inappropriately lengthened, if there is posteriorly protruded cement, bony fragments or proud screws or any other possible cause for the foot drop. This should be done before you take the patient to theatre.

If the footdrop is partial and/or painless the situation is more debatable as to what to do next and you may wish to consider ordering an MRI scan before surgery.

32. Answer A. **Bone marrow oedema syndrome**

Bone marrow oedema syndrome (BMES) is a diagnosis of exclusion that is characterised by pain and increased interstitial fluid within bone marrow without an obvious cause. It is a distinct, benign disorder with a distinctive self-limiting course.

With BMES radiographs are normal but an MRI has characteristic findings. An MRI scan will demonstrate diffuse marrow oedema, that can extend to the intertrochanteric area, with no focal or subchondral findings.

It generally affects middle-aged men (30–50 years) or women in the third trimester of pregnancy. In most cases no triggering events can be found. The clinical course of the disease is often self-limiting, with a spontaneous resolution in 4–24 months.

The first month is characterised by initial pain and dysfunction. The next 1–2 months are characterised by maximum pain levels. Finally, symptoms regress over the next few months following the period of maximal pain, but it should be noted that the presentation and resolution of symptoms are highly variable.

Many theories have been proposed about the pathogenesis of BMES. These include microvascular injuries, venous obstructions, abnormal mechanical stress, metabolic and endocrine factors.

There are other conditions that can cause bone marrow oedema. They can be classified according to their mechanism. The first group, which is associated with an ischaemic mechanism, includes osteonecrosis and osteochondritis dissecans. The second group have a mechanical aetiology and includes stress fractures, microfractures and bone bruise. In the third group the bone marrow oedema is reactive and includes arthritis, tumour and post-operative oedema.

Balfousias T, Karadimas EJ, Kakagia DD, Apostolopoulos A, Papanikolaou A. Lower limb pain attributed to bone marrow edema syndrome: a commonly ignored pathology. *Cureus* 2020;**12**:e7679.

33. Answer A. **Decreased ductility**

Compared with standard UHMWPE HXLPE has:

- Better wear resistance.
- The PE particles tend to be smaller in size and produce less osteolytic reaction. There is generally a decreased number of particles generated.

Disadvantages include:

- Decreases tensile strength which is the pulling force to break.
- Decreased fatigue strength which is the maximum cyclic stress the material can withstand.
- Decreased fracture toughness which is the force to propagate a crack.
- Decreased ductility which is elongation without fracture.

Although compared with standard UHMWPE HXLPE has much better wear characteristics its mechanical properties are reduced.

34. Answer D. **There are equivalent clinical results with a ceramic and HCPLE bearing surface combination**

The incidence of squeaking varies in the literature with a figure around 7% being acceptable. It is extremely rare to have to revise a hip due to squeaking. It is more of an annoyance to patients than anything else. The use of a CoC bearing surface combination has halved in recent years due to the risk of catastrophic failure, cost and squeaking. More importantly for most surgeons is that long-term results of ceramic and new-generation HCPLE bearing surface are now equivalent to that of CoC without all the drawbacks of using a CoC bearing combination.

Ceramic-on-ceramic bearings require meticulous surgical technique both to avoid chipping of the liner during insertion and to place both the acetabular and femoral components in the appropriate anatomic position. Failure to place the implants in the correct position has led to early failure of the acetabular liner due to impingement.

Many surgeons have abandoned the use of a ceramic articulation due to the concerns of squeaking, limited intraoperative options, failure of randomised clinical trials to demonstrate significantly improved survival rates, and the necessity for 'perfect' component placement to reduce the risk of catastrophic failure. Emerging long-term results of ceramic on HCPLE are showing compatible survival rates when compared with CoC bearing surfaces.

35. Answer B. **Arrange for urgent clinic follow up**

Radiographs demonstrate an anteverted and open cup. These radiographs have not been reviewed whilst the patient was in hospital. An anteverted cup increases the risk of impingement, edge loading, instability, dislocation, increased wear and reduced longevity of the implant. This SBA is about how to deal and prioritise two problems.

- What (if anything) needs to be done about the anteverted cup?
- Is there a need for a duty of candour and on what basis?

Bringing the patient back to the next available arthroplasty clinic to discuss the radiographs is the best option. You can tell the patient that you are not entirely happy with the post-operative radiographs and mention your concerns with the anteverted cup. The options are a wait and see policy or revision of the cup.

On balance there is a duty of candour issue due to (1) excessive anteversion of the cup and (2) no post-operative review of radiographs.

Protocols in place to ensure patients have their radiographs reviewed by a medical team before they are discharged are important. However, they are not an immediate issue, and can be dealt with at a later date with drafting of new department rules.

Asking the patient to attend the ED so that the orthopaedic team on call can review them is likely to significantly and unnecessarily worry the patient. It is also futile as you are not going to admit the patient acutely to a ward.

A duty of candour should be arranged and preferably added at the end of the urgent outpatient review.

Ideally a senior nurse should be present when you see the patient. Avoid a duty of candour letter being sent out to the patient before you see them.

Whilst it is vital to discuss the case at an MDT a patient-centred approach means that the surgeon should meet with the patient as soon as possible and not wait for an MDT meeting before making contact.

In summary your main priority is to arrange an urgent outpatient appointment to discuss the anteverted cup and make a shared care decision about what next if anything to do about it.

Reikerås O, Gunderson RB. Acetabular component anteversion in primary and revision total hip arthroplasty: an observational study. *Open Orthop J*. 2013 Oct 4;7:600–4.

36. Answer A. **Adopting a watch and wait policy for the hip**

This SBA is forcing you to rationalise your own decision-making choices rather than default to an MDT. The debate is whether the cup needs to be immediately revised or whether to adopt a watch and wait policy. This would need to be fully discussed and documented with the patient. In real life the case would have been discussed at an MDT and the MDT's recommendations explained to the patient.

With a CoP bearing surface a position of watch and wait may be the best policy If the patient develops pain or instability then these symptoms would be strong indications for a revision

If the bearing surface was CoC and because he is young, fit and active the cup should ideally be revised as there is a significant risk of catastrophic failure.

Be guided by what the patient wants to do and what the MDT recommends.

Physiotherapy whilst helpful is peripheral to the two main choices of either to revise or adopting a wait and see.

Most surgeons are highly unlikely to revise the cup to a dual liner as prophylaxis to reduce the dislocation risk.

Ultrasound scan would be to check for iliopsoas tendinitis but this is a feature of a retroverted cup.

Prophylactic hip bracing can be very useful in certain situations but is a poor choice in this particular patient.

37. Answer D. **To recommend that THA should be performed before TKA**

The patient has end-stage rheumatoid disease and is struggling with pain control and mobility. In this situation there is not a huge amount of benefit delaying surgery to perform steroid injections. In most situations most surgeons would choose to perform a THA before a TKA. It is therefore not critical to resolve the source of any knee pain (including referred pain) with a steroid injection into the hip unless there were major worries from the patient about the decision to proceed with the hip first.

38. Answer B. **In patients with brittle rheumatoid arthritis hip surgery is likely to be more straightforward than knee surgery and a patient's confidence will be gained with performing relatively easy surgery**

THA in a rheumatoid patient can be just as equally difficult to perform as TKA so this statement is not as correct or valid a reason as the other four options.

There is some controversy regarding the priority of joint surgery in patients with both joints affected in the same limb; however, in most cases, it is accepted that THA should be undertaken before TKA, when both are indicated. The symptoms of these two conditions may overlap and pain relief obtained from hip replacement may delay knee replacement. The rehabilitation may be more tolerable after hip replacement even with significant ipsilateral knee involvement, whereas the converse is not always true. Additionally, adequate arc of hip motion is required for deep knee flexion, which is often required for successful TKA procedures.

If the knee is operated first the pain and difficult rehabilitation may put the patient off going ahead with THA.

39. Answer A. **Decreasing the neck shaft angle**

It is important for a hip arthroplasty surgeon to have some idea about how to be able to alter the offset of a THA. Five methods are available to increase femoral offset (Charles et al. 2005). Four of these are based on altering the geometry of the femoral component or the proximal femoral anatomy. The fifth one involves alteration of the geometry of the acetabular liner.

1. **Increasing the length of the femoral neck or head**

   Increasing the length of the femoral neck or head increases the resting length of the hip abductors and, depending on the angle of the femoral neck, increases their contractile efficiency while concomitantly lengthening the abductor lever arm. Unfortunately, an increase in the neck length also increases the limb length, resulting in a limb-length

discrepancy. This is an undesirable clinical outcome in most cases.

2. **Decreasing the neck shaft angle**
   Decreasing the neck shaft angle reduces the height of the femoral head, and thus the limb length, while increasing offset. This construct directly increases the magnitude of the abductor lever arm. It also has the positive effect of increasing abductor tension, making the muscles more efficient. However, this change in implant dimension has the negative effect of increasing the rotational torque imparted to the implant from out-of-plane forces.
3. **Medialising the femoral neck while concomitantly lengthening the femoral neck (high-offset femoral components)**
   High-offset femoral components either vary the neck shaft angle of the implant or medialise the neck to vary offset. This geometry maintains the neck-shaft angle relationship while concomitantly restoring offset. A major advantage of this technique is that it can be used to enhance abductor tensioning without substantially affecting limb length. Therefore, medialisation and concomitant lengthening of the femoral neck represents the basis for the high-offset femoral design.
4. **Trochanteric osteotomy**
   Trochanteric osteotomy provides a biomechanical advantage by laterally and distally advancing the point of insertion of the abductors. It has a positive effect in that it increases the strength of the abductors and hence decreases the likelihood of a Trendelenburg gait.
5. **Use of lateralised acetabular liners**
   Modular 'offset' or 'lateralised' liners have been shown to increase offset while preserving limb length. The offset may be altered by modifying the relationship of the articulation at the socket so that the centre of rotation at the hip is translated both laterally and inferiorly. A laterally displaced socket increases the abductor tension, which is a desirable outcome. However, it also increases the body weight lever arm which is considered an adverse outcome.

   Use of a dual motion implant is a distractor.

   Charles MN et al. Soft-tissue balancing of the hip: the role of femoral offset restoration. *Instr Course Lect.* 2005;**54**:131–141. PMID: 15948440.

40. Answer C. **With the patient supine, the hip is brought from a position of flexion, abduction and external rotation into extension, adduction and internal rotation**
This SBA topic is about snapping but it is focusing on its clinical diagnosis. With the reduced amount of patient exposure in the clinical exams there has been an evolving process of including more clinically based SBAs into the Part 1 exam. This is a classic example of this process.

This is the test for internal snapping of the hip. This is a well-recognised pathological hip condition particularly seen in young athletes such as ballet dancers. On occasion, the iliopsoas tendon can snap over the anterior capsule or iliopectineal ridge during hip movements. This is because the iliopsoas tendon moves from lateral to the iliopectineal ridge in flexion to medial in extension. The clue to separate the iliopsoas tendon from the ITB is ballet dancer and groin pain.

Coxa saltans refers to snapping hip and encompasses three main causes, extra-articular (either external or internal) or intra-articular.

- **Extra-articular external** (Coxa saltans externa) involves the posterior iliotibial band as it travels over the greater trochanter during hip flexion and extension or internal and external rotation. It is one of the causes of greater trochanteric pain syndrome, which also includes greater trochanteric bursitis and strains or tendinopathy of the hip abductor mechanism. However, many patients can present with a snapping hip that does not cause pain.
- **Extra-articular internal** (Coxa saltans interna) most commonly involves snapping of the iliopsoas tendon over the iliopectinal eminence or the anterior capsule during hip movements.
- **Intra-articular** causes can be variable and can result in different clinical manifestations, which can be intermittent. Causes include labral tears, ligamentum teres tears, loose bodies (osteochondral, chondral fragments, synovial chondromatosis) and even subtle instability of the joint. The sensation of snapping may be described as a clicking or catching and may reflect movement of the labral tear or loose body.

In the supine position, dynamic testing, starting in a position of FAbER (flexion, abduction and external rotation) to EAdIR (extension, adduction and internal rotation), will often elicit the snapping of the iliopsoas tendon.

- A is the piriformis test. This piriformis test evaluates pathology within the piriformis muscle itself or irritation of the sciatic nerve. The test stretches the piriformis muscle.
- B is the test for an external snapping hip. The ITB snaps over the greater trochanter. A snap is felt over the greater trochanter during movement.
- D is FAdIR for anterior impingement. The FAdIR (flexion, adduction and internal rotation or impingement) test can be used to assess for labral or intra-articular pathology.
- E is the posterior impingement test (hip extension, adduction, external rotation). A positive test elicits pain deep within the groin and/or medial aspect of the buttock. This tests for posterior rim impingement. Posterior hip impingement results from the abnormal contact of the lesser trochanter/intertrochanteric ridge or posterior femoral neck with the ischium (including the posterior acetabulum).

41. Answer E: **Tissue culture of intraoperative biopsies**

There is no single test that can reliably and reproducibly predict infection. Therefore, a combination of clinical assessment, biochemical testing and diagnostic imaging should be utilised. ESR and CRP are key tests that should always be analysed in assessment for PJI. However, these markers can be affected by age and medical co-morbidities. An ESR >30mm/h and a CRP >10mg/L have been shown to represent elevated levels. If both the ESR and CRP are normal, the probability of infection has been shown to be around 3%.

Joint aspiration is an invasive diagnostic method often used as the first step in suspected PJI cases. Antibiotics should be withheld for a minimum of 2 weeks before aspiration. The analysis of the synovial fluid typically includes synovial WBC and synovial PMN%. In acute infections, a synovial WBC of 20,000 cells/ml and synovial PMN% of 89% are considered threshold values (Fink et al. 2008). These figures differ in the context of chronic infection. The aspirate should be sent for enriched cultures and antimicrobial sensitivity.

Sampling of joint fluid through aspiration has variable results with a wide range of reported sensitivities (50–93%) and specificities (82–97%). The diagnostic accuracy of synovial fluid culture is lower than intraoperative sampling of periprosthetic tissue and sonication fluid culture from biofilms. Furthermore, joint fluid collection is limited in the case of dry tap.

The MSIS consensus meeting stressed several points regarding intraoperative biopsies. Each tissue sample is taken with separate, sterile instruments. They also stated that at least three, but no more than five samples should be taken and incubated in both aerobic and anaerobic environments. The use of sterile broth containing Ballotini beads can increase the pick-up of

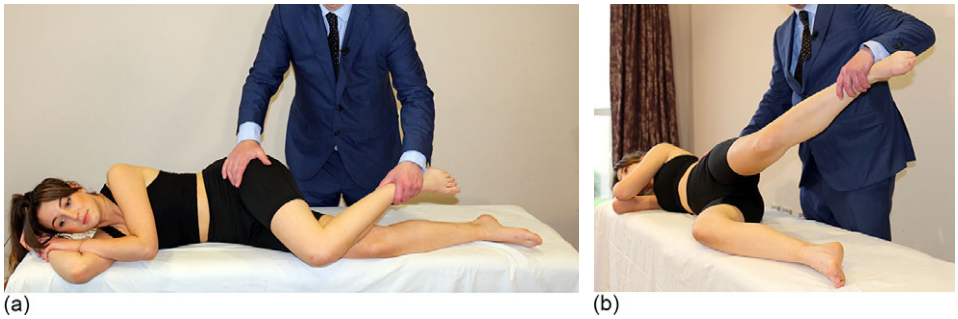


Figure 5.28 External snapping hip. Iliotibial band snapping. (a) The patient lies on their side with the affected side uppermost. Patient actively flexes their hip and then adducts. (b) From this position it is passively brought by the candidate into extension and abduction. A snap is felt over the greater trochanter

low-grade organisms (83% sensitivity compared with 38% sensitivity with direct culture plates).

After the surgeon places the sample in the sterile broth pot, it can be shaken enabling the Ballotini beads to dislodge the bacteria from the tissue samples, enhancing the chance of a positive culture, without risking contamination by multiple laboratory steps.

The benefit of obtaining multiple samples for culture is not only to increase the yield of difficult to identify organisms but also to be able to decide when a bacterium is more likely to be a contaminant or not. For example, if 3 of 5 specimens culture an identical organism, there is a 96% chance that this is the true causative organism, compared with a 25% chance with 2 positive identical samples (Walker et al. 2020).

In recent years, polymerase chain reaction (PCR) has been used in the diagnosis of PJI. A recent meta-analysis of PJI diagnosed by synovial fluid PCR concluded that the diagnostic capability of synovial fluid PCR is not superior to that of synovial fluid culture.

Gram staining of synovial fluid has shown a poor sensitivity (~30%) in diagnosing *S. aureus* PJI, and therefore, its clinical utility appears to be low.

Intraoperative frozen section will indicate whether an infection is likely but not tell you the organism responsible. Mirra et al. (1976) were the first to describe a heavy infiltrate of acute inflammatory cells on frozen section pathology in infected periprosthetic tissues, while in contrast there was an absence of PMN cells in non-infected cases. Lonner et al. (1996) showed a significantly higher PPV (89 vs. 70%) when the threshold for infection was raised to 10 PMN/HPF. A skilled and experienced pathologist should analyse all the tissue sections.

Fink B et al. The value of synovial biopsy, joint aspiration and C-reactive protein in the diagnosis of late peri-prosthetic infection of total knee replacements. *J Bone Joint Surg Br.* 2008;**90**:874–878.

Lonner JH et al. The reliability of analysis of intraoperative frozen sections for identifying active infection during revision hip or knee arthroplasty. *J Bone Joint Surg Am* 1996;**78**:1553–1558.

Mirra JM et al. The pathology of the joint tissues and its clinical relevance in prosthesis failure. *Clin Orthop Relat Res* 1976;**117**:221–240.

Walker LC et al. The importance of multisite intra-operative tissue sampling in the diagnosis of hip and knee periprosthetic joint infection – results from a single centre study. *J Bone Joint Infect.* 2020;**5**:151–159.

42. Answer D. **Gluteal muscle (abductor) deficiency**
Constrained liners should only be considered when all other factors related to the total hip arthroplasty have been corrected or optimised. Component malposition leading to instability of hip arthroplasty is best addressed by correcting the malposition.

Indications for constrained liners in the revision situation include cases with previously failed operations for instability, elderly low-demand patients with instability, cases with poor or absent hip musculature, and cases with well-positioned acetabular and femoral components and with hip instability. Whilst constrained liners may be used in revision hip surgery to reduce the risk of dislocation this should only be in carefully considered situations where less constrained options have been considered but discounted.

If an acetabular cup has been revised to an uncemented metal shell the immediate use of a constrained acetabular insert is best avoided as osseointegration has not taken place and there is a significant risk of cup pull out from the acetabulum even with the use of screws.

Some recommended technical tips for placement of constrained liners. (1) Avoid impingement; (2) avoid placement of constrained liner with component malalignment; (3) avoid placement of constrained liner in acetabular allograft or when the shell has inadequate osteointegration.

43. Answer D. **Use of a small femoral head**
Four variables that affect THA stability are (1) Component design; (2) Component position; (3) Soft tissue tensioning; (4) Soft tissue functioning.

The SBA options focus on components.

Femoral component design

Large femoral heads

- Head to neck ratio

- Avoidance of skirts as these decrease head to neck ratio
- Increased jump distance

Femoral offset

Acetabular component design

Elevated rim liner

Lateralised liner (increases soft tissue tension)

Articulation

Dual motion

Captive cup

This SBA focuses only on component factors and steers clear of mentioning abductor deficiency, a vertically orientated cup or reduced femoral offset in the stem options as in these situations the risk of dislocation is hard to quantify.

A 2005 study of more than 20,000 THA found a significantly decreased rate of dislocation with the use of larger femoral heads. Stratified by femoral head size, dislocation rates were 3.6% for 28 mm, 4.8% for 26 mm and 18.8% for 22 mm. Other studies have noted the effectiveness of even larger head sizes ranging from 28–40 mm.

Despite the theoretical reasons to expect a larger femoral head to be associated with a lower rate of dislocation, this predicted effect had not been identified in many older studies as sample size was too small and also dislocation is a multifactorial phenomenon.

The risk of dislocation may be influenced by a number of other factors, including patient-related factors (such as diagnosis, age and sex) and surgical technique. Dislocation is more common in association with the posterior approach and with a highly abducted acetabular component orientation and is less common following soft-tissue repair.

Howie et al. (2012) reported that the incidence of dislocation within one year after primary arthroplasty was five times lower in patients with a 36-mm articulation (0.8%) than in those with a 28-mm articulation (4.4%). This difference was both clinically important and statistically significant.

Larger diameter femoral heads have a larger femoral head to neck ratio, which increases hip motion before impingement between components occurs. Jump distance is increased. The jump distance (JD) is the degree of lateral translation of the femoral head centre required before dislocation occurs.

Concerns about polyethylene wear in larger diameter articulations involving $\geq$36mm femoral heads prevented their use with earlier generations of UHMWPE.

When choosing a femoral head of a certain diameter, the surgeon must consider many factors other than hip stability such as the expected volumetric wear rate of the bearing surface, risk of trunnionosis, long-term THA survivorship, frictional torque, hip ROM and hip function. Furthermore, hip stability is determined by many factors, of which femoral head diameter is only one feature.

The use of a skirt significantly increases the dislocation risk. Skirts are attachments used to extend the length of the femoral neck and reduce the head to neck ratio. This would have been good to use as a plausible distractor but we could find no direct evidence quantifying the dislocation risk. Skirts are only infrequently used in special situations in arthroplasty surgery.

Berry DJ, von Knoch M, Schleck CD, Harmsen WS. Effect of femoral head diameter and operative approach on risk of dislocation after primary total hip arthroplasty. *J Bone Joint Surg Am.* 2005;**87**:2456–2463.

Howie DW, Holubowycz OT, Middleton R. Large Articulation Study Group. Large femoral heads decrease the incidence of dislocation after total hip arthroplasty: a randomized controlled trial. *J Bone Joint Surg Am.* 2012;**94**:1095–1102.

Tsikandylakis G, Mohaddes M, Cnudde P, Eskelinen A, Kärrholm J, Rolfson O. Head size in primary total hip arthroplasty. *EFORT Open Rev.* 2018 May 21;3(5):225–231.

44. Answer D. **Risk of injury to inferior gluteal and pudendal vessels is high with posterior-inferior quadrant**

No apologies for repeating this SBA topic as the subject is of significant practical importance and is also frequently asked in *viva* examinations. It is an 'A' list topic.

The posterior superior and posterior inferior acetabular quadrants contain the best available bone stock and are relatively safe for the transacetabular placement of screws. The anterior superior and anterior inferior quadrants should be avoided whenever possible, because screws placed

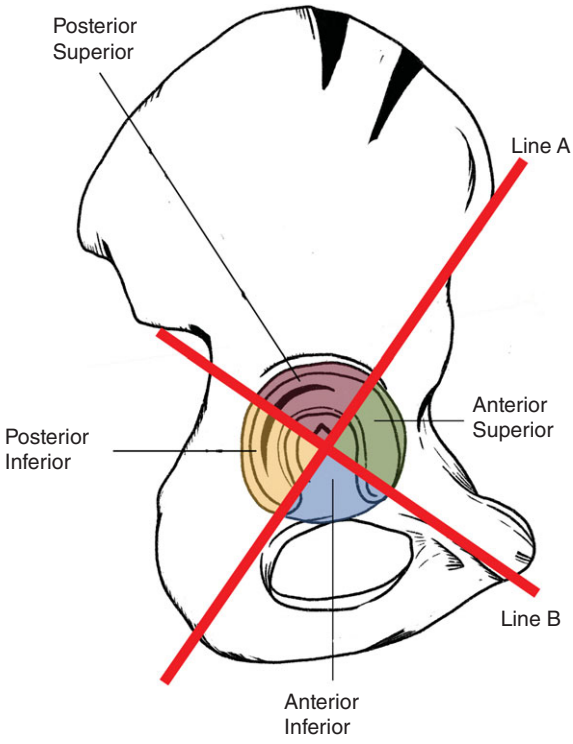


Figure 5.29 The acetabular-quadrant system. The quadrants are formed by the intersection of lines A and B. Line A extends from the anterior superior iliac spine (ASIS) through the centre of the acetabulum to the posterior aspect of the fovea, dividing the acetabulum in half. Line B is drawn perpendicular to line A at the mid-point of the acetabulum, dividing it into four quadrants

improperly in these quadrants may endanger the external iliac artery and vein, as well as the obturator nerve, artery and vein (Wasielewski et al. 1990).

The acetabular-quadrant system provides the surgeon with a simple intraoperative guide to the safe transacetabular placement of screws during primary and revision acetabular arthroplasty. A constant relationship was found to exist between specific acetabular quadrants and specific intrapelvic structures.

Screws originating from the **anterior superior quadrant** were found to lie near the external iliac artery and vein. However, because of the more medial position of the vein with respect to the artery and the paucity of interposed tissue along the pelvic brim, the external iliac vein was more in danger of injury than was the artery.

Screws originating from the **anterior inferior quadrant** were directed toward the obturator nerve and vascular structures. This is most evident at the superolateral aspect of the obturator foramen, where the nerve, artery and vein exit the true pelvis through the obturator canal.

When an anatomical variant was present (the aberrant obturator artery or accessory obturator vein) these vessels were even more susceptible to injury. The accessory or aberrant obturator vessels travel across a section of the pelvic brim (located just opposite the anterior inferior quadrant) with little interposed soft tissue. This section of the osseous acetabulum is thin (6–12 mm), which increases the possibility of vascular injury.

Screws that are located centrally in the **posterior superior quadrant** may be directed toward the superior gluteal nerve, artery and vein as they exit the pelvis through the greater sciatic notch.

Screws that are located centrally in the **posterior inferior quadrant** are directed toward the inferior gluteal and internal pudendal nerves and vessels. These structures are rarely endangered, due to surrounding intrapelvic tissue and their distance from the posterior column.

Wasielewski RC, Cooperstein LA, Kruger MP, Rubash HE. Acetabular anatomy and the trans acetabular fixation of screws in total hip arthroplasty. *J Bone Joint Surg Am.* 1990;**72**:501–508. PMID: 2324135.

45 Answer D. **Reduced femoral offset**

If a patient has a long-standing significant leg length discrepancy, then as a general rule leaving the leg slightly shorter on the affected side is a preferred option rather than equalising leg lengths. Patients will have got used to the shortening and will struggle to adapt to normalisation of leg lengths. Stem mismatch is more of an issue with an oversized stem rather than an undersized stem. The patient should not have any residue symptoms from Perthes disease compared with an inflammatory arthritis where residue inflammation in a joint may still be present. There is no suggestion on the radiographs of failure of femoral stem osteointegration.

The patient has a reduced femoral offset and is complaining of a limp and leg weakness. This is likely to be due to failure to restore femoral offset. The femoral stem has been undersized but there is no real evidence of proximal/distal femoral stem mismatch.

Notes

1 This SBA is similar to SBA Question 59 in Chapter 4. Both provide a structured framework to discuss the pathogenic causes of ON.

We prefer the newer more simplified system contained in question 59 in which the pathological mechanisms are divided into three components: (1) mechanical vascular interruption, (2) intravascular occlusion and (3) extravascular compression.

However, this structured framework is perfectly acceptable and one also worth knowing especially if you are wanting to score higher than an average 6 pass.

Chapter 6

Knee I Structured SBA

Oliver Bailey and Pradyumna Raval

KNEE I STRUCTURED SBA QUESTIONS

1. **While performing a posteromedial approach to the knee, which of the following structures helps you identify the correct plane?**
   A. Saphenous nerve
   B. Saphenous vein
   C. Semitendinosus tendon
   D. Sural nerve
   E. Tibial artery

2. **When performing a knee posterolateral corner reconstruction, which of the following structures has the most anterior femoral insertion point?**
   A. Arcuate ligament
   B. Lateral collateral ligament
   C. Lateral head of the gastrocnemius
   D. Popliteofibular ligament
   E. Popliteus

3. **All of the following are considered part of the posteromedial corner of the knee apart from which structure?**
   A. Medial collateral ligament
   B. Oblique popliteal ligament
   C. Posterior oblique ligament
   D. Posteromedial joint capsule
   E. Semimembranosus tendon and its expansions

4. A 24-year-old male sustained a grade III posterolateral corner injury of his knee following a skiing injury 2 years previously. He is listed for surgery for chronic pain and instability.
   Which of the following is the most essential structure to identify prior to performing a posterolateral corner reconstruction?
   A. Common peroneal nerve
   B. Iliotibial band
   C. Lateral collateral ligament
   D. Popliteus
   E. Tibial nerve

5. **When climbing stairs, roughly how does a patient's body weight correlate with the joint reaction force of their patellofemoral joint?**
   A. 0.5 times body weight
   B. 2–3 times body weight
   C. 20 times body weight
   D. 7–8 times body weight
   E. Unrelated to body weight

6. **Which of the following is not a validated knee outcome measure?**
   A. IKDC
   B. KOOS
   C. Lysholm Score
   D. Oxford Knee Score
   E. SF-30

7. You review a young adult who presents with a painless knee swelling and intermittent locking with no history of trauma. MRI is shown in Figure 6.1.

Figure 6.1
MRI scan knee

This demonstrates a joint effusion with a mass-like synovial proliferation with lobulated margins.

What is the most likely diagnosis?

A. Lipoma arborescens
B. Pigmented villonodular synovitis
C. Rheumatoid arthritis
D. Synovial cell sarcoma
E. Synovial chondromatosis

8. You are supervising a trainee perform a knee arthroscopy on a 25-year-old female. You notice they have made their anterolateral arthroscopy portal quite inferior to where you had wanted. A complication occurs due to this portal placement.

What piece of equipment will you ask for to deal with this complication?

A. ACL repair kit
B. All-inside meniscal repair kit
C. Chondral fixation kit
D. Microfracture kit
E. Outside-in meniscal repair kit

9. A young female presents with snapping of her knee with episodes of locking. Sagittal MRI images of her lateral compartment show three 5mm-thick contiguous images of her meniscus from anterior to posterior horns with no tears obvious.

What is your next management step?

A. Inject with steroid
B. List for arthroscopy
C. List for arthroscopy + saucerisation
D. List for arthroscopy + saucerisation +/– meniscocapsular repair
E. Refer to physiotherapy

10. You review a young female with the results of her MRI after a twisting knee injury. You are pleased to see she is now asymptomatic but note that within the lateral compartment of the knee her MRI demonstrates 'a minimal meniscal width to maximal tibial width (on coronal slice) of 40%, and a ratio of the sum of the width of both lateral horns to the maximal meniscal diameter (on sagittal slice) of 80%'.

What is your management plan?

A. Discharge to physiotherapy
B. Discharge with no follow up
C. List for arthroscopic meniscal repair
D. List for arthroscopic saucerisation
E. List for diagnostic arthroscopy

11. You review a 10-year-old boy with lateral knee pain. MRI shows five sagittal slices of 5mm-thick contiguous lateral meniscus from anterior to posterior horns.

Which of the following X-ray findings is associated with the diagnosis?

A. Hypoplastic patella
B. Lateral tibial plateau fracture
C. Narrowing lateral joint space
D. Segond fracture
E. Tibial eminence hypoplasia

12. You are performing an arthroscopic PCL reconstruction and utilise X-ray guidance while drilling the tibial tunnel.

Which complication are you hoping to reduce with the use of X-ray fluoroscopy?

A. Graft impingement
B. Malplacement of the tunnel
C. Overconstraint
D. Popliteal artery injury
E. Tibial fracture

13. During ACL surgery, you prematurely amputate the semitendinosus hamstring graft at a length of about 7cm.

What is the likely intraoperative mistake?

A. You had not appreciated the patient had a positive Dial test
B. You had not fully released the extratendinous tethers to the medial head of gastrocnemius
C. You had released the semitendinosus from the sartorial facia prior to using the tendon stripper
D. You had used a closed loop tendon stripper rather than an open loop tendon stripper
E. Your graft harvest wound was too small

14. At a 6-week post-operative review of one of your ACL reconstructions they complain of ongoing numbness over the medial border of their foot on the same side as their ACL reconstruction.

What is the likely graft that this patient has had?

A. Bone–patella–tendon–bone allograft
B. Bone–patella–tendon–bone autograft
C. Hamstring allograft
D. Hamstring autograft
E. Quadriceps

15. You have been asked to review one of your ACL reconstructions at 3 months post-operatively by the physiotherapist. They are concerned that the patient is unable to fully extend their knee.
What is the likely intraoperative mistake?
A. The entry point for the femoral tunnel is at the 12 o'clock position
B. The entry point for the tibial tunnel is 2mm anterior to the anterior horn of the lateral meniscus
C. You have a cortical 'blowout' while reaming the femoral tunnel; therefore, you secured the graft with a larger-than-normal femoral button
D. You prematurely amputate the hamstring graft during harvest, leading you to change your graft choice from quadrupled stranded hamstring graft to a bone–patella–tendon–bone graft
E. You tensioned the graft in 30° of knee flexion rather than full extension

16. You are reviewing a 19-year-old female who plays netball nationally and who underwent an isolated ACL reconstruction 11 months ago. She was really happy with her rehabilitation, but on return to her first contact game at 10 months post-operatively her ACL graft failed. Lachman and pivot shift tests are positive, Dial test is negative. On review of her preoperative MRI, you note an ACL rupture with the presence of a Segond fracture, but no other abnormality.
What is the most likely cause of their re-rupture?
A. The surgeon failed to address the anterolateral complex
B. The surgeon failed to address the posterolateral complex
C. The surgeon used hamstring autograft
D. The surgeon used patella tendon autograft
E. The tibial graft tunnel was too anterior

17. You are performing a total knee replacement using a measured resection technique with a PS design using anterior femoral referencing; however, on trialling the implants, the knee is ok in flexion but loose in extension.
Which of the following is the best option to gain a stable knee?
A. Anteriorise the femoral component and use distal augments
B. Downsize the femur and use a thicker insert
C. Resect more bone off the tibia and downsize the femur
D. Resect more bone off the tibia and upsize the femur
E. Resect the PCL

18. You are performing a total knee replacement using a measured resection technique with a PS design using anterior femoral referencing; however, on trialling the implants, you notice the knee is loose in flexion but ok in extension.
Which of the following is the best option to gain a stable knee?
A. Posteriorise the femoral component
B. Proximalise the femur and use a thicker insert
C. Resect more bone off the femur and upsize the femur
D. Resect more bone off the tibia and upsize the femur
E. Upsize the femur

19. You see an unhappy patient in clinic who underwent a total knee replacement 3 years ago. They have no history of wound problems, no history of trauma and no infective symptoms, but state they have never really been happy with their knee. Symptoms include anterior knee pain, clunking and difficulty walking. There is no evidence of osteolysis on X-ray.
Which of the following investigations is most likely to demonstrate an abnormality?
A. Bloods
B. CT rotational profile of the leg
C. Knee aspiration with a request for extended cultures
D. Knee aspiration with a request for Gram stain
E. Knee aspiration with a request for white cell count

20. You are performing a total knee replacement in a valgus knee and trying to balance the components. It is well balanced in extension but remains tight laterally in flexion.
What is the next best appropriate intraoperative step?
A. Downsize your femoral component with anterior referencing

B. Release the LCL
C. Release the PCL
D. Release the popliteus
E. Resect more of the tibia and distalise the femur with augments

21. A patient presents after a fall with a periprosthetic knee fracture extending proximally from the femoral component.
What intraoperative decision has the original knee surgeon made that has increased the chances of this happening?
A. In an attempt to improve patella tracking, they externally rotated the femoral component
B. In an attempt to improve the extension gap, they performed a posterior release
C. In an attempt to improve the flexion gap, they released the PCL and subsequently changed from a CR to a PS implant design
D. On measuring the femoral component size using posterior referencing, it measured 4.5 and the decision was made to use a size 4 implant, as a size 5 may overstuff the PFJ
E. They proximalised the femoral component due to preoperative fixed flexion

22. One-year post-operatively from a total knee replacement (without patella resurfacing) a patient presents to your clinic with severe worsening anterior knee pain and grinding over the PFJ. Skyline radiographs of the patella demonstrate fragmentation of the patella and accelerated arthritic changes.
What decision intraoperatively has most likely led to this presentation?
A. Denervation of the patella was performed with diathermy
B. Due to poor patella tracking, a lateral retinacular release was performed
C. The femoral component was anteriorised to increase the flexion gap
D. The femoral component was externally rotated
E. The patella was not resurfaced

23. You review a patient in clinic who is 4 years post-operative from a total knee replacement. They are complaining of increasing pain for the past 6 months. X-ray demonstrates an area of osteolysis behind the femoral component. Aspiration of the joint has the following results: Gram stain negative, WCC 4 000, PMN count 90%. Culture does not grow anything.
Which is the most appropriate next step?
A. Arthroscopic washout of the knee
B. DAIR procedure
C. Nuclear medicine bone scan
D. One-stage revision
E. Two-stage revision

24. A patient complains of numbness after undergoing a total knee replacement for an arthritic valgus knee.
What is the likely area that has sensory disturbance?
A. Dorsal aspect of the foot
B. L4 dermatome
C. Lateral aspect of foot
D. Medial aspect of the foot
E. Sole of the foot

25. **Which of the following radiographic findings makes a TKA more difficult?**
A. A Caton–Deschamps index of 0.7
B. A Dejour grade of C type
C. An Insall–Salvati ratio of 0.7
D. Bipartite patella
E. TT-TG of 12mm

26. You are examining a patient in the anaesthetic room just prior to surgery. The patient has been listed for an Oxford knee replacement.
Which of the following examination findings are you most worried about?
A. 0–95° range of movement
B. 10° fixed flexion
C. 11° correctable varus
D. Age 68
E. Previous arthroscopy scars

27. A 45-year-old male presents with a chronic history of knee pain, swelling and locking. There is no history of trauma and they are systemically well. MRI shows multiple lobular cartilage lesions within the joint.
What is the next best management option?
A. Anti-inflammatory medication + intra-articular steroid injection
B. Arthroscopic synovectomy, removal of loose bodies and histopathological analysis

C. Joint aspiration
D. Neoadjuvant radiotherapy followed by wide local excision
E. Open biopsy

28. A 67-year-old patient presents with an acutely swollen knee with no history of trauma. They are systemically well. X-ray of the knee is normal apart from an effusion. A joint aspirate has a negative Gram stain but demonstrates positively birefringent crystals.
What is the next best management?
A. Admit patient to await full culture and sensitivities
B. Book on trauma list for emergency joint washout
C. Reassure and discharge with anti-inflammatory medication
D. Reassure and discharge with anti-inflammatory medication and ask GP to start allopurinol
E. Refer for a knee MRI

29. There are multiple options for graft choice when reconstructing an ACL. Load to failure is one factor that can help decision making.
What is the load to failure of a 4-strand hamstring autograft?
A. 2000 N
B. 2000 N – 4000 N
C. 2500 N – 3000 N
D. 3000 N
E. 3000 N – 4000 N

30. A patient attends with a dislocation of an Oxford mobile bearing UKA. On review of the operation note you do not see any documentation of any complication but note the bearing size to be 9mm thickness.
What is the likely intraoperative complication that has increased the chance of bearing dislocation?
A. 15° malalignment of the femoral component in the coronal plane
B. ACL injury
C. MCL injury
D. Tibial fracture
E. Unrecognised lateral joint wear

31. A 24-year-old patient presents with a 1-year history of medial sided knee pain. The only abnormality demonstrated on MRI is a 1cm × 2cm full thickness cartilage defect over the weight bearing portion of their medial femoral condyle. Other imaging demonstrates a Mikulicz line 20% from medial to lateral.
What is the next appropriate management?
A. Closing wedge DFO + nanofracture/AMIC
B. Nanofracture/AMIC
C. OATS
D. Opening wedge HTO + nanofracture/AMIC
E. Posterolateral corner reconstruction + nanofracture/AMIC

32. A 17-year-old female is referred to you with ongoing lateral knee pain which is stopping them perform any moderate degree of exercise. Mikulicz line is 48% from medial to lateral and she has no subjective or objective instability. You note that in a previous arthroscopy they had a bucket handle lateral meniscal tear that was irreducible.
What is the next appropriate management?
A. Distal femoral osteotomy
B. List for repeat arthroscopy
C. Proximal tibial osteotomy
D. Refer to physiotherapy with patient-initiated return appointment
E. Refer to regional centre for consideration of meniscal transplantation

33. A 15-year-old female presents to you with recurrent dislocation of their patella. She has been told by one of your colleagues that she needs a distalising and medialising TTO + MPFL reconstruction.
Which of the following results makes you uneasy at performing this plan?
A. Caton-Deschamps ratio of 1.4
B. Dejour grading B
C. Foot thigh progression angle of 12°
D. Hand-wrist bone age of 14
E. TTTG distance 21mm

34. You have a patient on your list for a mobile bearing medial unicompartmental knee replacement.
Which of the following radiographic features would make you concerned?
A. Fixed flexion of 5°
B. Lateral radiograph with medial wear posteriorly
C. Long leg mechanical varus alignment of 10°
D. MRI findings of medial osteonecrosis
E. Osteophytes within the notch

35. You are following up a 25-year-old patient 1 year after tibial plateau fixation. They are unhappy with the stability of the knee and describe it giving way when going down stairs.
What is the most likely fixation of their tibial plateau?
A. Anterolateral locking plate
B. Lateral to medial subarticular raft screws
C. Medial locking plate
D. Medial to lateral subarticular raft screws
E. Posterolateral buttress plate

36. You are following up a 31-year-old patient 6 months after tibial plateau fixation with one medial locking plate. They are mobilising well, however complain of medial sided pain on weight bearing. You note that their knee is stable and has an excellent range of motion.
What is the likely next management plan for this patient?
A. Continue physiotherapy
B. Ongoing physiotherapy
C. Theatre listing for ACL reconstruction
D. Theatre listing for arthroscopy
E. Theatre listing for removal of plate

37. A patient comes into your department with a Schatzker 6 tibial plateau fracture. You fix it with a medial and an anterolateral plate. At the 3-month follow up the knee is subluxed with failure of fixation.
What mistake has occurred?
A. You failed to address the ACL rupture
B. You failed to assess the patient's neurovascular status
C. You failed to organise an MRI prior to surgical fixation
D. You relied on the Schatzker classification to aid management
E. You started weight bearing the patient too early

38. A patient who has had a BTB ACL reconstruction is involved in an RTA and sustains an ipsilateral bicondylar 2 column tibial plateau fracture. Your colleague fixes it with a dual plate technique utilising the patient's previous scars.
What is the most likely complication?
A. Metalwork fails and the knee subluxes anteriorly
B. Metalwork fails and the knee subluxes posteriorly
C. Symptomatic DVT
D. The metalwork becomes infected
E. The patient complains of stiffness

39. You are the senior registrar supervising a junior colleague applying a tourniquet for a patient who is set up for a total knee arthroplasty surgery. This patient is a short lady with truncal obesity and slightly conical shaped limbs.
Which of the following statements regarding application of a tourniquet is false?
A. Compressive exsanguination should not be used in the presence of infection
B. The use of straight tourniquets on conical thighs is recommended, especially in extremely muscular or obese individuals
C. Tourniquets should be applied over a thin, even layer of padding
D. Tourniquet width should be more than half the limb diameter
E. Wide tourniquet cuffs are more effective at lower inflation pressures than are narrow ones

40. A 26-year-old amateur footballer presents to the ED of your hospital following a football injury. Anteroposterior (AP) radiograph is shown in Figure 6.2. The knee is swollen and clinical examination is difficult.
Which of the following statements about this injury is true?
A. The anterolateral ligament has no role in knee stability
B. The anterolateral ligament is an intra-articular structure with a clear course from the lateral femoral epicondylar region,

Figure 6.2 Anteroposterior (AP) radiograph knee

running anteroinferiorly to the proximal tibia at a site midway between Gerdy's tubercle and the head of the fibula

C. The anterolateral ligament was originally identified by Gerdy in 1879

D. The entire anterolateral ligament is visible from its proximal insertion to its distal insertion, with excellent agreement between ultrasound and anatomical findings

E. The sensitivity of an MRI scan in detecting an anterolateral injury ranges from 80–90%

41. A 35-year-old dance teacher is referred to your elective knee clinic with a complaint of pain in her knee which has been ongoing for 3 months. There is no history of antecedent trauma. She does not have any mechanical symptoms of her knee locking; however she is quite distressed by what she describes as a 'disappearing' swelling on the outer (lateral) aspect of her knee.

What is this lady suffering from?

A. A ganglion on the lateral aspect of the knee

B. A lateral meniscal cyst

C. Lateral meniscus tear

D. Snapping iliotibial band syndrome

E. Symptomatic discoid meniscus

42. A 35-year-old dentist is referred to your clinic with a 6-month history of anterior knee pain. The dentist tells you that he fell while running and the anterior aspect of his right knee took the impact of the fall. He ever since has a constant ache and discomfort in the anterior aspect of his knee worsened by activities. He sometimes feels a clicking sensation on flexion and extension of his knee. Imaging investigations do not help much in the diagnosis and conservative treatment has failed.

You decide to perform a knee arthroscopy. What is the cause of his symptoms?

A. Infra-patellar plica

B. Lateral patellar plica

C. Medial patellar plica

D. Patello-femoral arthritis

E. Supra-patellar plica

43. You are consenting a young football player about anterior cruciate ligament reconstruction surgery. This young man does not want his hamstring tendon or bone-patellar tendon-bone graft. He wants to know about allograft for ACL reconstruction.

Which of the following statements is incorrect?

A. Allograft maturation takes longer than autograft maturation

B. Increased use of allografts in primary procedures is making it more difficult to obtain these for revision or for multiple ligament procedures

C. The failure rate of allografts is similar to autografts

D. The potential for infection with allograft is low

E. Use of allografts decreases post-operative morbidity

44. A 3rd year orthopaedic registrar injures his knee while playing football and MRI scan reveals that he has an anterior cruciate ligament injury. He consults you in your clinic and wishes to undergo ACL reconstruction surgery. He is happy for you to use an autograft but requests you to use the strongest autograft which has a high ultimate strength to failure.

What advice would you give him?

A. Allografts are stronger than autografts and have higher ultimate strength to failure

B. Bone patellar tendon bone is the strongest graft of all known ACL autografts

C. Quadriceps tendon graft is stronger than patellar tendon and quadrupled hamstring tendon

D. Quadrupled hamstring tendon graft is the strongest at 4140 Newton

E. There is no difference in the ultimate strength to failure of any grafts

45. Studies involving gene therapy have shown promising results in treatment of knee osteoarthritis in animal models. The cytokine Interleukin-1 (IL-1) is highly expressed in chronic inflammatory conditions such as rheumatoid arthritis and osteoarthritis. The IRAP gene is interleukin-1 receptor antagonist protein.

Inhibition of cartilage breakdown has been shown by insertion of?

A. Interleukin-10 (IL-10)

B. IRAP gene alone

C. Simultaneously injecting IRAP and IL-10

D. TGF-β1

E. Vascular endothelial growth factor (VEGF)

46. You examine a 40-year-old medical secretary with a 3-day-old history of twisting injury to her knee. She tells you that her symptoms have improved significantly. On examination you do not find any specific area of tenderness around the knee. You decide to discharge her with an open appointment. Your SHO wants to know why you did not request a knee radiograph for this lady. You explain to your SHO that she does not fit the OTTAWA criteria for a knee radiograph.

Which one of the following is not an OTTAWA criterion for a radiograph in a traumatic knee injury?

A. Age >70 years
B. Inability to bear weight immediately after injury
C. Inability to flex the knee to 90°
D. Isolated patellar tenderness
E. Tenderness at the head of fibula

47. On a busy on call in a major trauma centre you get called to review a labourer who has fallen off a height. The air ambulance team is concerned about a potentially dislocated right knee. On initial evaluation the patient is conscious with a GCS of 15. You then examine the knee and find it to be in an anatomic alignment with a good palpable pulse.

With regards to the vascular injury in a knee dislocation which of the following statements is true?

A. Amputation rates increase dramatically when revascularisation is delayed for more than 12 hours
B. Anterior dislocations are more often associated with intimal injuries because of vessels getting stretched over the distal femur
C. Lower Extremity Assessment Project (LEAP) study had reported a 50% incidence of amputation in patients with a knee dislocation and vascular injury
D. The posterior tibial artery is the primary vessel supplying the knee joint
E. The rate of arterial injury is different in anterior and posterior dislocation

48. In the above patient a vascular injury is ruled out. Further imaging in the form of an MRI scan reveals that he has multi-ligament injury involving the anterior and posterior cruciate ligament. You discuss management options with him. He would like to consider surgery. While explaining common complications you mention about stiffness of the knee, instability, any missed fractures, early arthritis and heterotrophic ossification.

Which of the following statements is true about HO formation in a case of knee dislocation?

A. An open surgical procedure is mandatory to address the HO formation
B. Heterotrophic ossification (HO) occurs in all cases of knee dislocation
C. Knee stiffness in these patients improves over time without requiring any additional procedure
D. Posterior cruciate ligament reconstruction has a strong association with formation of HO
E. Radiotherapy is advised in all patients with knee dislocation to reduce the incidence of HO formation

49. A Core trainee approaches you asking for an audit project. You advise her to gather data about patients who were diagnosed with gout in the past 6 months. The data reveal that gout in women generally presents after menopause as compared with men who are relatively younger when diagnosed with gout.

Which of the following statements with regards to pathophysiology of gout is true?

A. Eating seafood such as sardines, mackerel and herring is healthy and does not cause gout
B. Oestrogen is uricosuric
C. Testosterone is uricosuric
D. There is no association of sex hormones with gout
E. Urate clearance is independent of kidney function

50. A 68-year-old lady is referred to your elective Orthopaedic clinic with a long-standing history of right knee pain. Conservative measures have failed, and she wishes to undergo a joint replacement procedure. On inspection you notice a large psoriatic patch on the anterior aspect of her knee.

Which of the following is not a part of the CASPAR criteria for psoriatic arthritis?

A. A current psoriatic skin or scalp lesion with a family history of psoriasis
B. Current dactylitis or previous history of dactylitis as reported by a rheumatologist
C. Positive test for rheumatoid factor
D. Psoriatic nail dystrophy including pitting, onycholysis and hyperkeratosis

E. Radiological evidence of juxta-articular new bone formation

51. On a busy Orthopaedic on call you get called by the Paediatric Registrar requesting you to review a neonate with abnormal position of his knee. You examine this baby and diagnose that this child has a congenital dislocation of his knee.
With regards to congenital dislocation of the knee (CDK) which of the following statements is incorrect?
A. Abnormal foetal position can lead to a unilateral CDK
B. Bilateral CDK is never associated with any syndromes
C. Clubfoot and hip dysplasia are commonly associated conditions
D. Hypoplasia of the patella and iliotibial band contracture may be present
E. One extended and one flexed knee can be present in neurological conditions such as arthrogryposis

52. You are consenting a 65-year-old former beautician for a total knee replacement procedure. This patient tells you that she is allergic to nickel, and you assure her that you will use components in surgery which do not have nickel in them.
With regards to the genetic aetiology of contact sensitisation, null mutations in which polypeptide are associated with nickel allergy?
A. Cecropin
B. Filaggrin
C. Integrin
D. Magainin
E. Saporin

53. The ED refers a 25-year-old to you with a history of traumatic right knee pain and swelling. You take a detailed history and note that this young man suffers from a bleeding disorder. His radiographs show a 'squared patella'.
What is the commonest type of this bleeding disorder and how is it inherited?
A. Factor VII deficiency and X-linked dominant
B. Factor VIII deficiency and X-linked dominant
C. Factor VIII deficiency and X-linked recessive
D. Factor IX deficiency and autosomal dominant
E. Factor IX deficiency and X-linked dominant

54. A 35-year-old chartered accountant presents to you with a history of right knee pain and swelling. There is no history of trauma. Blood investigations are within normal limits. Radiographs do not show any obvious bony abnormality. You organise an ultrasound examination which reveals a markedly thickened synovium, but the radiologist advises an MRI scan for understanding the pathology better. MRI scan reveals a prominent low signal intensity on T2-weighted images and a 'blooming' artefact from haemosiderin seen with gradient-echo sequences.
What is this young man suffering from?
A. Haemophilia A
B. Haemophilia B
C. Non-specific synovitis of the knee joint
D. Pigmented villonodular synovitis
E. Synovial sarcoma

55. You review a 64-year-old retired army personnel in your elective clinic. This patient has been referred by his general practitioner for consideration of bilateral knee arthroplasty. The patient is keen to undergo both knee replacement surgeries in the same sitting (SBTKA – simultaneous bilateral total knee arthroplasty) because his friend had a good outcome from such a procedure. You discuss the procedure in detail and consent him.
Which of the following statements is incorrect about SBTKA?
A. Haemoglobin of less than 11g/dl and Jehovah's Witness patients should not be offered SBTKA
B. On comparing SBTKA with staged bilateral total knee replacements 3 months apart, fit and healthy patients undergoing SBTKA have equivalent or better outcomes than those who undergo staged BTKA
C. Patients undergoing SBTKA have a lower post-operative 30-day mortality rate
D. Patients undergoing SBTKA have faster return to work, faster recovery and lower overall pain medication requirement
E. Simultaneous bilateral tourniquet deflation has shown reperfusion injury and has resulted in cases of cardiac arrest immediately after deflation

56. On a busy Orthopaedic on-call you are referred a case of a newborn with an abnormal-looking

knee joint. You review the patient and diagnose this condition as a case of 'congenital dislocation of the knee'.

Which of the following is not associated with congenital dislocation of the knee?

A. Abnormal foetal malposition of hyperflexion
B. Congenital absence of the cruciate ligaments
C. Fibrosis of the quadriceps
D. Intrauterine ischaemia causing compartment syndrome – like fibrosis
E. Maternal history of herpes

57. You review a 9-year-old child in your elective clinic with a vague history of pain in his knee. There is no known history of trauma and blood investigations are within normal limits. Your working diagnosis is that of osteochondritis dissecans.

While examining this patient you flex his knee to 90°, then internally rotate the tibia as the knee is extended from 90° toward full extension. The patient has pain at approximately 30° short of full extension.

What is the name of this clinical sign?

A. Destot's sign
B. Grey Turner's sign
C. Gower's sign
D. Kehr's sign
E. Wilson's sign

58. A retired football player is referred to your elective clinic with a history of bilateral knee pain. Radiographs reveal that he has advanced osteoarthritis. The patient tells you that he always had slightly 'curved' knees since childhood but had no concerns and played football at a very competitive level. He wants to discuss the need for knee arthroplasty surgery.

With regards to restoration of alignment in this particular case, which of the following statements is true?

A. Development of varus knee deformity is due to increased compression on the medial side and accelerated growth on the lateral side. This is explained by Wolff's law
B. In the classic alignment philosophy the surgeon aims to obtain a perpendicular implant position with reference to the anatomical axis of tibia and femur in the coronal plane
C. Intense sporting activities during growth leads to varus knees and this typically occurs during the end of growth spurt
D. 'Kinematic alignment' and 'constitutional alignment' are two different types of knee alignments
E. Perpendicular cuts on the distal femur and tibia do not change the orientation of the medial and lateral joint lines

59. You are consenting a patient for total knee arthroplasty and explain about the potential complication of extensor mechanism disruption.

With regards to quadriceps tendon rupture which of the following statements is false?

A. Chronic kidney disease is not a risk factor for quadriceps rupture
B. Patients with diabetes mellitus have a higher risk of quadriceps rupture
C. Patients with rheumatoid arthritis have a higher risk of quadriceps rupture
D. Previous multiple knee surgeries are a known risk factor
E. The incidence of quadriceps rupture is less than 1%

60. You consult a 55-year-old lady with post-traumatic knee arthritis for a total knee arthroplasty. This patient was in a road traffic accident years ago and injured her knee which led to the early onset of osteo-arthritis. She tells you that she lost a dear friend in that accident and has been on antidepressants since then. She also has a history of fibromyalgia. With regards to her knee replacement surgery, she is particularly worried about post-operative pain.

As her primary surgeon what should you be concerned of in this case?

A. There is a very high risk of chronic regional pain syndrome (CRPS) in this patient and she should be commenced on vitamin C 1 month before her proposed surgery date
B. This patient can be a potential pain catastrophiser and her post-operative pain symptoms should be quantified using a PCS quantification scale
C. This patient has post-traumatic stress disorder and should be referred for counselling before surgery
D. This patient is at a high risk of suicide and immediate psychiatric opinion should be sought

E. This patient is normal and does not need anything special. She should be listed for surgery and post-operative pain managed as per routine

61. In your elective clinic a 75-year-old well-controlled diabetic patient is consented for a total knee arthroplasty. This patient has a history of recurrent urinary tract infections in the past and is currently awaiting a colonoscopy for irregular bowel movements. His blood reports are within normal limits.

With regards to haematogenous infectious after a total knee arthroplasty, the rate of bacteraemia after invasive procedures is highest with which of the following procedures?

A. Dental procedures
B. Ear and nasal procedures such as mastoidectomy and polypectomy
C. Gastrointestinal procedures such as colonoscopy
D. Laparoscopic cholecystectomy
E. Urogenital procedures

62. Concerning knee examination tests to diagnose a meniscal tear.

In which of the following tests does the joint line tenderness change position with flexion and extension?

A. Apley grind
B. Bragard
C. Duck walking
D. McMurray
E. Steinmann second

63. A 15-year-old school student is referred to your elective knee clinic by his general practitioner with a 3-month history of right knee pain. The boy is a centre forward in his school football team. He does not recollect any trauma to his knee. Your examination reveals that he has a stable knee. His blood investigations are within normal limits. You perform a radiograph followed by an MRI scan (Figure 6.3).

What is this image suggestive of?

A. Brodie's abscess
B. FOPE (focal periphyseal oedema)
C. Osteochondritis dissecans
D. Osteoid osteoma
E. Salter Harris Type 1 injury

64. In a follow-up clinic you review a 26-year-old young man who underwent ACL ligament reconstruction 3 months ago. His primary complaint is inability to completely straighten his leg. He tells you that he is still doing his exercises as taught by the physiotherapist but is unable to gain complete knee extension. On examination his knee is stable, and you have no concerns about graft stability. Clinically you feel that 'graft impingement' has led to his symptoms.

Which of the following statements is false with regards to ACL graft impingement?

A. Abnormal contact between ACL graft and roof of the intercondylar notch on an MRI scan
B. Increased signal intensity between distal two-thirds of the graft on an MRI scan
C. Roof osteophytes abutting the ACL graft on an MRI scan
D. The best radiograph for ACL graft impingement is a hyperextension lateral radiograph
E. The Multicenter ACL Revision Study (MARS) group stated that approximately 30% of patients undergoing revision ACL reconstruction had no impingement

65. A 17-year-old college student is referred to your clinic with a complaint of recurrent patella dislocation. The patient's symptoms are primarily of locking and pain.

Figure 6.3
MRI scan knee

On examination of this patient how can you clinically differentiate between a locking episode due to patellar pathology versus a locking episode due to a meniscal tear?

A. Locking episodes due to patellar subluxation and meniscal tear are similar and cannot be differentiated on clinical examination
B. Locking episodes in patellar subluxation are constant and painless
C. The knee is not able to flex or extend in a locking episode because of patellar pathology whereas in a bucket handle tear of meniscus the knee can be further flexed
D. Pain is very well defined and located posteriorly
E. In a bucket handle tear of meniscus there is no restriction to terminal extension

66. A 56-year-old professor of economics presents to the emergency department on a Saturday with a bilateral knee injury while playing a game of tennis. He tells you that he does not regularly play tennis. On examination of his knees you notice a bruise and swelling just proximal to the knees and he is unable to do a straight leg raise bilaterally.

What is the genetic link associated with the injury of this patient?

A. COL1A2
B. COL1A1
C. COL5A1
D. GDF5
E. HOXB9

67. A 45-year-old accountant presents to the ED with a history of a fall while playing cricket. The patient fell with a direct impact on his left knee. Radiographs reveal that he has a patella fracture.

With regards to the biomechanics of the patella, which of the following statements is incorrect?

A. A decrease in the moment arm of the extensor mechanism is caused by the patella by anterior displacement from the knee's centre of rotation
B. A total patellectomy can result in up to 50% decrease in isokinetic strength testing of the extensor mechanism
C. From full flexion to 45°, the load is shared between tendinous portion of the extensor mechanism and the patella
D. The only component of the extensor mechanism in contact with the distal femur is the patella at less than 45° of knee flexion
E. The terminal 15° of knee extension require twice the torque required to extend the knee from full flexion to 15°

68. An 18-year-old male is referred to your elective knee clinic with an atraumatic history of right knee pain. There is no significant past medical history and all his blood investigations are within normal limits. His MRI is shown in Figure 6.4. A consultant radiologist has reported this as a benign lesion and suggests imaging the other knee to look for bilaterality.

A. Fibrous cortical defect
B. Osteoid osteoma
C. Dorsal defect of patella
D. Non-ossifying fibroma
E. Ewing's sarcoma

Figure 6.4 MRI scan knee

KNEE I STRUCTURED SBA ANSWERS

1. Answer C. **Semitendinosus tendon**
   To accurately perform the posteromedial incision, the semitendinosus tendon, flexion crease and medial head of the gastrocnemius are used for anatomical reference. In grossly swollen patients with distorted anatomy, finding the semitendinosus tendon is an easy structure to identify and can be helpful as it has fascial bands connecting it to the medial head of the gastrocnemius muscle thereby allowing you to confirm the correct plane of dissection.

2. Answer E. **Popliteus**
   The popliteus tendon is the most anterior femoral attachment of the posterolateral corner and as per Laprade (2014) in his anatomical dissections is on average 18.5mm anterior to the femoral attachment of the LCL with the knee at 70° flexion (Figure 6.5).

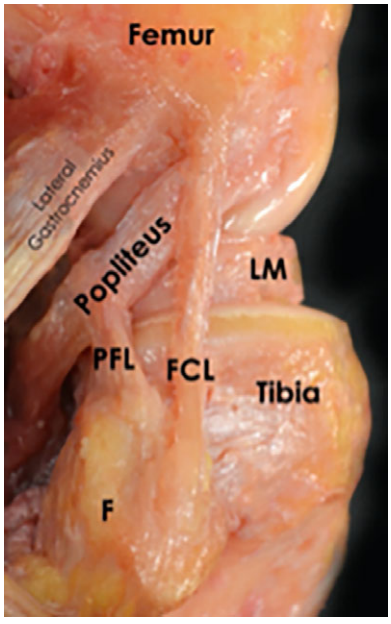


Figure 6.5
Popliteus tendon

Laprade RF et al. Improving outcomes for posterolateral knee injuries. *J Orthop Res.* 2014;**32**:485–491.

3. Answer A. **Medial collateral ligament**
   The superficial and deep portions of the MCL function in close association with the structures of the PMC; they are, however, not typically considered to be part of the PMC. The PMC is typically formed of 5 main components: the semimembranosus tendon and expansions, the oblique popliteal ligament, the posterior oblique ligament, the posteromedial joint capsule and the posterior horn of the medial meniscus.

   Dold AP, Swensen S, Strauss E, Alaia M. The posteromedial corner of the knee: anatomy, pathology, and management strategies. *J Am Acad Orthop Surg.* 2017;**25**:752–761.

4. Answer A. **Common peroneal nerve**
   One of the first structures you should identify when performing a PLC reconstruction is the common peroneal nerve, which is at risk of injury if not identified and protected throughout.

   The LCL and popliteus are useful to identify and repair but not essential when performing a reconstruction. The ITB is incised as part of the approach. The tibial nerve should not be seen during this approach.

5. Answer B. **2–3 times body weight**
   The forces at the knee increase significantly with increasing degrees of flexion. At about 45° of flexion (needed to climb the stairs), joint reaction forces are about 2–3 times body weight.

   When walking on the flat, joint reaction forces equal roughly 0.5 times body weight.

   When squatting, joint reaction forces equal roughly 7–8 times body weight.

   When jumping, joint reaction forces can increase to over 20 times body weight.

   Masouros S, Bull A, Amis A. Biomechanics of the knee joint. *Orthop Trauma* 2010;**24**:84–91.

6. Answer E. **SF-30**
   The SF-36 is a popular general health outcome measure; the SF-30 is not.

   KOOS (Knee Injury and Osteoarthritis Outcomes Score) is useful in evaluating soft tissue knee injuries.

   IKDC (International Knee Documentation Committee) is useful in evaluating symptoms, function and activity.

   Lysholm Score was developed to evaluate knee ligament surgery.

   Oxford Knee Score was designed for patients with knee arthritis.

7. Answer B. **Pigmented villonodular synovitis**
Pigmented villonodular synovitis (PVNS) is a benign proliferative condition of the synovial membrane and tendon sheath. In the knee, patients can present with a painless effusion and symptoms of locking, catching and instability. It is characterised by synovial inflammation and haemosiderin deposits.

Lipoma arborescens is a slow-growing benign intra-articular lesion whereby the normal synovial tissue is replaced by adipose tissue. The macroscopic appearance is like a tree, hence the Latin for *arborescens* meaning 'treelike'. It can present the same way as PVNS, however the presentation is more common in the middle to older aged group, and most likely localised to one part of the joint such as the suprapatella pouch unlike the MRI demonstrated which is more generalised.

Patients with rheumatoid arthritis demonstrate generalised synovial hyperplasia with panus formation on MRI. Other signs on MRI would be subchondral cysts and erosions, juxta-articular bone oedema, and decreased thickness of cartilage.

Synovial cell sarcoma is an intermediate to high grade soft tissue sarcoma. Although the knee is one of the most common sites for this tumour it arises from the soft tissues surrounding the knee rather than within the knee itself.

Synovial chondromatosis (otherwise called Reichel syndrome) can be primary (unknown aetiology) or secondary (known aetiology such as trauma, osteoarthritis or neuropathic arthropathy). This condition is characterised by abnormal synovial growth of cartilage, which then breaks off thereby creating floating bodies of cartilage which if calcified can damage the joint further. The condition is most common in 30–50-year-old males.

8. Answer E. **Outside-in meniscal repair kit**
Typically, the anterolateral portal is placed blind; therefore, to reduce iatrogenic injury to the anterior horn of the lateral meniscus, this portal should be placed high. Inferior placement risks creating a radial tear in the anterior horn of the lateral meniscus.

Anterior horn tears are best approached from outside-in, purely from a point of view of direction of instruments in relation to direction and area of the tear. Anterior tears can also be approached using inside-out techniques using an introducer with a 90° curve, however this was not part of the answer stem. Using an all-inside technique usually does not allow the surgeon to accurately position the repair sutures and is not the preferred method.

Although chondral and ligament injuries can occur with poor arthroscopic technique, these are not the main risk with inferior placement of the anterolateral portal.

9. Answer D. **List for arthroscopy + saucerisation +/– meniscocapsular repair**
Three or more contiguous 5mm-thick sagittal images of the meniscus from anterior to posterior horns is suggestive of a discoid meniscus. 'Snapping knee syndrome' in the presence of a discoid meniscus is suggestive of defective posterior meniscocapsular attachments, thus allowing increased mobility of the meniscus.

The treatment of choice of symptomatic patients is saucerisation and repair of the posterior meniscocapsular deficiency if needed.

An asymptomatic discoid meniscus does not require treatment.

10. Answer B. **Discharge with no follow up**
The MRI is suggestive of a discoid lateral meniscus. Having a minimal meniscal width to maximal tibial width (on coronal slice) of >20% and having a ratio of the sum of the width of both lateral horns to the maximal meniscal diameter (on sagittal slice) >75% is highly suggestive of a discoid meniscus (sensitivity 95% and specificity 97%). Other MRI findings of a discoid meniscus is three or more 5mm-thick contiguous sagittal slices from anterior to posterior horns. Regardless of diagnosis, this is an incidental finding, and the asymptomatic patient can be reassured and discharged.

11. Answer E. **Tibial eminence hypoplasia**
The MRI findings suggest a symptomatic lateral discoid meniscus. Plain X-ray findings associated with a lateral discoid meniscus include (1) widening of the lateral joint space, (2) squaring of the lateral femoral condyle, (3) cupping of the lateral tibial plateau and (4) tibial eminence hypoplasia.

12. Answer D. **Popliteal artery injury**
Drilling under X-ray guidance reduces the risk of perforating too far into the popliteal fossa. Tibia

tunnel placement can be improved using X-ray; however, it is mainly dictated by visualisation through a posteromedial portal, clearance of the PCL tibial footprint and usage of a PCL jig.

13. Answer B. **You had not fully released the extratendinous tethers to the medial head of gastrocnemius**
The hamstring tendons typically have extratendinous tethers that require release. This is particularly prevalent for the semitendinosus, which quite reliably has a number of tethers between itself and the medial head of gastrocnemius up to 10cm proximal from its distal attachment. If these are not released prior to tendon stripping, then the tendon stripper can follow the attachment rather than the true tendon, thereby amputating the tendon prematurely.

The Dial test is used to identify PCL and PLC injuries clinically. This should be done preoperatively, as patients with a PLC injury that has not been identified prior to ACL reconstruction have a higher rate of graft failure.

Both a closed loop tendon stripper and an open loop stripper can be used to harvest the graft.

A harvest wound that is small will make graft harvest more difficult and will make it more difficult to release the tethers; however, the wound length is not the primary cause of graft amputation.

Releasing the semitendinosus from the sartorial fascia can be done before or after graft harvest.

14. Answer D. **Hamstring autograft**
The medial side of the foot is supplied by the saphenous nerve. Saphenous nerve injury can be a complication of hamstring graft harvest.

Possible complications with BTB autograft would be patella fracture or persistent anterior knee pain.

Possible complications with quadriceps autograft would be quadriceps rupture.

Possible complications with allograft are disease transmission and higher risk of re-rupture.

15. Answer B. **The entry point for the tibial tunnel is 2mm anterior to the anterior horn of the lateral meniscus**
The ideal tibial tunnel entry point is about 2mm posterior to the anterior horn of the lateral meniscus. If the tibial tunnel is too anterior, then this can cause impingement in extension and an extension block.

The entry point for the femoral tunnel is 2 or 10 o'clock (depending on the side). If the femoral tunnel is too vertical, then this can lead to rotational instability of the graft rather than extension block.

Tensioning of the graft should ideally be made in about 30° of knee flexion.

Cortical blowouts can occur during tunnel reaming and are dealt with by changing your fixation strategy; one such way is to use a larger suspensory button (which rarely causes issues).

There are a number of different techniques to deal with premature amputation of a hamstring graft. One such way is to use an alternative graft such as a bone–patella–tendon–bone graft. This type of graft may have a larger diameter than a proposed quadrupled hamstring therefore might cause impingement issues, but these should not occur if the tibial tunnel has an accurate placement.

16. Answer A. **The surgeon failed to address the anterolateral complex**
The anterolateral ligament complex is now widely understood to be a secondary stabiliser for the ACL for rotational stability. Injury of it can be demonstrated radiographically by the presence of a Segond fracture; however, the lack of a Segond fracture does not mean the anterolateral complex is not injured. Sonnery-Cottet et al. (2017) have shown a significantly reduced rate of graft rupture in young patients returning to pivoting sports when they have a combined ACL and ALL reconstruction as opposed to an isolated ACL reconstruction. This is further backed up by the results of the International Anterolateral Complex Consensus Group Meeting (Getgood et al. 2019).

The posterolateral complex is an important structure to address if injured and would lead to increased re-rupture rates if not addressed; however, a negative Dial test would suggest the PLC is intact.

A tibial graft tunnel that is too anterior can lead to impingement in extension and graft

failure; however, this is unlikely in this scenario as the patient states they were happy during their rehabilitation.

There is a lack of consensus as to the best type of graft to use; both hamstring autograft and patella tendon autograft are acceptable choices.

Sonnery-Cottet B et al. Anterolateral ligament reconstruction is associated with significantly reduced ACL graft rupture rates at a minimum follow-up of 2 years: a prospective comparative study of 502 patients from the SANTI Study Group. *Am J Sports Med.* 2017;**45**:1547–1557.

Getgood A et al. The anterolateral complex of the knee: results from the International ALC Consensus Group Meeting. *Knee Surg Sports Trauma Arthroscopy* 2019;**27**:166–176.

17. Answer B. **Downsize the femur and use a thicker insert**
Downsizing the femur using anterior referencing increases the flexion gap, thereby making this knee looser in flexion. The flexion-extension gap will therefore be loose in both flexion and extension which can then be corrected by inserting a thicker insert.

With regards to the other options, resecting more bone off the femur will increase the extension gap (upsizing the femur will only change the flexion gap or PFJ). Using distal femoral augments is an option; however, anteriorising the femoral component will overstuff the PFJ and cause a loose flexion gap. Resecting the PCL increases the flexion gap however the question states a PS technique is used therefore the PCL should already be released. Resecting more bone off the tibia will increase the flexion and extension gap and will not balance the knee.

18. Answer E. **Upsize the femur**
If you have a loose knee in flexion, all of the following will reduce the flexion gap: Upsizing the femur using anterior referencing, using a thicker insert, posteriorising the femoral component.

Proximalising the femur and using a thicker insert will balance the knee; however, proximalising the femur is a bigger undertaking than upsizing the femur. Posteriorising the femoral component will notch the femur if using anterior referencing and therefore is not recommended.

19. Answer B. **CT rotational profile of the leg**
The history is not really pointing you towards a diagnosis of infection (although this should remain a potential diagnosis). Someone who has no history of infection or trauma and states they were 'never really happy' with their knee should point you towards malrotation of the components. Bell et al. (2014) demonstrate that internal rotation of the tibial or femoral components increases the risk of ongoing knee pain. One reason for internal rotation leading to poor outcomes is that this interferes with patella tracking in a negative way, increasing lateral patella facet wear, clunking and anterior knee pain.

Bell SW et al. Component rotational alignment in unexplained painful primary total knee arthroplasty. *Knee* 2014;**21**:272–277.

20. Answer D. **Release the popliteus**
In a valgus knee, the following lateral compartment release maybe required: (1) osteophytes, (2) lateral capsule, (3) iliotibial band, (4) popliteus. The LCL can be released; however, if you are requiring to do this, you should be thinking about increased constraint.

Release of the PCL, downsizing the femoral component and resecting more off the tibia will universally increase the flexion gap; however, in this case it is only tight laterally in flexion.

21. Answer D. **On measuring the femoral component size using posterior referencing, it measured 4.5 and the decision was made to use a size 4 implant, as a size 5 may overstuff the PFJ**
When using posterior referencing, the femoral component size is measured referenced off the posterior femoral condyles. If downsizing (as in this case), then you risk notching the femur, which introduces a point of weak bone and increases the risk of periprosthetic knee fractures. When using posterior referencing and wanting to downsize the femoral component, then anteriorising the cutting jig will mitigate the risk of notching; however, doing so carries the risk of overstuffing the PFJ.

All other responses are valid intraoperative decisions.

22. Answer B. **Due to poor patella tracking, a lateral retinacular release was performed**
The radiographic changes are consistent with osteonecrosis of the patella. Performing a lateral retinacular release can damage the lateral superior genicular artery, which supplies the patella (the other arterial supply being the medial superior genicular artery, which is incised during a medial parapatellar approach).

Denervation of the patella has not been demonstrated to increase this complication.

There is no good evidence for or against patella resurfacing; therefore, not resurfacing the patella is a valid surgical decision.

Rotating the femur externally is an important step in total knee replacements and helps with patella tracking.

Anteriorising the femoral component can overstuff the PFJ and lead to anterior knee pain, but is unlikely to lead to such aggressive presentation as above.

23. Answer E. **Two-stage revision**
A WCC over 2500 and a PMN count of over 70% is indicative of infection. This, coupled with the increasing pain and osteolysis, leads to the most likely diagnosis being prosthetic joint infection. Arthroscopic washout and DAIR procedures are not applicable in chronic infections. A bone scan can be a useful investigation; however, it is likely to be positive in the presence of the above and therefore unlikely to be helpful. As culture did not grow anything, there is an argument to repeat the aspiration; however, this is not in the answer stem. A one-stage revision for infection is best performed when the organism is known and is an easily treated organism; as we do not know the organism, the most appropriate management is offering a two-stage revision.

24. Answer A. **Dorsal aspect of the foot**
During correction of a valgus knee to neutral mechanical alignment, the common peroneal nerve can be stretched. This would lead to sensory disturbance over the dorsal aspect of the foot and foot drop.

25. Answer C. **An Insall–Salvati ratio of 0.7**
Insall–Salvati (normal 0.8–1.2) and Caton–Deschamps (normal 0.6–1.3) are assessments of patella height. An Insall–Salvati ratio of 0.7 demonstrates patella baja, which can make a TKA more difficult.

Dejour grade C represents a degree of trochlear dysplasia; this on its own does not increase TKA difficulty. A bipartite patella is a normal variant.

TT–TG is a measurement of the distance from the tibial tubercle to the trochlear groove in the axial plane. It is a useful measurement in patella instability. A TT–TG of 0–15mm is normal, 15–20 borderline, >20 abnormal.

26. Answer A. **0–95° range of movement**
You need at least 110° of knee flexion to perform an Oxford knee replacement. This will allow you good access to the femur during preparation.

Previous scars can make surgery more challenging; however, arthroscopy scars are fine. You can perform an Oxford knee on knees with up to 15° of fixed flexion or correctable varus. Age is not a contraindication.

27. Answer B. **Arthroscopic synovectomy, removal of loose bodies and histopathological analysis**
This presentation is consistent with synovial chondromatosis. This is a benign proliferative disease of the synovium characterised by multiple intra-articular loose bodies of cartilage at various stages of calcification. This is most prevalent in the fourth or fifth decade, with males being more commonly affected. The knee is by far the most commonly affected joint. Malignant change into synovial chondrosarcoma is rare.

Synovial chondromatosis is best managed with arthroscopic removal of loose bodies and synovectomy. The chance of local recurrence is reasonably common, with studies quoting between 3% and 23%.

28. Answer C. **Reassure and discharge with anti-inflammatory medication**
Pseudogout (calcium pyrophosphate dihydrate deposition) is characterised by effusion and weakly positive birefringent crystals on joint microscopy. It is more common in the elderly population. X-ray findings can demonstrate chondrocalcinosis and erosions, but in the early stages can be normal. Causes can be idiopathic, hereditary (AD pattern) or secondary to another systemic disease such as haemochromatosis, hyperparathyroidism, hypothyroidism, SLE or

renal disease. Treatment of pseudogout includes anti-inflammatory medication, steroid joint injection and management of the causative condition if present.

If there were signs consistent with septic arthritis, then joint washout or admitting awaiting full culture results would be appropriate.

An MRI would be appropriate if there was a history of trauma with a normal knee X-ray.

Gout is negatively birefringent on joint microscopy, and management includes starting anti-inflammatory medication for an acute flare-up with allopurinol started in the community once the acute flare-up has improved.

29. Answer E. **3000 N – 4000 N**
Four-strand hamstring has one of the highest load to failure of graft choice for ACL reconstruction. Other options include allograft (2000 N – 4000 N) which has a wide range of load to failure as its strength can change significantly depending on sterilisation technique, quadriceps tendon (3000 N), or middle third patella tendon (2500 N – 3000 N). The native ACL has a load to failure of around 2000 N.

30. Answer C. **MCL injury**
All of the answer stems will increase the chance of the UKA failing. However, a 9mm insert is one of the largest inserts available and would raise the suspicion that the MCL was injured intraoperatively and the surgeon struggled to balance the knee.

31. Answer D. **Opening wedge HTO + nanofracture/AMIC**
This patient's issues are twofold. Firstly, they have a full thickness cartilage defect which is likely causing their pain, but just as important they have malalignment of their limb with a weight bearing line (Mikulicz) transversing the medial compartment. When addressing cartilage defects it is best to correct alignment issues and instability issues first or in conjunction with treatment of the cartilage defect. With a varus malalignment an opening wedge high tibial osteotomy is a good option for correction. Closing wedge distal tibial osteotomies are a good option for valgus malalignment.

With regards to treatment of the cartilage defect, this is $<4cm^2$ therefore amenable to nanofracture or AMIC (Autologous Matrix-Induced Chondrogenesis). OATS (Osteochondral Autologous Transfer Surgery) is normally reserved for larger defects of $>4cm^2$.

32. Answer E. **Refer to regional centre for consideration of meniscal transplantation**
This patient has had a previous irreducible lateral meniscal bucket handle tear which will have been resected. Their leg alignment is normal so there is no requirement for any corrective osteotomy. The 2015 consensus statement from the IMREF (Getgood et al. 2017) provided 3 indications for meniscal transplantation: (1) symptomatic meniscal deficient knee, (2) concomitant procedure to protect revision ACL reconstruction and (3) concomitant procedure to protect cartilage repair.

Meniscal transplantation is relatively rare, however there is an expanding amount of evidence to suggest it is a good option in the correct individual. Within the UK there is ongoing research into this topic with the Meteor 2 study currently underway which will assess if there is any significant difference between meniscal transplantation vs dedicated physiotherapy alone.

Getgood A et al.; IMREF Group. International Meniscus Reconstruction Experts Forum (IMREF) 2015 Consensus Statement on the Practice of Meniscal Allograft Transplantation. *Am J Sports Med.* 2017;**45**:1195–1205.

33. Answer D. **Hand-wrist bone age of 14**
Hand-wrist bone age radiographs are very useful at helping to identify the true bone age of the patient and therefore how much growth they have left. With a bone age of 14 the patient likely has at least a couple more years of growth remaining. Growth in children is complex but can be divided into four time periods: (1) antenatal growth, (2) birth to 5 years of age, (3) 5 years of age to puberty, (4) puberty. Peak lower-limb growth during puberty occurs around age 14 in boys and 12 in girls (Kelly & Diméglio 2008). One should be careful about performing surgery around the proximal tibial or distal femoral growth plates in this age group. To reduce risk of growth arrest delaying surgery until skeletally mature may be the better option.

A Caton–Deschamps ratio of 1.4, Dejour grading B and TTTG 21mm all fit with patello-femoral instability. A foot progression angle of 12° is within normal range.

Kelly PM, Diméglio A. Lower-limb growth: how predictable are predictions? *J Child Orthop.* 2008;**2**:407–415.

34. Answer B. **Lateral radiograph with medial wear posteriorly**
A lateral radiograph with posterior wear would lead to a high suspicion of ACL incompetency, which increases the risk of early failure in mobile bearing UKAs.

All the other answer stems are acceptable to continue with a UKA.

35. Answer C. **Medial locking plate**
The patient describes instability symptoms with the most likely ligament injury that would relate to these symptoms being an ACL injury. ACL injuries are most common in high energy type 4 and type 6 injuries, which would likely require a medial plate. Anterolateral plates are commonly used but in isolation would be for lower energy type 1–3 injuries. Posterolateral buttress plates are uncommon to use in isolation. Subarticular raft screws can also be useful in complex fractures but in isolation they do not provide much mechanical strength therefore are usually utilised in conjunction with a buttress or locking plate.

Wang J, Wei J, Wang M. The distinct prediction standards for radiological assessments associated with soft tissue injuries in the acute tibial plateau fracture. *Eur J Orthop Surg Trauma.* 2015;**25**:913–920.

36. Answer D. **Theatre listing for arthroscopy**
As the patient has had a medial plate applied they have likely sustained a type 4 tibial plateau fracture. The overall incidence of additional soft tissue injuries in tibial plateau fracture is around 71%. Schatzker type 4 injuries carry a higher risk of medial meniscal tears and ACL tears. As the patient has a stable knee to examination the likely diagnosis is a medial meniscal tear.

Abdel-Hamid MZ et al. Arthroscopic evaluation of soft tissue injuries in tibial plateau fractures: retrospective analysis of 98 cases. *Arthroscopy* 2006;**22**:669–675.

37. Answer D. **You relied on the Schatzker classification to aid management**
The Schatzker classification was originally proposed in 1974 and based on a two-dimensional representation of the fracture in the coronal plane. Although it is widely used, it fails to address the posterior column as described by Luo et al. (2010), and therefore is not a good classification system to aid fixation strategies. Schatzker type 6 fractures are the most common fracture type to have a posterior column component, as identified on CT scan, and present in 59% of bicondylar fractures (Higgins et al. 2009). Around 25% of the articular surface is involved in the posterior fragment therefore it is important to reduce and stabilise. Patients who have a posterior column fracture that is not addressed in the definitive fixation have a significantly higher risk of failure of fixation.

Higgins TF, Kemper D, Klatt J. Incidence and morphology of the posteromedial fragment in bicondylar tibial plateau fractures. *J Orthop Trauma.* 2009;**23**:45–51.

Luo CF, Sun H, Zhang B, Zeng BF. Three-column fixation for complex tibial plateau fractures. *J Orthop Trauma.* 2010;**24**:683–692.

38. Answer D. **The metalwork becomes infected**
There is a wide range of infection rate for these types of fractures in the literature. Risk of infection in these high-energy type fractures ranges from around 22% (Guild et al. 2022) to 80% (Musahl et al. 2009). Historically, a single midline incision, as is the case in this scenario (previous BTB), carries the concern of producing a 'dead bone sandwich'. Guild et al. (2022) however suggest no difference in deep infection rate with single vs dual approaches (22% vs 23.5%).

Risks of metalwork failure are relatively low when bicondylar, 2-column fractures are treated with dual plates. Risk of failure if the patient also has a posterior column fracture (i.e. a 3-column injury) is higher if this fracture fragment is not addressed at the same time as the other two columns, however in this scenario the question stem suggests the patient only has a 2-column injury.

Risk of DVT after complex lower limb trauma is high, however symptomatic DVT is relatively low. A study by Wang et al. (2022)

demonstrates 8.4% incidence of clinically important DVT after tibial plateau fracture.

The risk of stiffness is around 20% at 1 year (Gaston et al. 2005).

The risk of having further instability can be higher than the risk of infection, however this was not in the answer stem. A study by Stannard et al. (2010) suggests 71% incidence of at least one major ligament tear following high-energy tibial plateau fracture.

Gaston P, Will EM, Keating JF. Recovery of knee function following fracture of the tibial plateau. *J Bone Joint Surg Br.* 2005;**87**:1233–1236.

Guild TT et al. Single versus dual incision approaches for dual plating of bicondylar tibial plateau fractures have comparable rates of deep infection and revision surgery. *Injury* 2022;**53**:3475–3480.

Musahl V et al. New trends and techniques in open reduction and internal fixation of fractures of the tibial plateau. *J Bone Joint Surg Br.* 2009;**91**:426–433.

Stannard JP, Lopez R, Volgas D. Soft tissue injury of the knee after tibial plateau fractures. *J Knee Surg.* 2010;**23**:187–192.

Wang P et al. Incidence and risk factors of clinically important venous thromboembolism in tibial plateau fractures. *Sci Rep.* 2022;**12**:20206.

39. Answer B. **The use of straight tourniquets on conical thighs is recommended, especially in extremely muscular or obese individuals**

The usage of a tourniquet requires proper knowledge and care. Tourniquets should be used only when clinically justified, such as in elective extremity surgeries or in emergency to control exsanguination.

Tourniquet width should be more than half the limb diameter and should be applied over a thin layer of padding. Application of more than two layers of padding results in a significant reduction in the actual transmitted pressure.

Compressive exsanguination is contraindicated in presence of infection, malignancy or history of deep venous thrombosis.

Wide tourniquet cuffs are more effective at lower inflation pressures than are narrow ones. Curved tourniquets on conical extremities require significantly lower arterial occlusion pressures than straight (rectangular) tourniquets. The use of straight tourniquets should be avoided in obese or extremely muscular individuals.

BSSH and BSCOS (BOAST) *The Safe Use of Intraoperative Tourniquets* [pdf]. London: British Orthopaedic Association; 2021.

Pedowitz RA et al. The use of lower tourniquet inflation pressures in extremity surgery facilitated by curved and wide tourniquets and an integrated cuff inflation system. *Clin Orthop Relat Res.* 1993;**287**:237–244.

40. Answer D. **The entire anterolateral ligament is visible from its proximal insertion to its distal insertion, with excellent agreement between ultrasound and anatomical findings**

The radiograph demonstrates a Segond injury. Segond identified the anterolateral ligament in 1879. It was earlier believed to be an anatomic variant of the lateral collateral ligament.

The primary function of the anterolateral ligament is to provide anterolateral stability, preventing anterior subluxation of tibia relative to the distal femur.

The stabilizing force is most significant at 30° and 90° of knee flexion.

Cavaignac et al. (2017) found that the entire anterolateral ligament was visible from its proximal insertion to its distal insertion, with excellent agreement between ultrasound and anatomical findings.

The anterolateral ligament is an extraarticular structure with a clear course from the lateral femoral epicondylar region, running antero-inferiorly to the proximal tibia at a site midway between Gerdy's tubercle and the head of the fibula

The reported MRI sensitivity has a wide variance from 51–98%.

Cavaignac E et al. Historical perspective on the 'discovery' of the anterolateral ligament of the knee. *Knee Surg Sports Traumat Arthrosc.* 2017;**4**:991–996.

Kennedy MI et al. The anterolateral ligament: an anatomic, radiographic, and biomechanical analysis. *Am J Sports Med.* 2015;**43**:1606–1615.

Van der Watt L et al. The structure and function of the anterolateral ligament of the knee: a systematic review. *Arthroscopy* 2015;**31**:569-82.e3.

41. Answer B. **A lateral meniscal cyst**

Lateral meniscal cysts are 3–10 times more common than cysts of the medial meniscus.

Trauma, degeneration, developmental inclusion of synovial cells within the meniscal tissue are some of the theories behind meniscal cysts.

There exists a close correlation between cyst formation and meniscal pathological conditions, most commonly tears of the peripheral portion of the middle third of the lateral meniscus.

Lateral meniscal cysts usually are palpable immediately anterior and proximal to the head of the fibula and anterior to the lateral collateral ligament.

Average size meniscal cysts are characteristically more prominent when the knee is extended and less prominent when the knee is flexed; small cysts may disappear within the joint on flexion. This is known as the 'Pisani' sign.

Scott WN, ed. *Insall & Scott Surgery of the Knee*, 4th Ed., Philadelphia, PA: Churchill Livingstone; 2006.

42. Answer C. **Medial patellar plica**

Synovial plicae are synovial folds, usually classified according to their anatomical relationship to the patella: suprapatellar, infrapatellar, medial patellar and lateral patellar.

The medial patellar plica is most common of these to be of clinical significance.

The medial patellar plica begins just superior to the patella running distally along the medial side wall of the joint and over the medial femoral condyle to insert onto the fat pad. It becomes thickened and inelastic from trauma or chronic inflammation and causes anterior knee pain. A common precipitating cause is a direct blow to the anteromedial knee region, traumatising the plica.

Initial treatment is conservative including activity modification to avoid repetitive flexion and extension. Arthroscopic examination of the knee and resection of the pathological plica may be required, if symptoms are persistent and conservative measures have failed.

Kramer DE et al. The effects of medial synovial plica excision with and without lateral retinacular release on adolescents with anterior knee pain. *J Child Orthop.* 2016;**10**:155–162.

43. Answer C. **The failure rate of allografts is similar to autografts**

Allografts decrease post-operative morbidity, improve cosmesis, decrease operating time and preserve extensor mechanism. This may eliminate some post-operative symptoms of tendinitis or chondromalacia.

The length of time for allograft maturation and the percentage of incorporation of the graft into the ligamentous structure vary.

The failure rates in athletes can be as much as 2–4 times that of autograft.

The potential for infection is low, including hepatitis and bacterial infection.

The possibility of HIV transmission is approximately 1 in 1.5 million.

Abouljoud MM, Everhart JS, Sigman BO, Flanigan DC, Magnussen RA. Risk of retear following anterior cruciate ligament reconstruction using a hybrid graft of autograft augmented with allograft tissue: a systematic review and meta-analysis. *Arthroscopy* 2018;**34**:2927–2935.

Joyce CD, Randall KL, Mariscalco MW, Magnussen RA, Flanigan DC. Bone-patellar tendon-bone versus soft-tissue allograft for anterior cruciate ligament reconstruction: a systematic review. *Arthroscopy* 2016;**32**:394–402.

44. Answer D. **Quadrupled hamstring tendon graft is the strongest at 4140 Newton**

Selection of grafts depends on the tissues available and surgeon's training.

The most commonly grafts are central one third patellar tendon and quadrupled hamstring tendon grafts. Quadriceps tendon is less commonly used.

The ultimate load-to-failure strength of patella tendon is 2977 N, quadrupled hamstring tendon is 4140 N and quadriceps tendon is 2353 N.

Graft creep or stress relaxation of the graft over time is more frequent with hamstring tendons than with ligaments, such as the patellar or quadriceps ligament.

Interference screws fixation provides sufficient strength with bone–patellar tendon–bone grafts. Graft incorporation into bone varies considerably from 3 weeks for bone plugs to more than 3 months for soft tissues.

Brand J Jr, Weiler A, Caborn DN, Brown CH Jr, Johnson DL. Graft fixation in cruciate ligament reconstruction. *Am J Sports Med.* 2000;**28**:761–774.

45. Answer C. **Simultaneously injecting IRAP and IL-10**
IL-1 is the cytokine responsible for inducing protease synthesis, which leads to catabolic changes within articular cartilage. The IRAP gene is interleukin-1 receptor antagonist protein. The IRAP gene was inserted in extracted synovial cells of rabbits using a retroviral vector, which leads to significant anti-inflammatory effects in rabbit knee joints.

IL-10 is known for its anti-inflammatory properties and independent effects on T-cell reactivity. Studies have shown that injecting the genes for both IRAP and IL-10 together resulted in greater inhibition of cartilage breakdown, suggesting that simultaneous gene delivery may be required to treat OA by targeting the activities of multiple inflammatory factors

Bandara G et al. Intraarticular expression of biologically active interleukin 1-receptor-antagonist protein by ex vivo gene transfer. *Proc Natl Acad Sci USA* 1993;**90**:10764–10768.

Evans CH et al. Gene therapy for rheumatic diseases. *Arthritis Rheum*. 199;**42**:1–16.

46. Answer A. **Age >70 years**
Emergency departments frequently have patients with traumatic injuries to their knees. In order to identify patients who are more likely to have a fracture and will therefore require a radiograph, the OTTAWA rules were devised.

Following are the criteria for performing a knee radiograph in a traumatic knee injury as per the OTTAWA rules:

1. Age more than 55 years.
2. Inability to bear weight immediately after injury.
3. Isolated patella tenderness.
4. Tenderness to the head of fibula.
5. Inability to flex the knee to 90°.

Stiell IG et al. Prospective validation of a decision rule for the use of radiography in acute knee injuries. *J Am Med Assoc.* 1996;**275**:611–615.

Tigges S et al. External validation of the OTTAWA knee rules in an urban trauma center in the United States. *Am J Roentgenol.* 1999;**172**:1069–1071.

47. Answer B. **Anterior dislocations are more often associated with intimal injuries because of vessels getting stretched over the distal femur**
The rate of arterial injury is equivalent in both anterior and posterior dislocations. The popliteal artery supplies the majority of the blood supply to the leg. It is a continuation of the superficial femoral artery which passes via the adductor canal into the popliteal fossa. A delay in revascularisation of more than 8 hours can lead to significant rise in the amputation rates from 13 to 86%.

The LEAP cohort reported a 20% incidence of amputation with knee dislocation and vascular injury. Anterior dislocations were associated with intimal injuries because of the vessel stretch over the distal femur whereas posterior dislocations resulted in transection injury secondary to the thrust of the tibia posteriorly into the artery.

Green NE, Allen BL. Vascular injuries associated with dislocation of the knee. *J Bone Joint Surg Am.* 1977;**59**:236–239.

Kennedy JC. Complete dislocation of the knee joint. *J Bone Joint Surg Am.* 1963;**45**:889–904.

Patterson BM et al. Knee dislocations with vascular injury: outcomes in the Lower Extremity Assessment Project (LEAP) Study. *J Trauma* 2007;**63**:855–858.

48. Answer D. **Posterior cruciate ligament reconstruction has a strong association with formation of HO**
Complications are common after knee dislocations. Apart from neurovascular injuries, arthrofibrosis, instability, missed fractures and early degenerative changes commonly occur. Deep venous thrombosis, pulmonary embolism, wound healing and infection are not as common as the ones listed earlier.

A study by Whelan (2014) revealed that PCL reconstruction was the only factor associated with formation of HO and 25% of their patients required an additional surgical intervention to address the knee stiffness.

Complication rates after a knee arthroscopy in patients with knee dislocation is around 4.7% with highest being when PCL reconstruction was performed (20%).

Salzler MJ et al. Complications after arthroscopic knee surgery. *Am J Sports Med.* 2014;**42**:292–296.

Whelan DB, Dold AP, Trajkovski T, Chahal J. Risk factors for the development of heterotopic ossification after knee dislocation. *Clin Orthop Relat Res.* 2014;**472**:2698–2704.

49. Answer B. **Oestrogen is uricosuric**

Men present with symptoms of gout generally between 30 and 60 years of age. Male sex hormones are known to reduce urinary excretion of urate, subsequently leading to a rise in serum uric acid levels. This is precisely the cause why gout in men is delayed until after a few years of attaining puberty.

However, on the other hand oestrogen is known to cause a uricosuric effect and hence women after menopause present with gout, once oestrogen levels start to decrease.

Urate clearance is dependent on kidney function and patients with impaired renal function have hyperuricaemia and subsequently suffer from gout.

Oily fish such as sardine, mackerel and herring are rich sources of purine and hence lead to gout because of increased purine breakdown products.

Choi HK, Curhan G. Gout: epidemiology and lifestyle choices. *Curr Opin Rheumatol.* 2005;**17**:341–345.

Hak AE, Choi HK. Menopause, postmenopausal hormone use and serum uric acid levels in US women – the Third National Health and Nutrition Examination Survey. *Arthritis Res Ther.* 2008;**10**:R116.

50. Answer C. **Positive test for rheumatoid factor**

Rheumatoid factor (RF) test is negative in the CASPAR criteria for psoriatic arthritis.

The Classification Criteria for Psoriatic Arthritis (CASPAR) explains the spectrum of this disorder by including patients who currently may not have an active psoriasis but have a past or family history of the disorder.

The CASPAR criteria are as follows

Established inflammatory articular disease (joint, spine or entheseal) with three or more of the following:

1. Psoriasis (PsO)
   - Current: Psoriatic skin or scalp disease present today as judged by a physician.
   - History: History of PsO that may be obtained from patient, family physician, dermatologist or rheumatologist.
   - Family history: History of PsO in a first- or second-degree relative according to patient report.
2. PsO: Typical psoriatic nail dystrophy including onycholysis, pitting and hyperkeratosis observed on current physical examination.
3. Negative test for RF: By any method except latex but preferably by enzyme-linked immunosorbent assay (ELISA) or nephelometry, according to the local laboratory reference range.
4. Dactylitis.
   - Current: Swelling of an entire digit.
   - History: History of dactylitis recorded by a rheumatologist.
5. Radiological evidence of juxta-articular new bone formation: Ill-defined ossification near joint margins (but excluding osteophyte formation) on plain radiographs of hand or foot.

Taylor W et al.; CASPAR Study Group. Classification criteria for psoriatic arthritis: development of new criteria from a large international study. *Arthritis Rheum.* 2006;**54**:2665–2673.

51. Answer B. **Bilateral CDK is never associated with any syndromes**

Congenital dislocation of the knee is extremely rare. Prenatal diagnosis is possible by ultrasound.

Clubfoot and hip dysplasia can be present in 50–70% of cases respectively.

Bilateral cases are almost always syndromic and associated with Ehlers-Danlos and Larsen syndrome.

In arthrogryposis and spinal dysraphism one knee may be dislocated while the other may have a flexion deformity.

Abnormal foetal position leads to a unilateral CDK and associated stiffness.

Teratological types present with quadriceps fibrosis and atrophy which develops because of lack of knee movement. This lack of movement also leads to iliotibial band contracture and hypoplasia of the patella.

Bell MJ, Atkins RM, Sharrard WJ. Irreducible congenital dislocation of the knee: aetiology and management. *J Bone Joint Surg Br.* 1987;**69**:403–406.

Bensahel H et al. Congenital dislocation of the knee. *J Pediatr Orthop.* 1989;**9**:174–177.

Jacobsen K, Vopalecky F. Congenital dislocation of the knee. *Acta Orthop Scand.* 1985;**56**:1–7.

Johnson E, Audell R, Oppenheim WL. Congenital dislocation of the knee. *J Pediatr Orthop.* 1987;**7**:194–200.

52. Answer B. **Filaggrin**

Filaggrin is a histidine rich polypeptide which has a role in formation of the skin barrier and keratin filament aggregation. Filaggrin is a highly phosphorylated polypeptide and null mutations are associated with nickel allergy. Histidine-rich polypeptides are nickel chelating agents and may cause accumulation of nickel in stratum corneum, possibly resulting in an allergic reaction in sensitive patients.

Magainin and cecropin are some of the earlier described peptides from higher organisms for which antimicrobial activity was noted.

Saporin is a cytotoxic protein with application in treatment of cancer.

Integrins are receptors used by animal cells to bind to extra-cellular matrix.

Alberts B et al. *Molecular Biology of the Cell*, 4th Ed. New York, NY: Garland Science; 2002.

Novak N et al. Loss-of-function mutations in the filaggrin gene and allergic contact sensitization to nickel. *J Invest Dermatol.* 2008;**128**:1430–1435.

Polito L, Bortolotti M, Pedrazzi M, Bolognesi A. Immunotoxins and other conjugates containing saporin-s6 for cancer therapy. *Toxins (Basel)* 2011;**3**:697–720.

Zasloff M. Magainins, a class of antimicrobial peptides from *Xenopus* skin: isolation, characterization of two active forms, and partial cDNA sequence of a precursor. *Proc Natl Acad Sci USA* 1987;**84**:5449–5453.

53. Answer C. **Factor VIII deficiency and X-linked recessive**

Haemophilia is a rare bleeding disorder with around 1 in 10,000 people born with it. The knee joint is most involved. Classic haemophilia is due to Factor VIII deficiency and is X-linked recessive. Classic haemophilia is also known as Haemophilia A.

The other type of haemophilia due to Factor IX deficiency is known as Haemophilia B and is also X-linked recessive.

Haemosiderin deposit due to bleeding in the joint leads to articular cartilage destruction.

Treatment involves arthrocentesis in the acute cases, to relieve the joint of pressure and prevent articular damage due to haemosiderin. Factor replacement has a role in prophylaxis before any planned surgery. Management is always multidisciplinary with an input from the haematologist.

Calviglia HA, Solimeno LP. *Orthopedic Surgery in Patients with Hemophilia.* Milan: Springer; 2008.

Lafeber FP, Miossec P, Valentino LA. Physiopathology of haemophilic arthropathy. *Haemophilia* 2008;**14**(Suppl. 4):3–9.

54. Answer D. **Pigmented villonodular synovitis**

Pigmented villonodular synovitis commonly presents with non-specific symptoms of pain and swelling in the knee joint. It commonly occurs in the younger age group of between 30– 40 years. Mechanical symptoms such as locking are rare.

Ultrasound examination often reveals heterogeneously hypoechoic masses in the Hoffa fat pad, markedly thickened synovium and some non-specific hyperaemia.

MRI scan reveals low signal intensity on the T2 weighted images and a 'blooming' artefact from haemosiderin deposit seen on the gradient echo images. MRI scan is the most accurate screening method used to get a diagnosis.

Haemophilia A and B are bleeding disorders due to Factor VIII and IX deficiency, respectively. Radiologically a 'squaring of patella' is classically visible.

Synovial sarcoma are rare intra-articular tumours of the knee and often can present with a long-standing history of pain and swelling. They

can have rapid progression within a short span of time. Often MRI scans can appear benign and non-specific. A biopsy leads to definitive diagnosis in suspicious cases.

Bui-Mansfield LT, O'Brien SD. Magnetic resonance appearance of intra-articular synovial sarcoma: case reports and review of the literature. *J Comput Assist Tomogr.* 2008;**32**:640–644.

Lafeber FP, Miossec P, Valentino LA. Physiopathology of haemophilic arthropathy. *Haemophilia* 2008;**14**(Suppl. 4):3–9.

LiBrizzi CL, Bitzer AM, Kreulen RT, Meyer CF, Morris CD. Sarcoma happens: a reminder for arthroscopic surgeons. *Cureus* 2022;**14**:e24457.

Ma X et al. Pigmented villonodular synovitis: a retrospective study of seventy-five cases (eighty-one joints). *Int Orthop.* 2013;**37**:1165–1170.

55. Answer C. **Patients undergoing SBTKA have a lower post-operative 30-day mortality rate**

Patients undergoing SBTKA have a higher post-operative 30-day mortality rate when compared with those who undergo a staged procedure. This is largely because of lack of stricter criteria of exclusion of patients with significant cardiovascular disease.

New York University Langone Medical Centre (NYULMC) has laid out exclusion criteria for patients undergoing SBTKA.

The rest of all the statements about SBTKA are correct.

Scott WN. In *Insall & Scott Surgery of the Knee*, 2nd Ed., pp. 1051–1054. New York, NY: Elsevier; 2018.

Zeni JA Jr, Snyder-Mackler L. Clinical outcomes after simultaneous bilateral total knee arthroplasty: comparison to unilateral total knee arthroplasty and healthy controls. *J Arthroplasty* 2010;**25**:541–546.

56. Answer E. **Maternal history of herpes**

Congenital dislocation of the knee has been described as early as the 1800s. It is often associated with syndromes such as Larsen's syndrome. Prenatally congenital dislocation can be diagnosed by ultrasonography.

Congenital dislocation of the knee most often is due to multifactorial causes. Many theories involving intrauterine events have been suggested such as abnormal foetal position of hyperextension, raised intrauterine pressure causing fibrosis secondary to compartment syndrome, absence of both cruciate ligaments and fibrosis of the quadriceps.

Maternal history of herpes has no causative effect on congenital dislocation of the knee.

Katz MP, Grogono BJ, Soper KC. The etiology and treatment of congenital dislocation of the knee. *J Bone Joint Surg Br.* 1967;**49**:112–120.

Middleton DS. The pathology of congenital genu recurvatum. *Br J Surg.* 1935;**22**:696–702.

Shattock S. Genu recurvatum on a foetus at term. *Trans Pathol Soc Lond.* 1891;**42**:280.

57. Answer E. **Wilson's sign**

Children with osteochondritis dissecans may present with anterior knee pain localised either to medial or the lateral side. They may have an antalgic gait.

Wilson's sign is wherein the knee is flexed to 90° followed by internal rotation of the tibia and extension of the knee from 90° toward full extension. This may bring on pain at 30° short of full extension but may not be present always.

Destot's sign is seen in pelvis fracture where ecchymosis is visible superior to the inguinal ligament in scrotum or of thigh.

Grey Turner's sign is seen as flank ecchymosis in cases of retroperitoneal haemorrhage.

Gower's sign is seen in cases of muscular dystrophy which is classically described as a 'climbing up on oneself'.

Kehr's sign is referred pain to left shoulder seen in cases of ruptured spleen.

Conrad JM, Stanitski CL. Osteochondritis dissecans: Wilson's sign revisited. *Am J Sports Med.* 2003;**31**:777–778.

Gowers WR. *A Manual of the Nervous System*, 2nd ed., Vol. 1. Philadelphia, PA: The Classics of Neurology and Neurosurgery Library/ Gryphon editions; 1895.

Rutkow IM. Rupture of the spleen in infectious mononucleosis: a critical review. *Archives of Surgery (Chicago, Ill.: 1960)*, 1978;**113**:718–720.

Turner GG. Local discoloration of the abdominal wall as a sign of acute pancreatitis. *Br J Surg.* 1919;**7**:394–395.

58. Answer C. **Intense sporting activities during growth leads to varus knees and this typically occurs during the end of growth spurt**

Insall and Freeman popularised the 'classic alignment' philosophy with respect to total knee arthroplasty. In this philosophy the surgeon aims to obtain a perpendicular implant position with reference to the mechanical axis of the tibia and femur in the coronal plane.

Perpendicular cuts on the distal tibia and femur lead to systematic distalisation of the lateral joint line.

Varus knee development happens during the end of growth spurt due to intense sporting activities as per Witvrouw et al. (2009).

Kinematic and constitutional alignment are synonymous terms and are used interchangeably by different authors.

Hueter-Volkmann law suggests that compression on the medial aspect of the knee leads to retardation of growth on the medial side, whereas less pressure on the lateral side leads to accelerated growth. This results in an overall constitutional varus alignment of the knee.

Freeman MA, Swanson SA, Todd RC. Total replacement of the knee using the Freeman-Swanson knee prosthesis. *Clin Orthop Relat Res.* 1973;**94**:153–170.

Insall J, Ranawat CS, Scott WN, Walker P. Total condylar knee replacement: preliminary report. *Clin Orthop Relat Res.* 1976;**120**:149–154.

Witvrouw E, Danneels L, Thijs Y, Cambier D, Bellemans J. Does soccer participation lead to genu varum? *Knee Surg Sports Trauma Arthrosc.* 2009;**17**:422–427.

59. Answer A. **Chronic kidney disease is not a risk factor for quadriceps rupture**

Dobbs et al. (2005) from Mayo clinic have reported a quadriceps tendon disruption of less than 1% in a series of 23,800 patients. Partial ruptures are twice as common as complete ruptures.

Diabetes mellitus, rheumatoid arthritis, chronic kidney disease and multiple previous knee surgeries are known risk factors for quadriceps rupture.

Partial ruptures can be managed non-operatively with the knee in extension and protected weight bearing for 4–6 weeks.

Operative treatment for complete quadriceps rupture has complications such as instability of the knee, recurvatum, infection and a re-rupture rate of 40%. The overall complication rate can be as high as 55%.

Dobbs RE, Hanssen AD, Lewallen DG, Pagnano MW. Quadriceps tendon rupture after total knee arthroplasty: prevalence, complications, and outcomes. *J Bone Joint Surg Am.* 2005;**87**:37–45.

Lynch AF, Rorabeck CH, Bourne RB. Extensor mechanism complications following total knee arthroplasty. *J Arthroplasty* 1987;**2**:135–140.

Parker DA, Dunbar MJ, Rorabeck CH. Extensor mechanism failure associated with total knee arthroplasty: prevention and management. *J Am Acad Orthop Surg.* 2003;**11**:238–247.

60. Answer B. **This patient can be a potential pain catastrophiser and her post-operative pain symptoms should be quantified using a PCS quantification scale**

Pain symptom following a total knee arthroplasty can sometimes be a difficult symptom to manage especially in younger patients, patients on opioids and patients with a history of fibromyalgia.

Some patients have a tendency of magnifying or exaggerating their pain symptoms and often may say that 'I wonder whether something serious may happen' or 'I can't stop thinking about the pain'. Such patients are pain catastrophisers.

The Pain Catastrophising Scale (PCS) is a quantifying tool which is useful in treatment of such patients. Pain catastrophising is a multidimensional construct and depends on three dimensions primarily – rumination ('I can't stop thinking how much it is going to hurt'), magnification ('I think this pain will not get better but will worsen') and helplessness ('I don't know how to get rid of this pain').

The PCS scale includes 13 items. Patients respond 'not at all' (scored as a 0 for each item) to 'all the time' (scored as a 4 for each item). The total score ranges from 0 (no catastrophising) to 52 (very high catastrophising).

Escitalopram and transcutaneous electrical nerve stimulation (TENS) have shown some benefit in patients with low PCS scores.

Grosu I, Lavand'homme P, Thienpont E. Pain after knee arthroplasty: an unresolved issue. *Knee Surg Sports Traumatol Arthrosc.* 2014;**22**:1744–1758.

Pinto PR, McIntyre T, Ferrero R, Almeida A, Araújo-Soares V. Predictors of acute postsurgical pain and anxiety following primary total hip and knee arthroplasty. *J Pain* 2013;**14**:502–515.

Sullivan MJ, Bishop SR, Pivik J. The pain catastrophizing scale: development and validation. *Psychol Assess.* 1995;**7**:524–532.

61. Answer A. **Dental procedures**
Acute haematogenous infection after total knee arthroplasty is a significant and persistent problem in many patients. The rate of bacteraemia after invasive procedures is highest with dental procedures.

Urogenital procedures and gastrointestinal procedures are also related with haematogenous infection with gastrointestinal procedures having the lowest association.

Invasive procedures known to cause bacteraemia are to be avoided for 3–6 months after total knee arthroplasty.

Durack DT. Prevention of infective endocarditis. *New Engl J Med.* 1995;**332**:38–44.

Waldman BJ, Mont MA, Hungerford DS. Total knee arthroplasty infections associated with dental procedures. *Clin Orthop Relat Res.* 1997;**343**:164–172.

62. Answer E. **Steinmann second**
Joint line tenderness that moves posteriorly with knee flexion and anteriorly with knee extension is the basis of the Steinmann second test. A meniscal tear which is mobile with knee range of movement gives rise to a positive test.

External tibial rotation and knee extension increases tenderness along the medial joint line in the presence of a medial meniscus tear in a Bragard's test. While performing this test the medial meniscus comes more anterior and closer to the examining finger and therefore causes pain whereas internal rotation and flexion movement cause less tenderness by moving the meniscus farther from the area of palpation.

A palpable click on the joint line is elicited by the McMurray's test. External tibial rotation and passive motion from flexion to extension causes pain medially in a case of medial meniscus tear whereas with the tibia in internal rotation and passive motion from flexion to extension elicits pain laterally in a case of lateral meniscal tear.

In the Apley grind test the tibiofemoral surfaces are forced together to elicit pain. If the patient has pain then it is an indication of a positive test.

Duck walking increases pressure on the posterior aspect of the knee. A positive test is indicative of a tear in the posterior horn of the meniscus.

Tria AJ Jr, Klein KS. *An Illustrated Guide to the Knee*. New York: Churchill Livingstone; 1992.

63. Answer B. **FOPE (focal periphyseal oedema)**
Salter-Harris Type 1 fractures are often associated with a history of trauma. Radiologically a physeal widening is visible. In cases with subtle widening a comparison with the contralateral knee is often helpful.

Brodie's abscess and osteoid osteoma are often associated with history of a previous infection, night pain relieved with aspirin etc. This is not the case in this young man. Also, his blood investigations are reported to be normal.

Focal periphyseal oedema (FOPE) is a manifestation of normal skeletal maturation. They are generally central in location because the physis are in a process of closing. This differentiates FOPE lesion from Salter-Harris Type 1 injuries.

Zbojniewicz AM, Laor T. Focal periphyseal edema (FOPE) zone on MRI of the adolescent knee: a potentially painful manifestation of physiologic physeal fusion? *Am J Roentgenol.* 2011;**197**:998–1004.

64. Answer E. **The Multicenter ACL Revision Study (MARS) group stated that approximately 30% of patients undergoing revision ACL reconstruction had no impingement**
Anterior cruciate ligament graft impingement primarily occurs due to improper tibial tunnel placement. This may lead to loss of normal knee extension and can cause tearing of the graft. In an abnormally anteriorly placed tibial tunnel the distal two-thirds of the graft shows a high signal on MRI. An osteophyte in the intercondylar notch can result in graft impingement. If the anterior wall of the tibial tunnel is placed anterior to the Blumensaat line, a roof impingement may occur due to the graft impacting the roof of the intercondylar notch. A hyperextension lateral radiograph is associated with increased effusion,

lack of complete extension in cases of anterior ACL graft impingement.

The MARS study group stated that approximately 51% of patients undergoing revision reconstruction had no impingement, 47% had some impingement, while 2% had complete impingement.

Stoller DW. *Magnetic Resonance Imaging in Orthopaedics and Sports Medicine*, 3rd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2006.

Weber WN et al. Lateral tibial rim (Segond) fractures: MR imaging characteristics. Radiology 1991;**180**:731–734.

Group M. Radiographic findings in revision anterior cruciate ligament reconstructions from the MARS cohort. *J Knee Surg.* 2013;**26**:239–248.

Miller MD, Olszewski AD. Posterior tibial tunnel placement to avoid anterior cruciate ligament graft impingement by the intercondylar roof. An in vitro and in vivo study. *Am J Sports Med.* 1997;**25**:818–822.

65. Answer: **C. The knee is not able to flex or extend in a locking episode because of patellar pathology whereas in a bucket handle tear of meniscus the knee can be further flexed.** Patients with patellofemoral (PF) disorders primarily present with one or all the following symptoms: pain, instability and locking or catching.

The pain is located anteriorly and is not well defined. Anterior knee pain and moderate pain with climbing stairs have been shown to have a high specificity with isolated PF injury.

Instability episodes can be subjective or objective. Initial episodes are generally traumatic leading to dislocation of the patient. Subsequent episodes are subjective with reflex contraction of the quadriceps resulting in a subluxation.

Locking is the third common symptom and can be differentiated from a meniscal tear by physical examination. The knee is a fixed position, and no further flexion or extension is possible. In a bucket handle tear of meniscus, the knee can be further flexed but has restricted terminal extension.

Locking episodes are generally momentary but sudden quadriceps contraction can cause painful and prolonged locking episodes.

Stefanik JJ et al. The diagnostic performance of anterior knee pain and activity-related pain in identifying knees with structural damage in the patellofemoral joint: the Multicenter Osteoarthritis Study. *J Rheumatol.* 2014;**41**:1695–1702.

66. Answer: **C. COL5A1**
Spontaneous rupture of the quadriceps commonly occurs because of the sudden eccentric contraction of the muscle. This sudden contraction exceeds the phase of plastic deformation and can lead to incomplete or complete rupture.

In patients more than 40 years of age the site of rupture is at the muscle tendon interface whereas in younger patients it is a mid-substance tear.

Bilateral quadriceps ruptures are reported in patients with underlying systemic illness, obesity and use of anabolic steroids. The COL5A1 gene is implicated in bilateral quadriceps injury.

GDF5 (encoding growth & differentiation factor 5) is associated with osteoarthritis.

HOXB9 and COL1A1 both are associated with dynamic dysplasia of hip (DDH).

COL1A2 is associated with osteogenesis imperfecta.

Galasso O et al. Collagen type V polymorphism in spontaneous quadriceps tendon ruptures. *Orthopedics* 2012;**35**:e580–e584.

Yoo JH, Sawan H, Parvizi J. Genetics of common musculoskeletal disorders in adults. *Orthopedic Muscul Sys.* 2014;**S2**:S2–009.

67. Answer A. **A decrease in the moment arm of the extensor mechanism is caused by the patella by anterior displacement from the knee's centre of rotation**
The patella and the tendinous portion of the extensor mechanism share the load from full knee flexion to 45°.

At less than 45° the patella is the only component of the extensor mechanism which is in contact with the distal femur.

An increase in the moment arm of the extensor mechanism is caused by the anterior displacement of the patella from the knee's centre of rotation.

Twice the amount of torque is required for the terminal 15° of knee extension as compared with the torque required from full flexion of the knee to 15° short of extension.

Kaufer H. Mechanical function of the patella. *J Bone Joint Surg Am* 1971; **53**:1551–1560.

Lieb FJ, Perry J. Quadriceps function: an anatomical and mechanical study using amputated limbs. *J Bone Joint Surg Am.* 1968;**50**:1535–1548.

Peeples RE, Margo MK. Function after patellectomy. *Clin Orthop Relat Res.* 1978;**132**:180–186.

68. Answer C. **Dorsal defect of patella**
A dorsal defect of patella is an anatomical variant. It is most often an incidental finding when patients are imaged for other causes. Exactly why a dorsal defect of patella develops is unknown. Failed or delayed ossification of the patella leading to a developmental alteration of the epiphysis is thought to be a causative factor. Histologically a non-specific fibrous tissue with no features of inflammation is identified. This is a self-limiting condition and treatment is non-operative.

Johnson JF, Brogdon BG. Dorsal defect of the patella: incidence and distribution. *Am J Roentgenol.* 1982;**138**:339.

Chapter 7

Knee II Structured SBA

David Deehan, Philip Dobson and Daniel Hipps

KNEE II STRUCTURED SBA QUESTIONS

1. **The most common site for osteochondritis dissecans of the knee is?**
   - A. Anterolateral aspect of the lateral femoral condyle
   - B. Anteromedial aspect of the medial femoral condyle
   - C. Posterolateral aspect of the medial femoral condyle
   - D. Posteromedial aspect of the lateral femoral condyle
   - E. Trochlea groove

2. **In MPFL reconstruction, with regard to the lateral X-ray, the femoral tunnel should be positioned?**
   - A. 1mm anterior to a line extended from the posterior cortex, and 2.5mm proximal to the origin of the medial femoral cortex
   - B. 1mm anterior to a line extended from the posterior cortex, and 2.5mm distal to the Blumensaat line
   - C. 1mm anterior to a line extended from the posterior cortex, and 2.5mm distal to the origin of the medial femoral condyle
   - D. 1mm posterior to a line extended from the posterior cortex, and 2.5mm proximal to the origin of the medial femoral cortex
   - E. 1mm posterior to a line extended from the posterior femoral cortex, and 2.5mm distal to the origin of the medial femoral condyle

3. **An anterior closing wedge, high tibial osteotomy has what effect?**
   - A. Increases shear force on the ACL
   - B. Increases shear force on the ACL and PCL
   - C. Increases shear force on the PCL
   - D. Reduces shear force on the ACL
   - E. Reduces shear force on the PCL

4. **A rectangular shaped opening wedge medial high tibial osteotomy will have the effect of?**
   - A. Increasing valgus alignment and have no effect on tibial slope
   - B. Increasing valgus alignment and increasing posterior tibial slope
   - C. Increasing valgus alignment and reducing posterior tibial slope
   - D. Increasing varus alignment and have no effect on tibial slope
   - E. Increasing varus alignment and reducing posterior tibial slope

5. **With regard to the injury apparent on the MRI (Figure 7.1)?**
   - A. A posterior slope less than 12° can increase risk of graft failure
   - B. Reconstruction eliminates the increased risk of progression to arthritis
   - C. Reconstruction reduces risk of secondary meniscal injuries

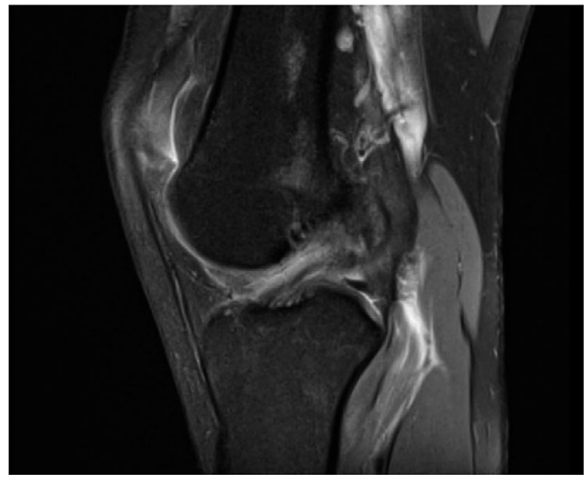


Figure 7.1 MRI scan knee sagittal T2 view

D. Reconstruction will reduce posterior tibial translation
E. The knee is clinically likely to exhibit increased tibial translation and internal rotation

6. **With regard to PCL function?**
   A. The ALB is the primary restraint to tibial posterior translation at 90° and when the knee is near to full extension
   B. The ALB serves as the primary restraint to tibial posterior translation at 90° and the PMB is the primary restraint when the knee is near to full extension
   C. The PMB has an insertion point closer to the trochlear groove than the PLB
   D. The PMB is the primary restraint to tibial posterior translation at 90° and when the knee is near to full extension
   E. With single bundle reconstruction, the PMB should be preferentially reconstructed

7. Stress radiography with valgus testing of the knee reveals increased gapping of 7mm in full extension and 10mm at 30°.
   These findings are likely to be in keeping with which of the following injury patterns?
   A. Grade II MCL injury combined with posterior oblique ligament injury
   B. Grade II MCL injury with ACL rupture
   C. Grade II superficial and deep MCL injury
   D. Grade III MCL injury combined with posterior oblique ligament injury
   E. Grade III superficial and deep MCL injury

8. With the knee flexed to 90° and the tibia in 10° external rotation, an anterior drawer is performed, causing forward subluxation of the anteromedial tibial plateau.
   This finding is suggesting of which of the following injury patterns?
   A. Combined ACL and MCL injury
   B. Combined ACL and PCL injury
   C. Combined MCL, posteromedial capsule and posterior oblique ligament injury
   D. Full thickness ACL rupture
   E. Posterolateral corner injury

9. A 23-year-old footballer presents acutely following an injury on the football field. The MRI demonstrates avulsion of the MCL from the femoral origin and a mid-substance tear to the ACL.
   Appropriate treatment for this patient would be as follows?
   A. Brace at 30° for 6 weeks followed by ACL reconstruction.
   B. Early MCL repair/reconstruction and ACL reconstruction
   C. Extension brace for 6 weeks followed by ACL and MCL reconstruction if MCL clinically incompetent at that stage.
   D. Extension brace for 6 weeks followed by ACL reconstruction if MCL clinically competent at that stage.
   E. ROM brace for 6 weeks followed by MCL reconstruction alone if MCL found to be incompetent at that stage.

10. A 27-year-old male sustains an injury to his knee when he falls from his motorbike at low speed. Clinical examination reveals increased tibial external rotation of 15° with the knee flexed to 30°. The same finding is evident with the knee flexed to 90°. Varus stress X-rays show an increase in lateral joint opening of 5mm compared with the uninjured side.
    Which of the following reconstructive options is most appropriate?
    A. Popliteofibular ligament and fibular collateral ligament reconstruction
    B. Popliteofibular ligament, posterior oblique ligament and fibular collateral ligament reconstruction
    C. Popliteus tendon, fibular collateral ligament and posterior cruciate ligament reconstruction
    D. Posterior oblique ligament, fibular collateral ligament and posterior cruciate reconstruction
    E. Popliteofibular ligament, posterior oblique ligament, fibular collateral ligament and posterior cruciate ligament reconstruction

11. Whilst examining a patient, you hold the knee flexed to 90°, apply a valgus force and hold the tibia in external rotation. Whilst continuing to apply a valgus and external rotation, you passively extend the knee, noting that the tibia subluxes anteriorly in relation to the tibia.
    This finding is most suggestive of injury to which structures?
    A. ACL

B. Combined ACL and PCL injury
C. Fibular collateral ligament and popliteofibular ligament
D. PCL
E. Posterior oblique ligament

12. A 32-year-old male sustains a knee injury. Clinical examination 4 days after the injury reveals increased tibial external rotation of 15° at 30° of knee flexion compared with the contralateral leg, but no significant increase in external rotation at 90° of knee flexion. Stress radiography reveals an increase in lateral joint opening of 5.2mm compared with the uninjured knee.
The most appropriate treatment for this injury is.
A. Application of a brace in 30° of flexion
B. Application of a brace which allows ROM
C. Reconstruction of the fibular collateral ligament and popliteus tendon
D. Reconstruction of the fibular collateral ligament, popliteus tendon and PCL
E. Reconstruction of the posterior oblique ligament and ACL

13. An 18-year-old female elite soccer player sustains an injury to her knee. On examination, significant laxity on Lachman's test is noted in addition to a grade 3 pivot shift. Hyperextension of both knees is also noted.
Appropriate management of this injury is?
A. ACL reconstruction with bone patella tendon graft
B. ACL reconstruction with hamstring graft and lateral extra-articular tenodesis
C. ACL reconstruction with quadriceps tendon graft
D. Combined ACL and PCL reconstruction
E. Trial of conservative treatment

14. **When performing a posterior root repair of the medial meniscus using a tibial tunnel to bring sutures down, the most appropriate place to position the tibial tunnel is?**
A. Anterior and lateral to the medial tibial eminence
B. Anterior and medial to the medial tibial eminence
C. Immediately anterior to the PCL tibial insertion
D. Posterior and lateral to the medial tibial eminence
E. Posterior and medial to the medial tibial eminence

15. A 32-year-old patient presents with acute onset posteromedial knee pain, mainly present when weight bearing. Symptoms have been present for 1 week.
In view of the MRI findings which show a full thickness injury, which of the following is the most appropriate management?

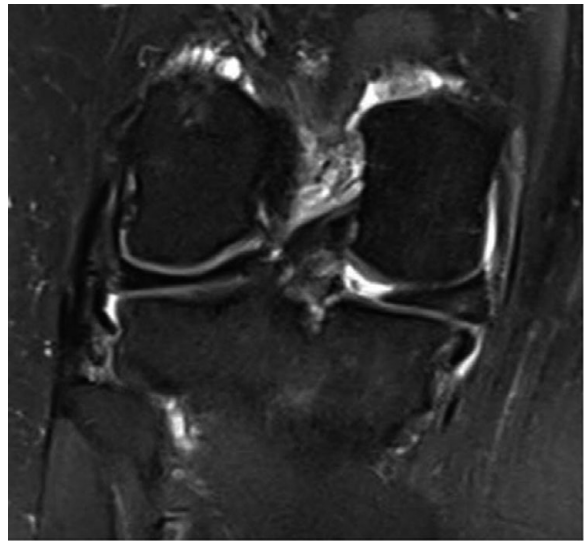


Figure 7.2 MRI scan knee T2 coronal view

A. Early surgical repair even if pain is the only symptom
B. Early surgical repair only if mechanical symptoms present
C. Non-weight bearing for 6 weeks and reassess
D. Surgical repair at 6 weeks if locking symptoms present
E. Weight bear as tolerated and reassess at 6 weeks

16. A 40-year-old male who has undergone previous partial meniscectomy following a full thickness medial meniscus radial tear, presents with medial sided knee pain. His mechanical axis passes through the centre of the knee and he has no significant articular wear. He wishes to maintain an active lifestyle.
Which of the following is likely to be the most appropriate treatment?
A. Further medial meniscal debridement
B. Lateral closing wedge high tibial osteotomy
C. Meniscal allograft transplant

D. Total knee replacement
E. Unicondylar knee replacement

17. A 64-year-old female presents with symptoms in keeping with mid flexion antero-posterior instability following a cruciate retaining knee arthroplasty. She is noted to have a 12° posterior slope on the tibial cut and a 6° valgus cut on the femur.
Which of the following is most likely to lead to symptom resolution?
A. One stage revision to upsize the femoral component AP size
B. One stage revision to change to a posterior stabilised implant and resurfaced patella
C. One stage revision to a rotating hinge prosthesis
D. One stage revision, changing tibial slope to 3° and increased femoral component size
E. Soft tissue procedure to reconstruct the MCL

18. A 25-year-old female with recurrent patella dislocations is noted to have a Q angle of 15° at 20° of knee flexion. A lateral knee X-ray shows a Caton-Deschamps ratio of 1.0 and no evidence of a crossing sign.
Which surgical option is likely to be indicated?
A. Isolated MPFL reconstruction
B. Isolated trochleoplasty
C. Tibial tuberosity distalisation and medialisation, combined with MPFL reconstruction
D. Tibial tuberosity distalisation and MPFL reconstruction
E. Trochleoplasty combined with MPFL reconstruction

19. A 20-year-old with disabling recurrent patella dislocations is noted to have a Caton-Deschamps ratio of 1.5, a TT-TG distance of 11mm on CT scan. There is evidence of a crossing sign on lateral X-ray, but no supratrochlear spur or double contour sign.
Which of the following would be the preferred treatment?
A. Continued physiotherapy
B. Tibial tuberosity distalisation and medialisation
C. Tibial tuberosity distalisation and MPFL reconstruction
D. Tibial tuberosity distalisation, medialisation, combined with MPFL reconstruction and trochleoplasty
E. Trochleoplasty and MPFL reconstruction

20. A 22-year-old presents following a first-time patella dislocation. Imaging reveals TT-TG distance of 22mm and a Caton-Deschamps ratio of 1.4.
Which of the following is the most appropriate treatment?
A. MPFL reconstruction
B. Referral to physiotherapy
C. Tibial tuberosity medialisation
D. Tibial tuberosity medialisation and MPFL reconstruction
E. Tibial tuberosity medialisation and distalisation

21. An 11-year-old boy presents with recurrent patella dislocations, having had 12 episodes of dislocation in the last year. Examinations and investigation reveal a positive apprehension test, normal rotational profile, 2° genu valgum, a TT-TG of 23mm, patella alta, no significant trochlea dysplasia.
Which of the following is the most appropriate treatment?
A. Application of 8 plates
B. Continued conservative management
C. MPFL reconstruction with screw fixation of semitendinosis hamstring graft into Schottle's point
D. Tibial tuberosity distalisation
E. Tibial tuberosity distalisation and medialisation

22. A 23-year-old rugby player sustains a valgus injury to his knee. On examination 6 weeks following his injury, he is noted to have medial joint line opening of 10mm at 30° of flexion and when an external rotatory force is applied in the same position, anterior subluxation of the medial tibial plateau is noted. In full extension, valgus force also produces some degree of medial joint opening.
Based on the information given, what is the most appropriate treatment?
A. Combined ACL and MCL reconstruction
B. Combined ACL, MCL and POL reconstruction
C. Combined MCL and POL reconstruction
D. Combined MCL, ACL and posterolateral corner reconstruction
E. Combined MCL, posterolateral corner reconstruction

23. A 26-year-old motorcycle rider injures their knee when they come off their bike at speed. Examination reveals increased external rotation of the tibia at 30° of flexion which is 15° more than the uninjured contralateral limb. With the knee at 90°, resisted extension also causes the tibia to move anteriorly 10mm in relation to the femoral condyles.
Which of the following is the most appropriate treatment?
A. ACL reconstruction
B. Combined ACL and posterolateral corner reconstruction
C. Combined ACL, PCL and posterolateral corner reconstruction
D. Combined PCL and posterolateral corner reconstruction
E. PCL reconstruction

24. A 60-year-old male presents with medial sided knee pain of 6 weeks duration, prior to which he was pain free. An X-ray shows grade D changes affecting the medial compartments with good preservation of the lateral and patellofemoral compartments. He has no fixed flexion deformity and no ligamentous instability. His mechanical axis passes through the centre of the medial compartment. He plays squash once a week.
Which of the following might be the most appropriate treatment?
A. Debridement of medial meniscal tear
B. Lateral closing wedge high tibial osteotomy
C. Physiotherapy
D. Total knee replacement
E. Unicondylar knee replacement

25. **With regard to the image (Figure 7.3), which of the following is most likely to lead to symptom improvement?**
A. ACL and PCL reconstruction
B. ACL reconstruction and lateral meniscal repair
C. Medial meniscal repair and ACL reconstruction
D. PCL reconstruction and lateral meniscal repair
E. PCL reconstruction and medial meniscal repair

26. **With regard to the image (Figure 7.4), which of the following is evident?**
A. ACL rupture and PCL rupture
B. ACL rupture, PCL rupture and medial meniscal injury

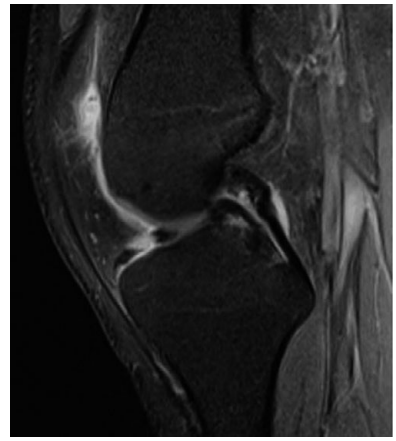


Figure 7.3 MRI scan knee sagittal T2 view

Figure 7.4 MRI scan knee T2 coronal view

C. Isolated ACL rupture
D. Medial meniscal injury and ACL rupture
E. Normal knee

27. A 17-year-old girl presents with medial sided knee pain and intermittent effusions of 12 months duration. Her MRI scan is shown in Figure 7.5.
With regard to this condition, which of the following is true?
A. Elevation, bone grafting and fixation would not be appropriate
B. Low levels of vitamin D have been shown to be associated with this condition
C. Non-operative treatment is likely to lead to resolution of symptoms
D. Surgical treatment with osteochondral autologous transfer would not be appropriate
E. The healing rate in skeletally immature bone is low when treated conservatively

Figure 7.5 MRI scan knee sagittal T2 view

28. **The MRI in Figure 7.6 is concerning for which of the following features?**

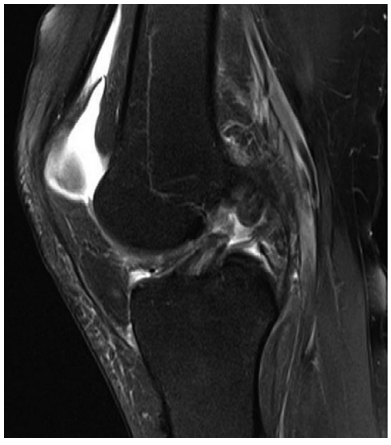


Figure 7.6 MRI scan knee sagittal T2 view

A. ACL rupture
B. Meniscal injury
C. Multiligamentous injury
D. PCL rupture
E. Venous thrombosis

29. **With regard to the anterior cruciate ligament, which of the following is correct?**
A. Both bundles are tight in full extension
B. The posterolateral bundle is tight and the anteromedial bundle is moderately lax in full extension
C. The posteromedial bundle is tight and the anterolateral bundle is moderately lax in full knee extension
D. Transection of the anterior bundle in isolation will not cause increased anterior tibial translation
E. Transection of the posterior bundle in isolation will not cause increased anterior tibial translation

30. **With regard to articular cartilage?**
A. Aggrecan is the primary proteoglycan in cartilage and contributes to its net negative charge
B. Cartilage is isotropic
C. Chondrocytes are derived from the monocyte lineage
D. Following articular injury, cartilage heals predominantly with type 2 cartilage
E. The deep zone contains the highest cell density and lowest proteoglycan content

31. **With regard to the MRI image (Figure 7.7), which of the following would be appropriate treatment?**

Figure 7.7 MRI scan knee sagittal T2 view

A. ACL reconstruction
B. Bone grafting and fixation
C. Meniscal repair
D. PCL reconstruction
E. Removal of loose body

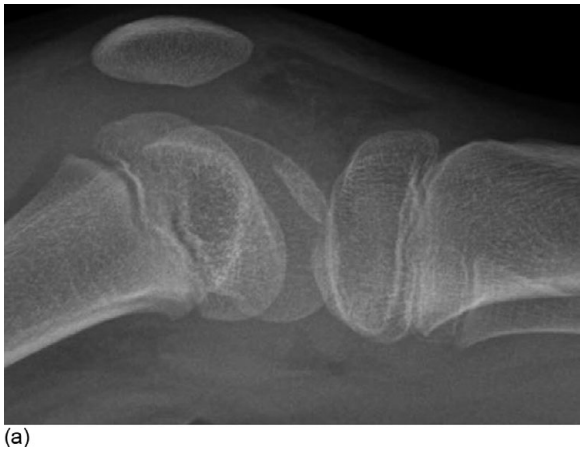
32. A 26-year-old presents with this MRI (Figure 7.8). **Which of the following would be most appropriate?**
A. ACL reconstruction
B. ACL reconstruction and MCL repair
C. Medial meniscus repair
D. Posterolateral corner reconstruction
E. Referral to bone tumour specialist

Figure 7.8 MRI scan knee T2 coronal view

33. You are performing a primary total knee arthroplasty and have made all your femoral and tibial cuts when you find the extension gap is perfect but the flexion gap is too tight. You have used anterior referencing on the femur and your anterior femoral cut is flush with anterior femoral cortex.
What action should you take?
A. Apply a smaller 4 in 1 femoral cutting block and recut for a smaller femoral component
B. Apply the distal femoral cutting block and resect a further 2mm and apply a smaller 4 in 1 cutting block and recut
C. Perform release of the iliotobial band and posterior capsule
D. Take 2mm more off the tibia
E. Take 2mm more off the tibia and 2mm more off the femur

34. You are performing a primary total knee arthroplasty and you have completed all your cuts when you find the flexion and extension gaps equal but are too tight to accommodate a standard spacer block.
What action should you take?
A. Downsize the femur and recur the tibia
B. Perform soft tissue releases of popliteus, ITB and MCL
C. Recut the femur with a smaller 4 in 1 block, to downsize the femoral component
D. Resect more from the distal femur
E. Resect more tibia

35. A 6-year-old child presents with this X-ray (Figure 7.9) after sustaining a knee injury.
Which of the following is the most appropriate management?
A. Application of cylinder cast
B. Closed reduction and application of cylinder cast
C. Mobilisation as able
D. Open reduction and application of cylinder cast
E. Open reduction and internal fixation, application of cylinder cast



(a)

(b)

Figure 7.9 (a) Lateral radiograph knee and (b) Anteroposterior (AP) radiograph knee

KNEE II STRUCTURED SBA ANSWERS

1. Answer C. **Posterolateral aspect of the medial femoral condyle**
Osteochondritis dissecans (OCD) is a condition for which the aetiology remains unknown. It affects subchondral bone and secondarily its overlying cartilage and is mostly found in the knee. It can occur in adults, but is generally identified when growth remains, when it is referred to as juvenile OCD. As the condition progresses, the affected subchondral bone separates from adjacent healthy bone, and can lead to demarcation and separation of its associated articular cartilage.

Early disease without separation of the lesion results in pain. Separation of the lesion leads to mechanical symptoms and swelling and, in advanced cases, the formation of loose bodies.

Early identification of OCD is essential as untreated OCD can lead to the premature degeneration of the joint, whereas appropriate treatment can halt the disease process and lead to healing.

Establishing the stability of the lesion is a key part of providing the correct treatment. Stable lesions, particularly in juvenile patients, have greater propensity to heal with non-surgical treatment, whereas unstable or displaced lesions usually require surgical management.

Most cases of OCD occur in the posterolateral aspect of the medial femoral condyle (70%). It occurs less frequently in other areas such as the inferior central aspect of the lateral condyle (15%), the patella (5–10%) and the trochlea (less than 1%) (Jones & Williams 2016).

Jones MH, Williams AM. Osteochondritis dissecans of the knee: a practical guide for surgeons. *Bone Joint J.* 2016;**98-B**:723–729.

2. Answer C. **1mm anterior to a line extended from the posterior cortex, and 2.5mm distal to the origin of the medial femoral condyle**
Medial patellofemoral ligament (MPFL) reconstruction is an accepted treatment for recurrent patellofemoral instability when patients have normal alignment and deficient proximal medial restraints. A malpositioned femoral tunnel will often lead to poor outcomes.

Schöttle's point was determined from a cadaveric study of eight knees as the centre of the MPFL insertion. It is 1mm anterior to the posterior cortex extension line, 2.5mm distal to the posterior origin of the medial femoral condyle and proximal to the level of the posterior point of the Blumensaat line on a true lateral radiograph (Stephen et al. 2012).

Stephen JM, Lumpaopong P, Deehan DJ, Kader D, Amis AA. The medial patellofemoral ligament: location of femoral attachment and length change patterns resulting from anatomic and nonanatomic attachments. *Am J Sports Med.* 2012;**40**:1871–1879.

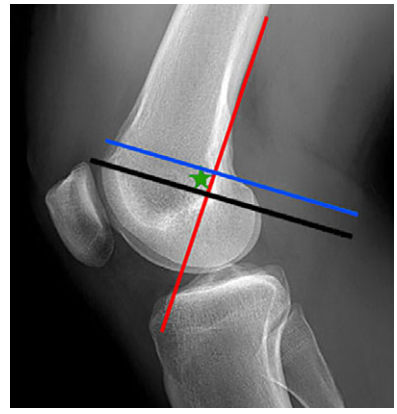


Figure 7.10
Schöttle's point

3. Answer D. **Reduces shear force on the ACL**
The larger the posterior slope, the greater the shear forces on the ACL. Increased slope reduced shear forces on the PCL. In cases of revision ACL surgery, the degree of posterior slope should be considered to reduce risk of further failure of reconstruction. An

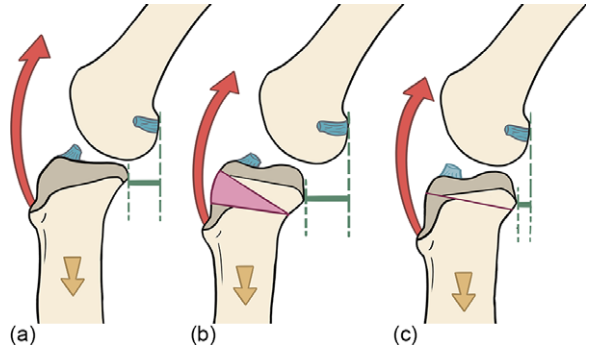


Figure 7.11 Diagram illustrating an anterior closing-wedge HTO to reduce the posterior tibial slope in the setting of ACL deficiency. (a) The red arrows represent the function of the extensor mechanism of the knee in the setting of ACL deficiency. (b) When the tibial slope is increased there is an exaggeration of the effect of ACL deficiency. (c) When the slope is reduced with an osteotomy this effect is also reduced

anterior closing wedge osteotomy will have the effect of reducing posterior slope and conferring reduced shear forces to the ACL graft (Amis 2013; Webb et al. 2013; Bernhardson et al. 2019).

Amis AA. Biomechanics of high tibial osteotomy. *Knee Surg Sports Trauma Arthrosc*. 2013;**21**:197–205.

Bernhardson AS et al. Tibial slope and its effect on force in anterior cruciate ligament grafts: anterior cruciate ligament force increases linearly as posterior tibial slope increases. *Am J Sports Med*. 2019;**47**:296–302.

Webb JM, Salmon LJ, Leclerc E, Pinczewski LA, Roe JP. Posterior tibial slope and further anterior cruciate ligament injuries in the anterior cruciate ligament-reconstructed patient. *Am J Sports Med*. 2013;**41**:2800–2804.

4. Answer B. **Increasing valgus alignment and increasing posterior tibial slope**
Inadvertent increase of the posterior slope can occur when medial opening wedge osteotomies are performed on the proximal tibia. The cross-sectional shape of the tibia is triangular, narrower at the anterior aspect. This means that when performing opening wedge osteotomy, the opening should be trapezoidal and slightly narrower anteriorly than posteriorly (Weiler et al. 2022).

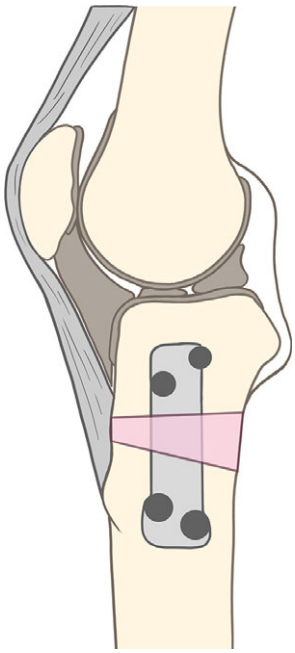


Figure 7.12 When the slope is unchanged it should be a trapezoid opening when seen from the medial side. That is your base measurement of whether to increase or decrease your slope

Weiler A et al. Significant slope reduction in ACL deficiency can be achieved both by anterior closing-wedge and medial open-wedge high tibial osteotomies: early experiences in 76 cases. *Knee Surg Sports Trauma Arthrosc*. 2022;**30**:1967–1975.

5. Answer C. **Reconstruction reduces risk of secondary meniscal injuries**
The MRI scan demonstrates an ACL disruption. Episodes of instability in an ACL deficient knee, predispose the patient to secondary injuries to chondral surfaces and menisci. A prospective cohort study of 209 patients comparing ACL reconstruction for high-risk patients and non-operative management for low-risk patients showed increased rates of secondary meniscectomy in the low-risk patients compared with early ACLR. Three further cohort studies, including one study of 6576 active-duty military patients, supported the principle that ACLR decreases the risk of subsequent meniscus surgeries (Giordano et al. 2023).

Giordano L, Maffulli N, Carimati G, Morenghi E, Volpi P. Increased time to surgery after anterior cruciate ligament tear in female patients results in greater risk of medial meniscus tear: a study of 489 female patients. Arthroscopy 2023;**39**:613–622.

6. Answer B. **The ALB serves as the primary restraint to tibial posterior translation at 90° and the PMB is the primary restraint when the knee is near to full extension**
The two PCL bundles serve different functions throughout the range of motion. The ALB is the primary restraint to posterior translation at 90°. The PMB functions similarly in near full extension and also resists internal rotation at greater flexion angles (Apsingi et al. 2008; Wang et al. 2014).

Apsingi S et al. The role of PCL reconstruction in knees with combined PCL and posterolateral corner deficiency. *Knee Surg Sports Trauma Arthrosc*. 2008;**16**:104–111.

Wang JH et al. Effects of knee flexion angle and loading conditions on the end-to-end distance of the posterior cruciate ligament: a comparison of the roles of the anterolateral and posteromedial bundles. *Am J Sports Med*. 2014;**42**:2972–2978.

7. Answer D. **Grade III MCL injury combined with posterior oblique ligament injury**

In grade I injuries of the MCL, valgus gapping is not apparent in stress radiography, although tenderness due to injury is present on clinical exam. In grade II injuries, increased gapping on valgus stress may occur but a clear end point will be felt. In grade III injuries, there is no clear end point on valgus stressing and the degree of joint opening on valgus stressing at 30° flexion is graded as 1+ (3–5mm), 2+ (6–10mm), 3+ (>10mm) compared with the uninjured side. Valgus laxity in full extension can indicate injury to the posteromedial structures or concurrent cruciate ligament injury (Rocha de Faria et al. 2020).

Rocha de Faria JL et al. Stress radiography for multiligament knee injuries: a standardized, step-by-step technique. *Arthrosc Tech*. 2020;**9**:e1885–e1892.

8. Answer C. **Combined MCL, posteromedial capsule and posterior oblique ligament injury**
Anteromedial instability is caused by injuries to the posteromedial capsule, posterior oblique ligament and the superficial MCL. The anteromedial drawer test can demonstrate this injury. The knee is flexed to 90° and the tibia is externally rotated 10–15° while an anteromedial rotatory force is applied, causing anterior subluxation of the medial plateau when the posteromedial structures are injured significantly. This test is commonly confused with the posterolateral drawer test so it is important to actively visualise the amount of increased rotation and the location of the rotation while performing this test.

With the posterolateral drawer test a coupled posterior force and external rotation torque is applied to the tibia to determine the amount of rotation of the tibial tubercle that occurs compared with the distal femur. The starting point for this test is similar to the posterior drawer test, but the foot is externally rotated about 15°.

Increased external rotation at both 30° and 90° of knee flexion resulting in a positive dial test is also indicative of this injury. If the tibial plateau shifts anteromedially, it is indicative of anteromedial instability, and if posterolateral subluxation occurs, this is a sign of posterolateral instability (Larson 1983).

With the dial test approximately 15° of increased external rotation of a tibia on the femur with a complete posterolateral corner injury compared with the contralateral side at 30° of knee flexion. With an isolated posterolateral corner injury, when the knee is flexed at 90°, this difference between sides becomes about 5°. However, when the PCL or the ACL are also injured, there will be a similar amount of 15° of increased external rotation at 90° of flexion.

One of the important things to recognise with the dial test, is that it can also be positive for an isolated or combined medial knee injury. It is important to concurrently assess for anteromedial or posterolateral tibial rotation to determine if it is a posterolateral or posteromedial (medial) knee injury (Hughston et al. 1976).

Larson RL. Physical examination in the diagnosis of rotatory instability. *Clin Orthop Relat Res*. 1983;**172**;38–44.

Hughston JC, Andrews JR, Cross MJ, Moschi A. Classification of knee ligament instabilities. Part I. The medial compartment and cruciate ligaments. *J Bone Joint Surg Am*. 1976;**58**:159–172.

9. Answer B. **Early MCL repair/reconstruction and ACL reconstruction**
Grade 3 MCL lesions will often heal successfully with bracing, assuming they are treated acutely and there is no Stener type lesion hindering normal healing. Bracing strategies include allowing free ROM and restricting movement within the range of 30–60° flexion. In the context of a patient who plays sport involving pivoting such as football and rugby, ACL insufficiency is unlikely to be tolerated and reconstruction is likely to required. Although bracing a grade III MCL injury for 6 weeks is not unreasonable, bracing in a fixed position, whether in full extension or at 30° would be inappropriate, leading to stiffness and muscle wasting. With a multiligament injury such as this scenario, acute reconstruction of the ACL and repair/reconstruction of the MCL is a reasonable option, especially in the context of an MCL avulsion injury (Bollier & Smith 2014; Shultz et al. 2023).

Bollier M, Smith PA. Anterior cruciate ligament and medial collateral ligament injuries. *J Knee Surg*. 2014;**27**:359–368.

Shultz CL et al. Nonoperative management, repair, or reconstruction of the medial collateral ligament in combined anterior cruciate and medial collateral ligament injuries – which is best?

A systematic review and meta-analysis. *Am J Sports Med.* 2023;3635465231153157.

10. Answer C. **Popliteus tendon, fibular collateral ligament and posterior cruciate ligament reconstruction**
The clinical findings are indicative of injuries to the posterolateral corner and the PCL. The PLC is a restraint to external rotation of the tibia. In isolated PLC injuries, the dial test will show significantly increased external rotation at 30° of knee flexion, but not at 90° flexion when compared with the uninjured contralateral limb. In the context of combined PLC and PCL injuries there will also be significantly increased rotation at 90° of knee flexion. Lateral joint opening on stress radiography of more than 4mm (side to side difference) is in keeping with a grade III PLC injury. An isolated PCL injury can produce a side to side difference of 2mm (Wascher. 2004; Apsingi et al. 2008).

Apsingi S et al. Control of laxity in knees with combined posterior cruciate ligament and posterolateral corner deficiency: comparison of single-bundle versus double-bundle posterior cruciate ligament reconstruction combined with modified Larson posterolateral corner reconstruction. *Am J Sports Med.* 2008;**36**:487–494.

Wascher DC. In *The Multiple Ligament Injured Knee: A Practical Guide to Management* (ed. GC Fanelli), pp. 95–110. New York: Springer; 2004.

11. Answer C. **Fibular collateral ligament and popliteofibular ligament**
This SBA describes the reverse pivot shift test. When posterolateral corner incompetence is present, holding the knee flexed at 90° with a valgus and external rotatory force applied will cause the tibia to sublux posterolaterally. When the knee is extended in the second part of the examination, the ITB will pull the tibia forward again as it goes from being a flexor to an extender of the knee and a visible reduction of the tibia can occur (LaPrade & Terry 1997). A positive test can however occur within a proportion of normal physiologically lax knees so it is important to compare findings with the contralateral knee.

LaPrade RF, Terry GC. Injuries to the posterolateral aspect of the knee: association of anatomic injury patterns with clinical instability. *Am J Sports Med.* 1997;**25**:433–438.

12. Answer C. **Reconstruction of the fibular collateral ligament and popliteus tendon**
This represents a grade III PLC injury. Nonoperative management has demonstrated favourable results with minimal radiographic changes and minimal symptoms at 8-year follow-up in grade I and grade II PLC injuries. Grade III PLC injuries managed conservatively have been shown to have less favourable outcomes (Kannus 1989).

Kannus P. Nonoperative treatment of grade II and III sprains of the lateral ligament compartment of the knee. *Am J Sports Med.* 1989;**17**(1):83–88.

13. Answer B. **ACL reconstruction with hamstring graft and lateral extra-articular tenodesis**
Several pieces of research have shown improved outcomes of ACL and anterolateral ligament (ALL) reconstruction compared with isolated ACL reconstruction, with significantly reduced risk of graft rupture in young patients. Persistent anterolateral rotatory laxity following isolated ACL reconstruction has been correlated with poor clinical outcomes and graft failure. Combined reconstruction is also less likely to result in residual pivot shift.

Patients under the age of 25 with hyperlaxity or high-grade pivot are reported to have better outcomes when ACL reconstruction is combined with lateral extra-articular tenodesis procedures (Getgood et al. 2020).

The main indication for ALL reconstruction is patients undergoing ACL reconstruction who have specific risk factors that predispose them to an increased risk of ACL graft rupture. These factors include the following:

- Young age (<20 years old).
- Participation in pivoting sports or a high-demand athlete.
- Evidence of a high-grade pivot shift on examination.
- Evidence of a lateral femoral notch sign on pre-operative imaging.
- A Segond fracture.
- Revision ACL reconstruction.
- Chronic (>12 months) ACL injury.

Getgood AMJ et al. Lateral extra-articular tenodesis reduces failure of hamstring tendon autograft anterior cruciate ligament reconstruction: 2-year outcomes from the STABILITY Study Randomized Clinical Trial. *Am J Sports Med.* 2020;**48**:285–297.

14. Answer D. **Posterior and lateral to the medial tibial eminence**
The posterior root of the medial meniscus inserts posterior to the medial tibial eminence. It is lateral to the articular cartilage margin of the posteromedial tibial plateau and anterioromedial to the tibial insertion of the PCL. The insertion is approximately 1cm posterior and 0.5cm lateral to the medial tibial eminence (Johannsen et al. 2012).

Johannsen AM et al. Qualitative and quantitative anatomic analysis of the posterior root attachments of the medial and lateral menisci. *Am J Sports Med.* 2012;**40**:2342–2347.

15. Answer A. **Early surgical repair even if pain is the only symptom**
A full thickness radial root tear, or indeed any full thickness radial tear affecting the meniscus will defunction it. Separation of the meniscus at the tear site relieves the meniscus of the hoop stresses usually imparted on it and leads to increased forces or contact pressures through the articular cartilage on weight bearing (Tachibana et al. 2017). Because of these factors, it is important to identify these tears and consider early repair. Non-operative treatment of

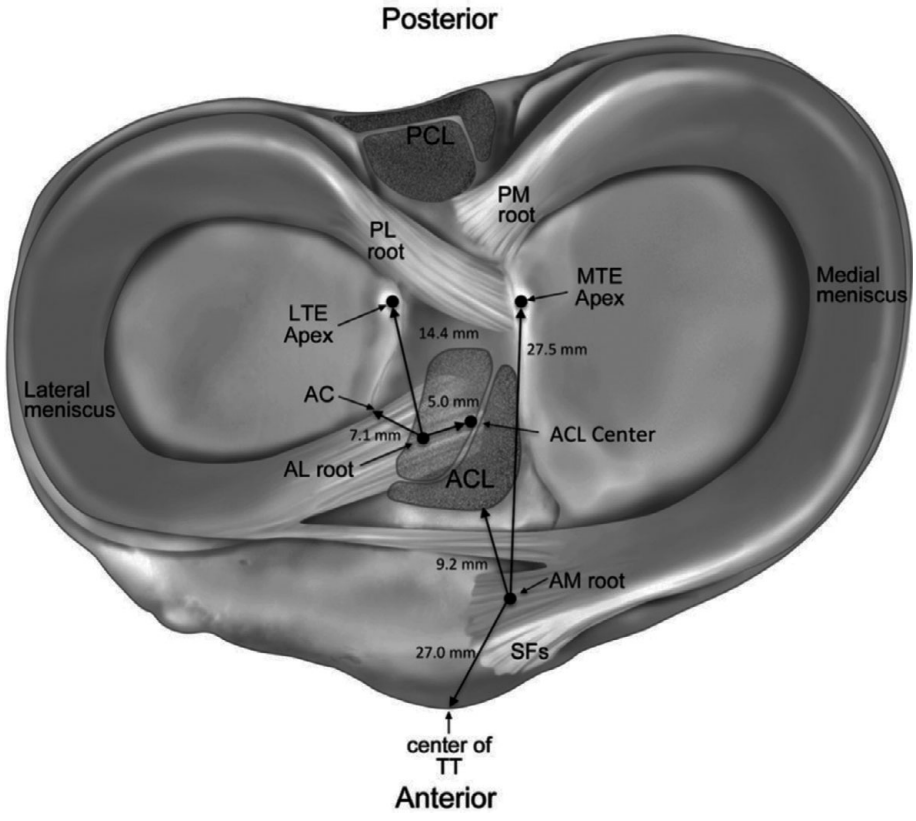


Figure 7.13 Anatomy of the anterior and posterior root attachments of the medial and lateral menisci. The anterior lateral (AL) meniscal root runs deeply beneath and overlap with the anterior cruciate ligament (ACL). The anterior medial (AM) meniscal root is depicted with the supplemental fibres (SFs) that were observed to be anterior and distal to the central root. Anterior meniscal root structure is also described in relation to pertinent bony and soft tissue landmarks. AC, articular cartilage; LTE, lateral tibial eminence; MTE, medial tibial eminence; PL root, posterior lateral meniscal root; PM root, posterior medial meniscal root; TT, tibial tuberosity

medial meniscus posterior horn root tears has been shown to result in poor clinical outcomes and accelerated development of osteoarthritis (Badlani et al. 2013; Tachibana et al. 2017).

Badlani JT, Borrero C, Golla S, Harner CD, Irrgang JJ. The effects of meniscus injury on the development of knee osteoarthritis: data from the osteoarthritis initiative. *Am J Sports Med.* 2013;**41**:1238–1244.

Tachibana Y et al. Effect of radial meniscal tear on in situ forces of meniscus and tibiofemoral relationship. *Knee Surg Sports Traumat Arthrosc.* 2017;**25**:355–361.

16. Answer C. **Meniscal allograft transplant**
Meniscal allograft transplantation (MAT) was developed for patients with an absence of meniscus to reduce pain, improve function, and potentially slow the rate of osteoarthritis (Smith et al. 2016). MAT can be considered in patients generally under the age of 40 with minimal or no arthritis.

In 2015 the International Meniscus Reconstruction Experts Forum (IMREF) produced a consensus statement recommending the following indications for MAT: Unicompartmental pain in the presence of total or subtotal 'functional' meniscectomy, as a concomitant procedure to revision anterior cruciate ligament (ACL) reconstruction to aid in joint stability when meniscus deficiency is believed to be a contributing factor to failure, as a concomitant procedure with articular cartilage repair in a meniscus-deficient compartment (Getgood et al. 2017).

Getgood A et al. International Meniscus Reconstruction Experts Forum (IMREF) 2015 Consensus Statement on the Practice of Meniscal Allograft Transplantation. *Am J Sports Med.* 2017;**45**:1195–1205.

Smith NA, Parkinson B, Hutchinson CE, Costa ML, Spalding T. Is meniscal allograft transplantation chondroprotective? A systematic review of radiological outcomes. *Knee Surg Sports Trauma Arthrosc.* 2016;**24**:2923–2935.

17. Answer D. **One stage revision, changing tibial slope to 3° and increased femoral component size**
Increased flexion gap and therefore flexion instability, can be caused by resecting too much bone from the posterior femoral condyles. This could occur if the femur was not measured properly by the surgeon leading them to apply a smaller cutting block for a smaller femoral component. An increased flexion gap can also occur if a large posterior slope is cut into the tibia. Typical cruciate retaining primary knee replacements are designed to be used with a tibial slope of 0–5°. A larger slope causes the flexion gap to increase with increasing flexion as femoral roll back occurs. To restore stability to the patient in this scenario, the large posterior slope should be corrected. There is not enough information to know if the femoral component has been undersized, but upsizing the femoral component in isolation would not be appropriate in view of the large posterior slope. Stability can be restored without resorting to increasing constraint to the level of a hinged prosthesis (Stambough et al. 2019).

Stambough JB, Edwards PK, Mannen EM, Barnes CL, Mears SC. Flexion instability after total knee arthroplasty. *J Am Acad Orthop Surg.* 2019;**27**:642–651.

18. Answer A. **Isolated MPFL reconstruction**
The patient's Q angle and patella height are within normal limits in this scenario. The TTTG is not mentioned, but with a normal Q angle, it is unlikely to be a significant factor. Patients with TT-TG >20mm are usually managed with TTO treatment. Isolated MPFL construction for patients with an increased TT-TG may result in lower post-operative outcomes and subsequent instability.

Crossing sign is a feature of trochlea dysplasia and this is not present. Dysplasia is more accurately assessed on an MRI scan. Other things that can predispose to patella instability such as valgus coronal alignment or increased femoral anterversion are not mentioned. Based on the information and options presented, in the context of recurrent dislocations, an isolated MPFL reconstruction would be appropriate and this has been shown to have good outcomes (Schneider et al. 2016).

Isolated trochleoplasty is indicated for abnormal patellar tracking with a J sign caused by femoral trochlear dysplasia and radiographic evidence of trochlear dysplasia.

Hughston osteotomy transfers the tibial tubercle distally and medially. This improves the TT-TG distance and also inferiorises the position of the patella and is a useful surgical procedure for severe patella alta. However, there is a risk with this procedure of globally increased patellofemoral contact pressure.

MPFL reconstruction may be indicated as a treatment for patellar instability in the absence of osseous abnormality such as patella alta, trochlear dysplasia, or TT-TG more than 15 mm. Tibial tuberosity transfer is indicated for patellar instability with abnormalities of patella height or TT-TG. Where indications for both exist, they may be combined with the objective of restoring normal joint kinematics.

Schneider DK et al. Outcomes after isolated medial patellofemoral ligament reconstruction for the treatment of recurrent lateral patellar dislocations: a systematic review and meta-analysis. *Am J Sports Med.* 2016;**44**:2993–3005.

19. Answer C. **Tibial tuberosity distalisation and MPFL reconstruction**
This is potentially a controversial area. Some surgeons believe in correcting every abnormality present. Most would agree in a stepwise approach and only employ more complex surgery in the context of recurrence after reconstruction. Patella alta is present in this case with a normal TTTG. A crossing sign on X-ray suggests some degree of trochlea dysplasia. This would require further clarification with MRI. Many surgeons would perform isolated MPFL reconstruction in this scenario (not an option here) and some would advocate for combining it with a tibial tubercle distalisation procedure to correct patella alta (a risk factor for recurrent dislocation) (Sappey-Marinier et al. 2019). Tibial tubercle medialisation is not indicated with a normal TT-TG.

Sappey-Marinier E et al. Clinical outcomes and predictive factors for failure with isolated MPFL reconstruction for recurrent patellar instability: a series of 211 reconstructions with a minimum follow-up of 3 years. *Am J Sports Med.* 2019;**47**:1323–1330.

20. Answer B. **Referral to physiotherapy**
Despite the increased TTTG and patella alta, conservative treatment should generally be the management for first-time patella dislocations (Vetrano et al. 2017). This can include functional mobilisation with bracing or application of patellar tape. Immobilisation has been shown to be associated with increased rates of recurrence and should be avoided. Studies comparing MPFL reconstruction and conservative treatment for first-time patella dislocations have shown conflicting results.

Patella alta, trochlear dysplasia and increased tibial tuberosity-trochlear grove (TT-TG) distance are major contributors of patella instability, alongside other minor factors, such as medial patellofemoral ligament (MPFL) injury or dysplasia that impair the restrain forces acting on the joint. In particular, patella alta, defined by a Caton–Deschamps index (CDI) >1.2 was found to be present in 24% of patients who suffered patellar dislocation and in 3% of normal controls (Caton et al. 1982).

For patients with recurrent patellar dislocation accompanied by patella alta and increased TT-TG distance, MPFLR combined with tibial tubercle transfer is preferred to MPFL reconstruction alone.

Caton J, Deschamps G, Chambat P, Lerat JL, Dejour H. Les rotules basses. A propos de 128 observations [Patella infera. Apropos of 128 cases]. *Rev Chir Orthop Reparatrice Appar Mot.* 1982;**68**:317–325. [In French]

Vetrano M et al. I.S.Mu.L.T. first-time patellar dislocation guidelines. *Muscles Ligaments Tendons J.* 2017;**7**:1–10.

21. Answer B. **Continued conservative management**
Surgical procedures that can potentially damage the physis and lead to growth disturbance should always be avoided in children if possible. Therefore, tibial tuberosity transfer options and MPFL reconstruction that involves drilling close to the femoral physis should be avoided. The patient here has slight valgus alignment but this is unlikely to be contributing to his symptoms and the application of tethering 8 plates is not indicated. Of the options presented, continued physiotherapy is the most sensible. There are soft tissue reconstructive options available for skeletally immature patients with recurrent dislocations such as transfer of a strip of the patella tendon, VMO advancement and

lateral release, but these are not as effective as anatomical reconstruction (Nelitz et al. 2013; Vavken et al. 2013).

Nelitz M, Dreyhaupt J, Reichel H, Woelfle J, Lippacher S. Anatomic reconstruction of the medial patellofemoral ligament in children and adolescents with open growth plates: surgical technique and clinical outcome. *Am J Sports Med*. 2013;**41**:58–63.

Vavken P et al. Treating patella instability in skeletally immature patients. *Arthroscopy* 2013;**29**:1410–1422.

22. Answer C. **Combined MCL and POL reconstruction**

The patient in this scenario displays clinical signs of incompetence of the superficial MCL and the posteromedial corner structures. He is 8 weeks post injury and continued bracing at this stage is unlikely to lead to healing. To restore knee stability, the sMCL and posterior oblique ligament (POL) require reconstruction with graft (Cinque et al. 2017).

Cinque ME et al. Posteromedial corner knee injuries: diagnosis, management, and outcomes: a critical analysis review. *JBJS Rev*. 2017;**5**:e4.

23. Answer D. **Combined PCL and posterolateral corner reconstruction**

The dial test performed on this patient reveals incompetence of the posterolateral corner of the knee with increased external rotation at 30° of knee flexion and combined PCL injury with increased external rotation at 90° of knee flexion. The quads active test performed in the scenario also suggests PCL injury. Missing a PLC injury or not reconstructing it puts a PCL reconstruction at increased risk of failure, and in an injury such as this, all injured structures should be reconstructed either as a one stage or two stage procedure (Petrillo et al. 2017).

Petrillo S, Volpi P, Papalia R, Maffulli N, Denaro V. Management of combined injuries of the posterior cruciate ligament and posterolateral corner of the knee: a systematic review. *Br Med Bull*. 2017;**123**:47–57.

24. Answer C. **Physiotherapy**

This patient's symptoms have only been present for 6 weeks. Whilst they may have radiological signs of severe arthritis, it would not be appropriate to perform an osteotomy or arthroplasty procedure at this time. Activity modification and referral to physiotherapy would be the most appropriate management at this stage (NICE 2022).

National Institute for Health and Care Excellence (NICE) *Osteoarthritis in over 16s: Diagnosis and Management*. PMID: 36745715. London: NICE; 2022.

25. Answer C. **Medial meniscal repair and ACL reconstruction**

The 'double PCL' sign as seen here is indicative of a bucket handle meniscus tear. In 80% of cases this is the medial meniscus rather than the lateral. From the sagittal image provided, there is no evidence of injury to the PCL (seen in this slice). The ACL is not seen in the slice but of the options given, medial meniscus repair and ACL reconstruction is the option most likely to lead to symptom improvement. Meniscal repair performed in the presence of ACL insufficiency is more likely to fail, and unless the meniscus is being resected due to it being irreparable, the ACL should be reconstructed (when ruptured) (Barber & Click,1997)(Westermann et al,2014)

Barber FA, Click SD. Meniscus repair rehabilitation with concurrent anterior cruciate reconstruction. *Arthroscopy* 1997;**13**:433–437.

Westermann RW et al. Meniscal repair with concurrent anterior cruciate ligament reconstruction: operative success and patient outcomes at 6-year follow-up. *Am J Sports Med*. 2014;**42**:2184–2192.

26. Answer D. **Medial meniscal injury and ACL rupture**

In this coronal image, meniscal tissue can be seen sitting in the femoral notch. The medial meniscal rim is also small compared to the lateral meniscus suggesting medial meniscus injury. A tear can also be seen in the meniscal rim. The ACL can also be seen on this slice, although not as clearly, but it is ruptured, and of the options presented, there is only one which includes medial meniscus injury.

27. Answer B. **Low levels of vitamin D have been shown to be associated with this condition**

Physeal closure is apparent and in skeletally mature knee, OCDs are unlikely to heal spontaneously in the long term. Studies have also shown that adults with OCD lesions treated conservatively develop arthritic changes 10 years earlier than the normal population. A study by Bruns et al. (2016) showed that 91% of consecutive patients treated surgically have low levels of vitamin D. Studies have shown an overall healing rate of over 60% in skeletally immature bone. There are multiple ways to treat such lesions including bone grafting and fixation, OAT, osteochondral allograft and autologous chondrocyte implantation.

Bruns J, Werner M, Soyka M. Is vitamin D insufficiency or deficiency related to the development of osteochondritis dissecans? *Knee Surg Sports Trauma Arthrosc.* 2016;**24**:1575–1579.

28. Answer A. **ACL rupture**
The image shows a proximal rupture of the ACL. There is haemarthrosis present in the knee, but on this slice, there is no evidence of any other pathology.

29. Answer B. **The posterolateral bundle is tight and the anteromedial bundle is moderately lax in full extension**
The ACL is a primary stabiliser for anterior tibial translation and a secondary restrain to internal tibial rotation. It consists of the anteromedial and posterolateral bundles. The posterolateral bundle is tight in full extension and the anteromedial bundle is relatively lax. Transection of either bundle will permit increased anterior tibial translation, each with different effects at different angles of knee flexion (Dargel et al. 2007).

Dargel J et al. Biomechanics of the anterior cruciate ligament and implications for surgical reconstruction. *Strategies Trauma Limb Reconstr.* 2007;**2**:1–12.

30. Answer A. **Aggrecan is the primary proteoglycan in cartilage and contributes to its net negative charge**
Isotropic materials are materials whose properties remain the same when tested in different directions. Cartilage is anisotropic, meaning it has different mechanical properties depending on the direction in which it is loaded.

Fibrocartilage can form following injury which consists predominantly of type 1 cartilage. Chondrocytes are derived from mesenchymal stem cells. The deep zone contains the lowest density of cells and the highest proteoglycan content (Bhosale & Richardson 2008).

Bhosale AM, Richardson JB. Articular cartilage: structure, injuries and review of management. *Br Med Bull.* 2008;**87**:77–95.

31. Answer B. **Bone grafting and fixation**
The image shows an osteochondral fragment sitting at the front of the knee. Subchondral bone and overlying cartilage can be seen on the rounded fragment. The source/defect is not seen on this sagittal slice but it came from the medial femoral condyle. This is a large fragment and simply removing it will leave a sizeable defect in the knee without any additional treatment. This would potentially lead to ongoing symptoms and accelerated medial compartment wear. Of the options presented, debriding the bed of the defect, bone grafting it and fixing the fragment back is the most viable option (Makino et al. 2005; Cruz et al. 2016).

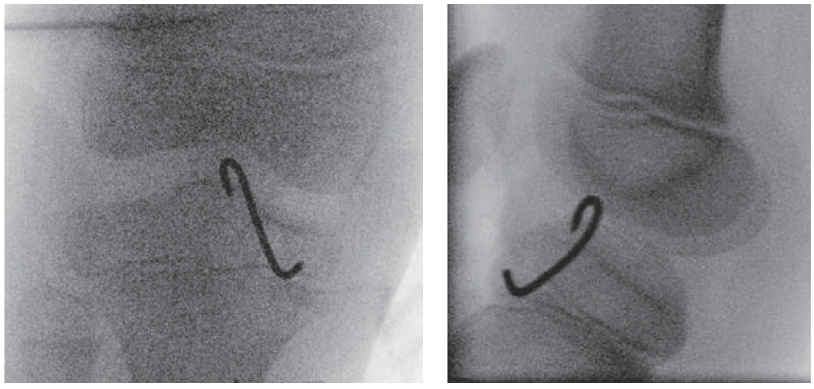
Cruz AI Jr, Shea KG, Ganley TJ. Pediatric knee osteochondritis dissecans lesions. *Orthop Clin North Am.* 2016;**47**:763–775.

Makino A, Muscolo DL, Puigdevall M, Costa-Paz M, Ayerza M. Arthroscopic fixation of osteochondritis dissecans of the knee: clinical, magnetic resonance imaging, and arthroscopic follow-up. *Am J Sports Med.* 2005;**33**:1499–1504.

32. Answer B. **ACL reconstruction and MCL repair**
The coronal image shows residual bone bruising/oedema affecting the lateral femoral condyle, the ACL can also be seen and is ruptured. There is oedema along the MCL and distally the image is suggestive of separation of the MCL from the tibial insertion. Of the options presented, ACL reconstruction and MCL repair would be most appropriate (Rao et al. 2022; Shultz et al. 2023). There is no evidence of malignancy.

Rao R, Bhattacharyya R, Andrews B, Varma R, Chen A. The management of combined ACL and MCL injuries: a systematic review. *J Orthop.* 2022;**34**, 21–30.

Shultz, C. L. et al. Nonoperative management, repair, or reconstruction of the medial collateral ligament in combined anterior cruciate and medial collateral ligament injuries – which is best?



(a) (b)

Figure 7.14 II images of tibial spine fixation. (a) anteroposterior; (b) lateral

A systematic review and meta-analysis. *Am J Sports Med*. 2023;doi:10.1177/03635465231153157.

33. Answer A. **Apply a smaller 4 in 1 femoral cutting block and recut for a smaller femoral component**
A tight flexion gap suggests that not enough bone has been resected from the posterior femoral condyles. Increasing the distal femoral cut will increase the extension gap but not change the flexion gap. Resecting more bone from the tibia will increase both the flexion and extension gap. To resect more bone from the posterior femoral condyles to increase the flexion gap, the femoral component must be downsized, so a smaller femoral cutting block must be applied and further cuts made.

34. Answer E. **Resect more tibia**
In order to increase the flexion and extension gap with one step, more bone should be resected from the tibia.

35. Answer E. **Open reduction and internal fixation, application of cylinder cast**
The radiograph demonstrates a displaced tibial spine avulsion injury. This is completely displaced and would constitute a type 3 injury as per the Myers and McKeever classification in which type 1 fractures are minimally displaced and type 2 fractures are hinged fragments, where the anterior portion of the fragment is displaced but the posterior portion remains in continuity. Closed management is generally appropriate for type 1 fractures and some type 2 injuries. Meniscal entrapment frequently makes closed reduction impossible in displaced injuries (Kocher et al. 2003). Fixation would be appropriate in this case (see Figure 7.14).

Kocher MS, Micheli LJ, Gerbino P, Hresko MT. Tibial eminence fractures in children: prevalence of meniscal entrapment. *Am J Sports Med.* 2003;**31**:404–407.

Chapter 8

Knee III Structured SBA

Kiran Singisetti

KNEE III STRUCTURED SBA QUESTIONS

1. A 65-year-old man presents to the clinic after initial improvement of knee pain with a knee arthroplasty performed 18 months previously. He now reports recent onset of patellar crepitus and jumping of the patella. Radiographs show no change in position of the posterior stabilised knee replacement with patella resurfacing.
   This presentation could be related to which of the following conditions?
   A. Hypertrophic scar tissue at the inferior pole of the patella impinging on the femoral component during extension
   B. Hypertrophic scar tissue at the inferior pole of the patella impinging on the femoral component during flexion
   C. Hypertrophic scar tissue at the superior pole of the patella impinging on the femoral component during extension
   D. Hypertrophic scar tissue at the superior pole of the patella impinging on the femoral component during flexion
   E. Patellar component loosening

2. During a cruciate retaining knee arthroplasty, the femoral size sagittal measurement comes up in between sizes 4 and 5.
   Which of the following statements is correct?
   A. If you are using anterior referencing, a size 5 femoral component may cause flexion instability
   B. If you are using posterior referencing, a size 5 femoral component may cause flexion instability
   C. If you are using anterior referencing, a size 4 femoral component may cause femoral notching
   D. If you are using posterior referencing, a size 4 femoral component may cause femoral notching
   E. If you are using anterior referencing, a size 5 femoral component may cause tightness of patellofemoral joint

3. Component alignment and balancing form a key step in total knee arthroplasty.
   Which of the following is a correct guide to optimise tibial component rotation?
   A. Junction of the lateral and medial two-thirds of the tibial tubercle
   B. Achieving optimal posterior medial and anterior lateral cortical contact
   C. Extra-medullary alignment rod overlaying the lateral–middle third junctions of the tibial tubercle, the centre of the ankle mortise and second ray of a neutrally aligned foot
   D. Minimal anterior lateral tibial plateau uncoverage
   E. Trial reduction with absolute congruence of the femoral component and the anterior edge of PE tibial bearing surface

4. A patient attends the arthroplasty knee clinic 2 years following right total knee replacement. In the past year, she has complained of a sense of distrusting the knee without giving way, difficulty with stair descent, recurrent effusions and anterior knee pain.
   Possible causes for her symptoms could include which of the following?
   A. Inadequate restoration of the tibial slope
   B. Oversizing of the femoral component
   C. Over-resection of the distal femur
   D. Too little posterior femoral condylar resection
   E. Use of an anterior referencing knee system

5. A 27-year-old female felt a pop during a tackle while playing football.

Which of the following ligament component deficiency causes a positive Pivot shift test?

A. Anterolateral bundle of ACL
B. Anteromedial bundle of ACL
C. Posterolateral bundle of ACL
D. Posteromedial bundle of ACL
E. Posteromedial bundle of PCL

6. A patient with a previous ORIF of a lateral tibial plateau is seen in clinic and listed for a total knee replacement.

Regarding the surgical approach for knee replacement, which of the following statements is correct?

A. Avoid previous incision scars
B. Dissect superficial to the deep fascia
C. If longitudinal scars exist, choose the medial-most incision that affords appropriate exposure
D. Respect the lateral-based vascular anatomy of the skin
E. Transverse scars may be crossed with an incision in a perpendicular manner

7. A 70-year-old woman with tricompartmental knee osteoarthritis is scheduled to have a total knee replacement.

Which of the following intraoperative steps is not useful in improving patellofemoral tracking during total knee arthroplasty?

A. External rotation of the femoral component
B. External rotation of the tibial component
C. Joint line preservation
D. Lateralisation of the femoral component
E. Lateralisation of the patellar component

8. A 56-year-old woman presents with a spontaneous onset of pain in the medial aspect of knee joint.

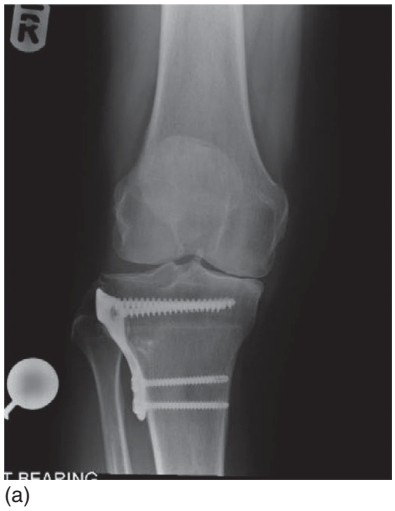
Which of the following is a false statement regarding spontaneous osteonecrosis of the knee (SONK)?

A. Bone scan has a low specificity and sensitivity in diagnosis of the condition
B. Core decompression is a useful treatment following subchondral collapse
C. Mainstay of initial treatment is non-operative
D. It is more common in females
E. MRI is useful in early diagnosis of the condition

9. A retired manual labourer presents with gradual worsening of knee pain with a previous history of high tibial osteotomy (HTO) performed 15 years earlier (Figure 8.1). Radiographs show progressive arthritis of the knee joint and you counsel patient about a total knee arthroplasty (TKA).

Which of the following is a likely issue that you may encounter during TKA following previous HTO?

A. Bipartite patella
B. Lateral patella instability
C. Patella baja
D. Patella fracture
E. Patella osteonecrosis


(a)

(b)

Figures 8.1a and 8.1b
(a) Anteroposterior (AP) and (b) lateral radiographs knee

(a)

(b)

Figures 8.2a and 8.2b
(a) Anteroposterior (AP) and (b) lateral radiographs right knees

10. A patient with medial compartment knee arthritis attends your clinic. He is keen to consider a medial (partial) unicompartmental arthroplasty on the right knee. His radiographs are shown in Figure 8.2.
Which of the following is not a contraindication for this procedure?
A. ACL deficiency
B. Anterior knee pain
C. Fixed flexion deformity
D. Inflammatory arthritis
E. Uncorrectable varus deformity of more than 15°

11. **Which of the following statements is false regarding the surgical approach for primary total arthroplasty in a 62-year-old patient with knee arthritis?**
A. Lateral parapatellar approach is useful in fixed valgus deformity of knee
B. Midvastus approach is relatively contraindicated in obese patients
C. Midvastus approach may potentially achieve earlier rehabilitation
D. Minimally invasive surgical (MIS) approach has no long-term functional advantage
E. Subvastus approach is an extensile approach

12. Your colleague encourages you to use a knee replacement prosthesis that has the option of using an 'all-polyethylene tibia component'. It would be prudent to look at the cost, advantage and disadvantages of the implant before considering a change of practice.
Which of the following is false regarding an 'all-polyethylene tibia component'?
A. Better functional outcome
B. Better stability
C. Less modularity
D. Less osteolysis
E. More expensive

13. A patient reports continuing instability following a previous single bundle ACL reconstruction using hamstring graft. MRI suggests intact graft.
Which of the following statements is correct regarding tunnel malposition?
A. Too anterior femoral tunnel limits flexion of knee
B. Too anterior femoral tunnel causes rotational instability
C. Too anterior tibial tunnel limits flexion of knee
D. Vertical femoral tunnel can risk femoral tunnel blowout
E. Vertical inclination of femoral tunnel is associated with rotational instability

14. A 20-year-old elite football player sustains an anterior cruciate ligament (ACL) rupture and reports instability symptoms despite a focused exercise plan. He attends a specialist knee clinic. He wants to know the best graft option for a potential ACL reconstruction that would allow early return to sports.
Which of the following graft options would you consider in this situation?

A. Bone–patella–tendon–bone autograft
B. Hamstring (four strand) autograft
C. Quadriceps tendon autograft
D. Synthetic graft
E. Tendo-Achilles allograft

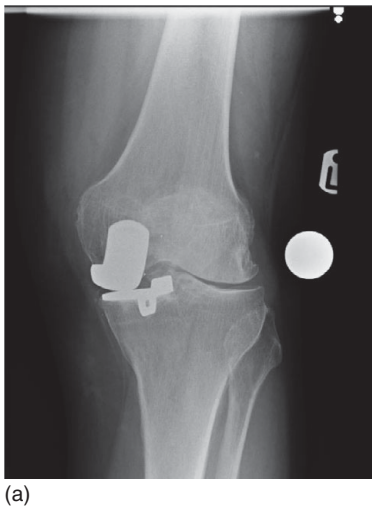
15. While performing a total knee arthroplasty, you are faced with a situation of normal extension gap but tight flexion gap.
Which of the following solutions can be useful in this situation for sagittal balancing of the knee?
A. Cut more proximal tibia
B. Decrease the size of the femoral component
C. Use distal femoral augmentation
D. Use a thicker polyethylene insert
E. Use a thinner polyethylene insert

16. A 24-year-old male walks into your clinic with a varus thrust at the right knee. He reports right knee pain and instability symptoms following a motorbike accident sustained 3 weeks ago. Dial test reveals increased external rotation of the right foot at 30° flexion but not at 90° flexion of knee.
Which of the following is the most likely ligament injury?
A. Isolated ACL injury
B. Isolated MCL injury
C. Isolated posterolateral corner injury
D. Isolated PCL injury
E. Posterolateral corner and PCL injury

17. A 22-year-old female office worker had a previous arthroscopic total medial meniscectomy at a different hospital.
Which of the following situations is not a contraindication for meniscal transplantation?
A. Asymptomatic meniscal loss
B. Chondral changes
C. Inflammatory arthropathy
D. Instability
E. Malalignment

18. A 21-year-old woman presents with recurrent instability of patella following an injury sustained 3 years ago.
How is the isometric point for the femoral tunnel referenced from adductor tubercle when considering a medial patellofemoral ligament (MPFL) reconstruction?
A. At the adductor tubercle
B. Distal and anterior to the adductor tubercle
C. Distal and posterior to the adductor tubercle
D. Proximal and anterior to the adductor tubercle
E. Proximal and posterior to the adductor tubercle

19. A 60-year-old male presents at the ED with a sudden onset of knee pain following a twisting incident at home. He underwent a medial unicompartmental knee replacement 5 years ago. His radiographs are shown in Figure 8.3.


(a)

(b)

Figures 8.3a and 8.3b
(a) Anteroposterior (AP) and (b) lateral radiographs left knee

Which of the following is a true statement regarding liner dislocation with unicompartmental knee arthroplasty?

A. Closed reduction of liner dislocation is usually successful
B. Early liner dislocation can be due to impingement
C. Fixed bearing has a higher risk of liner dislocation compared with mobile bearing
D. Lateral unicompartmental knee replacement has less risk of liner dislocation compared with medial unicompartmental knee
E. Residual cement debris is a common problem with newer uncemented prosthesis design

20. A 30-year-old presents with mechanical knee symptoms following an injury 3 months ago. MRI shows a medial meniscus tear involving the middle third.

Which of the following meniscal tear patterns has the worst prognosis for meniscal repair?

A. Bucket handle
B. Horizontal
C. Longitudinal
D. Parrot beak
E. Radial tear

21. A 20-year-old footballer presents with an unstable tear of the medial meniscus involving the body and anterior horn. You decide to repair the meniscus tear due its location in the red-red zone but find it difficult to access the anterior horn.

Which of the following arthroscopic meniscal repair techniques is useful for repair of an anterior horn meniscal tear?

A. All-inside
B. All-outside
C. Inside-out
D. Outside-in
E. Transtibial pull-out suture

22. A 13-year-old girl presents with a spontaneous onset of knee pain and mechanical symptoms in the last 6 months. MRI shows the following lesion on lateral femoral condyle (Figure 8.4).

Which of the following statements is true related to this diagnosis?

A. Condition is more common in females
B. Lateral aspect of medial femoral condyle is the most common location

Figure 8.4
MRI scan knee

C. Skeletally immature patients respond well to non-operative management
D. This condition is more common in the elbow compared with the knee joint
E. Unstable lesions can be treated by subchondral drilling

23. A 70-year-old woman with valgus knee arthritis is being considered for a total knee replacement. On examination, you find the medial collateral ligament to be intact.

Which of the following statements is false?

A. A constrained prosthesis is more likely to be used if there is a fixed valgus deformity
B. It is better to release the iliotibial band in knees too tight laterally in extension, but not in flexion
C. Patellar instability is a common problem with valgus knees
D. Peroneal nerve palsy is more common in valgus knee compared with varus knee deformity correction
E. The posterior condylar axis is more reliable than the transepicondylar axis for setting the correct femoral component rotation

24. A 30-year-old amateur footballer attends clinic following a knee injury sustained a few months previously. Examination and imaging confirm a high-grade ACL injury.

While counselling about ACL reconstruction, which of the following statements is not true about the benefits of an ACL reconstruction?

A. Better chance for return to sports
B. Better chance of meniscal repair healing, if associated with ACL reconstruction

C. Reduces instability symptoms of the knee
D. Reduces risk of future knee arthritis
E. Reduces risk of further meniscal injury

25. An 18-year-old gymnast presents with patellar instability where non-operative management (VMO exercises) has failed. CT scan of the knee is obtained to assess cross-sectional anatomy and measurements before considering a tibial tubercle osteotomy.

Which of the following is a false statement?

A. High Q angle can cause patellofemoral joint pain
B. Lateral patellofemoral angle opens laterally
C. Normal range for the Insall–Salvati ratio is 0.8–1.2
D. Sulcus angle of less than 140° may suggest trochlear dysplasia
E. TT–TG distance of more than 20mm is considered abnormal

26. A 21-year-old female presents with anterior knee pain, which has failed non-operative management. Imaging shows increased TT–TG distance with degeneration of the medial facet of the patella.

Which of the following tibial tubercle osteotomies is recommended in this situation?

A. Lateral and anterior displacement of tibial tubercle
B. Lateral and posterior displacement of tibial tubercle
C. Medial and anterior displacement of tibial tubercle
D. Medial and distal displacement of tibial tubercle
E. Medial displacement of tibial tubercle

27. During a revision knee arthroplasty procedure, assessment of remaining bone stock following removal of prosthesis shows some distal femoral bone loss. The surgeon decides to seat a femoral component on whatever remaining bone is present and implants a thicker polyethylene insert. At follow-up review, the patient reports anterior knee pain and flexion instability symptoms.

What is the most likely reason for these symptoms?

A. Lower joint line with decreased posterior condylar offset
B. Lower joint line with increased posterior condylar offset
C. Not resurfacing the patella
D. Raised joint line with decreased posterior condylar offset
E. Raised joint line with increased posterior condylar offset

28. A 25-year-old male underwent ACL reconstruction using quadrupled hamstring graft 2 weeks previously. He asks for your advice on post-operative rehabilitation, as the physiotherapist is currently on leave.

Which of the following exercises should be avoided in the first 4–6 weeks?

A. Closed chain (e.g. squatting) knee exercises
B. Isometric quadriceps exercises
C. Neuromuscular training
D. Open chain (e.g. seated leg extension) exercises
E. Patella mobilisation

29. A 25-year-old female attends clinic following a knee injury sustained while playing netball. Clinical examination reveals excessive anterior laxity with a soft end point on Lachman's test.

Which of the following statements is true regarding ACL reconstruction technique?

A. Anterior knee pain is common with hamstring compared with BPTB autograft use
B. Femoral tunnel expansion (windscreen wiper effect) is common with interference compared with suspensory fixation
C. The femoral tunnel is made before the tibial tunnel in a transtibial technique
D. There is a higher rate of failure in allograft compared with autograft use in ACL reconstruction
E. The outcome of single bundle ACL reconstruction is better with transtibial compared to anteromedial technique

30. A 12-year-old boy presents with a full-thickness ACL tear and instability symptoms. Tanner score is III. Parents are anxious about the long-term implications of the child's ACL injury.

Which of the following statements is true regarding ACL reconstruction in skeletally immature patients?

A. There is a high risk of growth disturbance with transphyseal technique

B. It is better to wait until skeletal maturity before considering ACL reconstruction
C. Interference screw fixation is preferred in transphyseal technique
D. Oblique femoral tunnel is preferred in transphyseal technique
E. Soft tissue grafts are better for transphyseal technique

31. A 20-year-old athlete attends clinic after an ACL reconstruction using hamstring graft 6 weeks ago. He reports hypersensitivity and numbness at the hamstring graft harvest site related to damage of infrapatellar branch of the saphenous nerve (IPBSN).
Which of the following statements is true regarding this risk of damage to IPBSN?
A. Horizontal incision is better than oblique incision for reducing the risk of nerve injury
B. Risk is higher in males
C. Risk is higher in younger age
D. The IPBSN is closer to semitendinosus compared with gracilis tendon
E. Vertical incision has higher risk of injury compared with oblique incision

32. A 25-year professional basketball player attends your sports knee clinic to discuss treatment options for ACL deficient right knee.
Which of the following statements is true when counselling about graft options for ACL reconstruction?
BPTB – Bone patella tendon bone graft
HT – Hamstring graft
A. BPTB graft has a low risk of donor site morbidity compared with HT
B. BPTB graft is useful for double bundle ACL reconstruction
C. BPTB graft requires a longer duration for integration compared with HT
D. Irradiated allografts have no donor site morbidity but are more likely to fail
E. Quadrupled HT graft has a lower tensile strength compared with intact native ACL

33. A professional footballer sustains a multiligament knee injury. Initial assessment shows intact distal neurovascular status. You are considering a PCL reconstruction along with dealing with other ligament injuries.
Which of the following statements is correct regarding PCL reconstruction technique?
A. Acute 'killer turn' of the graft is encountered in transtibial technique
B. Direct bone-to-bone healing is seen in transtibial technique
C. Single bundle PCL reconstruction is tensioned in extension or 20° of flexion
D. Transtibial technique allows for anatomic placement of the PCL graft at its tibial attachment
E. Open tibial inlay PCL reconstruction results in the formation of a long oblique tibial tunnel

34. A 40-year-old man sustains a direct blow injury to his knee ('dashboard type') resulting in a painful swollen knee. The knee feels stable on varus and valgus stress testing with a posterior sag detected on posterior drawer test.
Which of the following statements is false regarding non-operative management of isolated PCL injuries?
A. Early rehabilitation and bracing of isolated PCL injuries can result in a successful return to sports
B. Hamstring exercises should be avoided in the early stages
C. Patella mobilisations performed to minimise quadriceps inhibition
D. Quadriceps strengthening exercises should be encouraged
E. Range of movement knee exercise in a supine position in early stages

35. A 35-year-old woman presents with recurrent effusion of her knee. MRI shows low signal intensity on both T1 and T2 with a blooming artefact appearance (Figure 8.5).

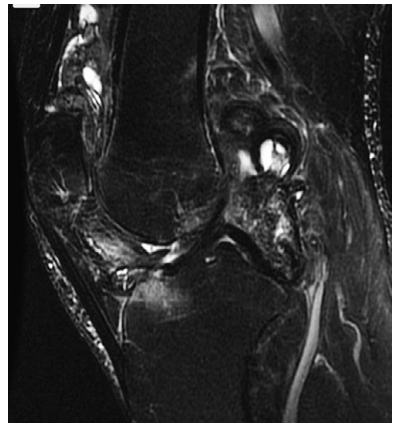


Figure 8.5
MRI scan knee

Which of the following statements is correct regarding this condition?

A. Arthroscopic synovectomy gives good clearance in the diffuse form of this condition
B. Blood coagulation test results are usually deranged
C. Affects males more than females
D. Histology shows haemosiderin stained multinucleated giant cells
E. Local recurrence of this condition is rare

36. A 70-year-old woman presents with worsening pain related to valgus knee arthritis. A plain radiograph of both knees on standing is shown in Figure 8.6. She is keen to consider a total knee arthroplasty as the pain is not well controlled with analgesics and is interfering with her walking.

Which of the following is not reliable in setting external rotation of femoral component?

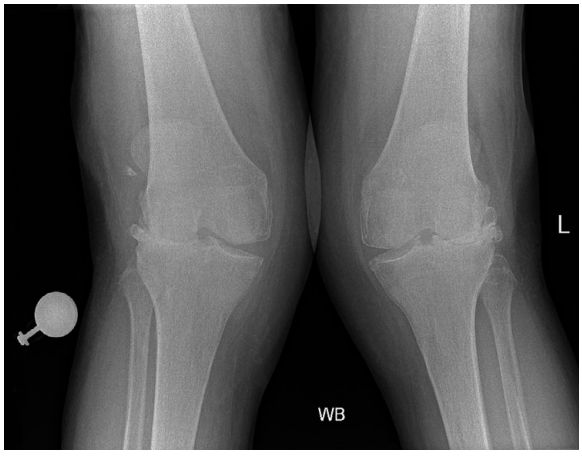


Figure 8.6 Anteroposterior (AP) radiograph both knees

A. Computer navigation
B. Proximal tibia cut
C. Posterior condylar axis
D. Transepicondylar axis (lateral to medial epicondyle)
E. Whiteside line (trochlear AP axis)

37. During a knee arthroscopy you encounter a displaced bucket handle medial meniscus tear in a tight medial compartment. You find it difficult to insert instrumentation for meniscal repair on the medial side.

What would be the most appropriate way to manage the situation?

A. Abandon the procedure and reschedule on a different day
B. Ask the anaesthetist to give a muscle relaxant
C. Continue with the procedure accepting excessive scuffing of articular cartilage
D. Perform meniscal resection
E. Pie-crusting to release the MCL

38. A 65-year-old patient underwent a total knee arthroplasty which resulted in excessive femoral notching (Figure 8.7).

Which of the following is the most likely cause of this complication?

A. Excessive external rotation of femoral cutting block
B. Larger size femoral cutting block with anterior referencing
C. Larger size femoral cutting block with posterior referencing
D. Smaller size femoral cutting block with anterior referencing
E. Smaller size femoral cutting block with posterior referencing

39. A 20-year-old gymnast sustains a twisting knee injury leading to painful mechanical symptoms. MRI scan suggests an unstable anterior horn lateral meniscus tear.

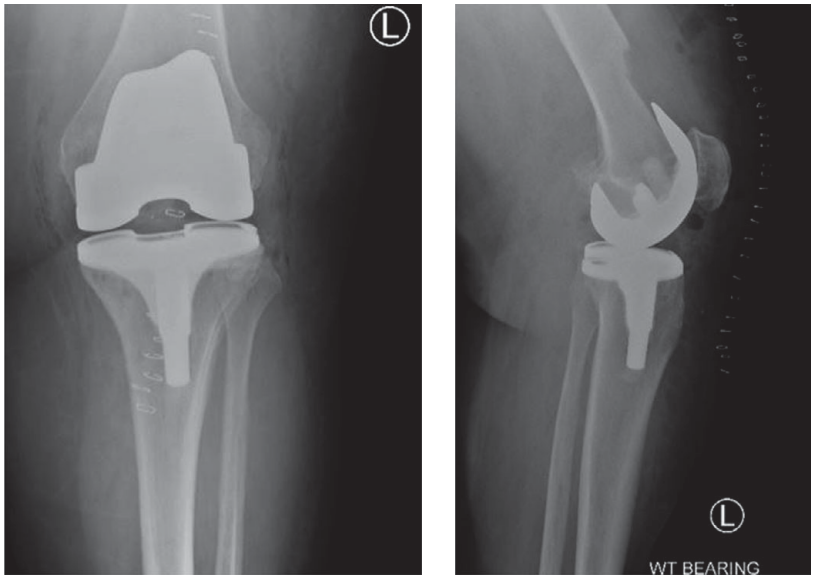
Which of the following treatment options would be the best way forward to manage the situation?

A. All inside meniscal repair
B. Inside-out meniscal repair
C. Non-operative treatment
D. Outside-in meniscal repair
E. Partial lateral menisectomy

40. You are performing a total knee arthroplasty for a 70-year-old woman with varus tricompartmental knee arthritis. During knee balancing, you are faced with a situation of a normal flexion gap but tight extension gap.

Which of the following solutions can be useful in this situation for sagittal balancing of the knee?

A. Cut more proximal tibia
B. Decrease the size of the femoral component
C. More distal femoral resection



(a) (b)

Figure 8.7 (a) and (b) Anteroposterior and lateral radiograph left knee

D. Use a thicker polyethylene insert
E. Use a thinner polyethylene insert

41. What is your preferred initial treatment of an active 28-year-old man who presents to you with tenderness at the insertion of the patella tendon into the patella?

It has been present for 2 years and mainly comes on with activity and sport.

A. Eccentric exercises
B. Patella tendon orthosis
C. PRP injection
D. Shock wave therapy
E. Steroid injection

42. A 25-year-old man sustained a twisting injury to his right knee whilst playing tennis. The next day he noticed some swelling. Clinical examination revealed medial joint line tenderness.

Which of the following tests will most likely suggest his diagnosis?

A. Axial force down the leg with the patient prone and the knee flexed to 90°
B. Internal rotation and external rotation of the flexed knee with axial pressure down the leg
C. Opening of the knee joint with a varus force
D. Rotating on a 20° flexed knee whilst weight bearing on that side
E. Squat and walk

KNEE III STRUCTURED SBA ANSWERS

1. Answer C. **Hypertrophic scar tissue at the superior pole of the patella impinging on the femoral component during extension**
Patellar clunk syndrome is related to the formation of a fibrous nodule on the undersurface of distal quadriceps, just above the patella. This is usually related to a posterior stabilised total knee arthroplasty. Treatment is arthroscopic or open debridement of the fibrous nodule.

Fukunaga K et al. The incidence of the patellar clunk syndrome in a recently designed mobile-bearing posteriorly stabilised total knee replacement. *J Bone Joint Surg Br.* 2009;**91**:463–468.

Gopinathan P. Patello-femoral clunk syndrome – current concepts. *J Orthop.* 2014;**11**:55–57.

2. Answer D. **If you are using posterior referencing, a size 4 femoral component may cause femoral notching**
The anterior referencing technique measures the size of the femur with the starting point from the anterior femoral cortex. This reduces the risk of notching of the anterior femoral cortex, but it is more difficult to control the posterior condylar offset. This carries the risk of flexion instability if the femoral component is undersized. With the posterior referencing technique, the measurement is referenced from the posterior condyles, the size of the flexion gap and posterior condylar offset can be better controlled, but there is a risk of anterior notching or overstuffing, if it is between sizes.

Posterior referencing is considered generally more reliable in reducing the risk of flexion instability. If you are using a posterior referencing system, when faced with a femur in between sizes, there are some tips you could use if you decided to go with a smaller size femoral component. First, you could translate the cutting block 2mm anteriorly using an anti-notch guide. This may increase the flexion gap by 2mm but is usually well tolerated in most cases and avoids the risk of anterior notching. Second, a 3° flexion of the femoral component may help in reducing the risk of anterior notching, though theoretically this may cause some loss of extension.

Fokin AA, Heekin RD. Anterior referencing versus posterior referencing in total knee arthroplasty. *J Knee Surg.* 2014;**27**:303–308.

Charette RS, Sheth NP, Boettner F, Scuderi GR, Melnic CM. Femoral component sizing during total knee arthroplasty: anterior versus posterior referencing. *J Bone Joint Surg Rev.* 2018;**6**:e4.

3. Answer E. **Trial reduction with absolute congruence of the femoral component and the anterior edge of PE tibial bearing surface**
There are multiple checks that need to be performed to make sure the tibial base plate is appropriately aligned. The base plate needs to be aligned with the junction of the medial and middle thirds of the tibial tubercle. This should be achieved through rotation and not just simply translation in the coronal plane. This rotation should create minimal posterior–medial tibial plateau uncoverage. Additionally, this rotation should achieve optimal anterior medial and posterior lateral cortical contact in order to optimise load transfer and reduce the risk of subsidence.

An additional check would be to use an extramedullary alignment rod clipped to the pinned tibial baseplate. The rod should overlay the medial–middle third junction of the tibial tubercle, the centre of the ankle mortise and point to the first or second ray of a neutrally aligned foot. Prosthetic clues for assessing tibial rotation include basing this relationship on a properly placed femoral component and the semi-congruous PE bearing surface. With the knee fully extended, there should be absolute congruency between the femoral component and anterior edge of the semi-congruent tibial PE component. The knee should then be flexed up to 90° and again the PE tibial bearing should be absolutely congruent and without edge loading.

4. Answer E. **Use of an anterior referencing knee system**
The patient is describing classic symptoms of flexion instability caused by an increased flexion gap compared with extension gap. Patients typically present with recurrent effusions, subjective instability (especially going downstairs), quadriceps weakness and diffuse peri-retinacular pain.

Flexion instability is the result of a flexion space that is larger than the extension gap. It is caused by an inability to balance the flexion and extension space at the time of index arthroplasty

or from gradual laxity of the posterior capsule or posterior cruciate ligament (PCL) in cruciate-retaining (CR) designed implants.

Technical factors that can lead to flexion instability include too little distal femoral resection in a pre-existing flexion contracture, overly aggressive posterior condylar resection with undersized femoral implants, excessive posterior slope on the tibia or over-release of the PCL in the CR knee.

An appropriate extension gap can exist but over-resection of the posterior femur and/or undersizing or anteriorising of the femoral component will lead to a large flexion gap. This most commonly occurs when using an anterior referencing system to size the femoral component. As such, many surgeons prefer a posterior referencing system.

5. Answer C. **Posterolateral bundle of ACL**
The anterior cruciate ligament (ACL) is composed of two bundles, anteromedial (AM) and posterolateral (PL). AM bundle of ACL is tight in flexion and loose in extension. PL bundle of ACL is tight in extension and loose in flexion.

The pivot shift test is performed with the patient's knee starting in full extension. Maintaining internal rotation of the tibia, a valgus force is applied while the knee is slowly flexed to about 30°. The examiner will feel for a subluxation of the lateral tibial plateau as it reduces to its normal position. The PL bundle of ACL is an important contributor to anteroposterior as well as rotational stability of the knee; deficiency of this component causes a positive pivot shift test.

Robinson J, Carrat L, Granchi C, Colombet P. Influence of anterior cruciate ligament bundles on knee kinematics: clinical assessment using computer-assisted navigation. *Am J Sports Med.* 2007;**35**:2006–2013.

6. Answer E. **Transverse scars may be crossed with an incision in a perpendicular manner**
If previous longitudinal incisions exist, try to incorporate the most lateral incision that can give adequate exposure. Due to the medially based blood supply, it is better to elevate a full-thickness medial flap rather than a lateral one. If you are unable to incorporate a lateral incision, then maintaining the widest possible skin bridge between incisions, without compromising exposure, is the best solution. When prior transverse incisions are present, it is safe to cross these incisions in a perpendicular manner.

Respect the medially based vascular anatomy of the skin and incorporate previous incisions. Maintain full-thickness flaps, avoiding dissection superficial to the deep fascia.

7. Answer E. **Lateralisation of the patellar component**
Patellofemoral tracking in total knee replacement is improved by the following steps: (1) external rotation of the femoral component, (2) avoidance of internal rotation of the tibial component, (3) joint line preservation, (4) medialisation of the patellar component, (5) avoidance of an oversized femoral component, (6) lateralisation of the femoral component and (7) secure repair of the medial retinaculum during closure. Lateralisation of the patellar component will increase the Q-angle and tendency to cause lateral maltracking of the patella.

8. Answer B. **Core decompression is a useful treatment following subchondral collapse**
SONK was previously related to ischaemia leading to necrosis; it is now considered due to a subchondral insufficiency fracture of the knee. It is seen more frequently in women (M:F 1:3) and typically affects those over the age of 55. Patients often report sudden onset of severe knee pain without significant trauma. This must be distinguished from secondary osteonecrosis of the knee. Bone scan may show a low uptake at the lesion but has a limited role in diagnosis due to its low specificity and sensitivity of diagnosis of the condition. Some association with meniscal root tears has been reported recently. The initial treatment is non-operative. Core decompression has a limited role in resistant cases prior to subchondral collapse. Arthroplasty (partial or total) is considered when there is a progressive degenerative change of the joint.

9. Answer C. **Patella baja**
Patella baja is a common problem encountered in total knee replacement following previous high tibial osteotomy. This is more common in

a closed wedge compared with an open wedge osteotomy. Posterior tibial slope should also be carefully considered, as a previous osteotomy has a tendency to alter this.

Song SJ, Bae DK, Kim KI, Lee CH. Conversion total knee arthroplasty after failed high tibial osteotomy. *Knee Surg Relat Res.* 2016;**28**:89–98.

10. Answer B. **Anterior knee pain**
Medial unicompartmental knee replacement is considered a suitable alternative to osteotomy for single compartment knee degenerative changes. The contraindications for this procedure include inflammatory arthritis, ACL deficiency, fixed varus deformity of more than 10° and stiff knee. Patellofemoral degenerative changes were previously considered a relative contraindication, but more recent literature suggests the contrary. The Oxford Group report that anterior knee pain and early patellofemoral degenerative changes are not considered a contraindication for the medial unicompartmental arthroplasty. Severe patellofemoral chondral changes are still considered a contraindication for this procedure.

Hamilton TW et al. Anterior knee pain and evidence of osteoarthritis of the patellofemoral joint should not be considered contraindications to mobile-bearing unicompartmental knee arthroplasty: a 15-year follow-up. *Bone Joint J.* 2017;**99-B**:632–639.

11. Answer E. **Subvastus approach is an extensile approach**
Medial parapatellar approach is the commonest approach used for total knee replacement. Lateral parapatellar approach can be used in a valgus knee that is not correctable; the access to the lateral compartment is good but can occasionally cause difficulty in distal closure after deformity correction. Midvastus approach is advocated for an earlier rehab, as it avoids disruption of VMO insertion. Both midvastus and subvastus approaches are less extensile and should not be attempted in obese patients and stiff knee and complex knee conditions. MIS knee replacement involves a smaller skin incision than does the traditional medial parapatellar approach; it may have less immediate post-operative pain but has not been shown to have better function in the long term.

12. Answer E. **More expensive**
The metal-backed tibial components are more commonly used across most arthroplasty registries, although all-polyethylene tibial components have been reported to have better (or comparable) survival and lower rates of infection, instability, tibial component loosening and periprosthetic fracture. They are also cheaper compared with metal-backed tibial components. The disadvantage of all-polyethylene tibia is the lack of modularity.

Gudnason A, Hailer NP, W-Dahl A, Sundberg M, Robertsson O. All-polyethylene versus metal-backed tibial components – an analysis of 27,733 cruciate-retaining total knee replacements from the Swedish Knee Arthroplasty Register. *J Bone Joint Surg Am.* 2014;**96**:994–999.

Houdek MT et al. All-polyethylene tibial components: an analysis of long-term out- comes and infection. *J Arthroplasty* 2016;**31**:1476–1482.

13. Answer E. **Vertical inclination of femoral tunnel is associated with rotational instability**
Too anterior femoral tunnel limits extension. Likewise, too anterior tibial tunnel causes roof impingement and limits extension. Too vertical femoral tunnel can lead to a non-anatomical femoral graft entry point, which has the potential to cause rotational instability.

Pinczewski et al. (2008) described the optimal tunnel position in their series of patients with good outcome. In the sagittal plane, the femoral tunnel was a mean of 86% posteriorly along the Blumensaat line and the tibial tunnel was 48% along the tibial plateau. In the coronal plane, the tibial tunnel was 46% across the tibial plateau and the mean inclination of the graft was 19°.

Pinczewski LA et al. Radiological landmarks for placement of the tunnels in single-bundle reconstruction of the anterior cruciate ligament. *J Bone Joint Surg Br.* 2008;**90**:172–179.

14. Answer A. **Bone–patella–tendon–bone autograft**
An autograft is tissue obtained from the patient's body. An allograft is tissue from a cadaver.

The most common choices available are bone–patella–tendon–bone autograft, hamstring autograft, quadriceps tendon autograft and various allograft options. Synthetic graft options are now uncommon. The bone-to-bone healing with the patellar graft has an advantage for athletes who are interested in early return to sports, although this has the risk of residual anterior knee pain due to the morbidity associated with patellar tendon graft harvest. Traditionally, the bone–patella–tendon–bone graft was considered gold standard amongst graft options, though more recent studies have shown comparable results with hamstring autograft.

Gifstad T et al. Lower risk of revision with patellar tendon auto- grafts compared with hamstring autografts: a registry study based on 45,998 primary ACL reconstructions in Scandinavia. *Am J Sports Med.* 2014;**42**:2319–2328.

Samuelsen BT, Webster KE, Johnson NR, Hewett TE, Krych AJ. Hamstring autograft versus patellar tendon autograft for ACL reconstruction: is there a difference in graft failure rate? A meta-analysis of 47,613 patients. *Clin Orthop Relat Res.* 2017;**475**:2459–2468.

15. Answer B. **Decrease the size of the femoral component**
Symmetric gap issues (such as tight or loose in both extension and flexion) are addressed with proximal tibia. Resecting more proximal tibia helps with tight extension and flexion.

Using a thicker insert or tibial augmentation helps if loose in extension and flexion.

Asymmetric gap issues:

Extension good and loose in flexion can be addressed with an increase in the size of the femoral component; other options are to translate the femoral component posteriorly or to use a thicker insert followed by addressing tight extension gap.

Extension tight and flexion good can be addressed by either more distal femoral resection or posterior capsule release.

Extension good and tight in flexion can be addressed by decreasing the size of the femoral component. Other options are to recess PCL and address posterior slope of tibia if needed.

Extension loose and flexion good can be addressed with distal femoral augmentation. Other options are to use a thicker insert followed by addressing tight flexion gap.

16. Answer C. **Isolated posterolateral corner injury**
Posterolateral corner (PLC) injuries are generally associated with other ligament injuries but can occasionally present as isolated injuries. Dial test is a useful assessment for PLC injuries; asymmetry of external rotation of foot on the affected side at 30 degrees of knee flexion is seen only in isolated PLC injury. Asymmetry of external rotation of the foot on the affected side at both 30° and 90° of knee flexion is suggestive of combined PLC and PCL injury. One of the causes of failure of an ACL reconstruction is a missed PLC injury.

Ranawat A, Baker CL 3rd, Henry S, Harner CD. Posterolateral corner injury of the knee: evaluation and management. *J Am Acad Orthop Surg.* 2008;**16**:506–518.

17. Answer B. **Chondral changes**
Chondral changes in the absence of osteophytes is not a contraindication for meniscal transplant. Osteophytes may interfere with the sitting of the meniscal graft. Instability and malalignment should be corrected before meniscal transplantation surgery. Most authors suggest that meniscal transplantation should be considered only in symptomatic meniscal loss, although some consider this in asymptomatic lateral meniscus loss. Inflammatory arthropathy, advanced arthritis, obesity and prior infection are also considered contraindications.

Figueroa F, Figueroa D, Calvo R, Vaisman A, Espregueira-Mendes J. Meniscus allograft transplantation: indications, techniques and outcomes. *EFORT Open Rev.* 2019;**4**:115–120.

Getgood A et al.; IMREF Group. International Meniscus Reconstruction Experts Forum (IMREF) 2015 Consensus Statement on the Practice of Meniscal Allograft Transplantation. *Am J Sports Med.* 2017;**45**:1195–1205.

18. Answer B. **Distal and anterior to the adductor tubercle**
In a cadaveric study Schottle et al. described the medial patellofemoral ligament (MPFL) was

found to insert 1.9mm anterior and 3.8mm distal to the adductor tubercle.

Schottle et al. described the MPFL anatomical insertion on the femur as the isometric point for MPFL tunnel placement in reconstruction cases. In their study, they defined a radiographic point 1mm anterior to a line extending from the posterior cortex and 2.5mm distal to the posterior origin of the medial femoral condyle and proximal to the level of the posterior point of the Blumensaat line.

Schottle PB, Schmeling A, Rosenstiel N, Weiler A. Radiographic landmarks for femoral tunnel placement in medial patellofemoral ligament reconstruction. *Am J Sports Med.* 2007;**35**:801–804.

19. Answer B. **Early liner dislocation can be due to impingement**

Lateral unicompartmental knee replacement is at a higher risk of liner dislocation. Hence, some authors recommend using a fixed bearing prosthesis on the lateral side. Bearing exchange alone should be carefully considered in selected patients having correctable causes such as impingement by remnant cement or bony spur, larger gap (thin bearing at the index operation), loss of entrapment by late bearing wear at the long-term follow up or acute trauma.

Kim SG, Kim HG, Lee SY, Lim HC, Bae JH. Redislocation after bearing exchange for the treatment of mobile bearing dislocation in medial unicompartmental knee arthroplasty. *Knee Surg Relat Res.* 2018;**30**234–240.

van der List JP, Zuiderbaan HA, Pearle AD. Why do medial unicompartmental knee arthroplasties fail today? *J Arthroplasty* 2016;**31**:1016–1021.

20. Answer E. **Radial tear**

Radial meniscus tears lead to decreased hoop stresses of the meniscus and effectively a non-functional meniscus.

Abram SGF, Beard DJ, Price AJ; BASK Meniscal Working Group. Arthroscopic meniscal surgery: a national society treatment guideline and consensus statement. *Bone Joint J.* 2019;**101-B**:652–659.

21. Answer D. **Outside-in**

The three main techniques for meniscal repair are inside-out, outside-in, all-inside. All-inside meniscal repair is the most common technique and can be performed with a variety of suture anchor devices. Inside-out technique has conventionally been considered a gold standard, as it gives a strong repair though this is associated with surgical risks. In this technique, the tear is fixed by placement and fixation of the passing sutures from the intra-articular region with the use of special cannulae to the extracapsular area over the capsule with a posterolateral or posteromedial incision. Outside-in technique is useful for anterior third or horn of meniscus repair, where the suture ends are tied over capsule. Transtibial pull-out suture repair is useful for posterior root avulsions. All-outside repair does not exist and is a misleading option.

22. Answer C. **Skeletally immature patients respond well to non-operative management**

The MRI image in Figure 8.4 shows a presentation of osteochondritis dessicans (OCD) with an unstable lesion. It is more common in males. Non-operative management is better tolerated by the skeletally immature compared with young adults. The knee (distal femur) is the most common joint for OCD; other sites include the elbow (distal humerus) and ankle (talus). Though the image shows a lesion on the medial aspect of lateral condyle, it is described most commonly at the lateral aspect of the medial condyle (almost 80%). An unstable lesion is best managed by fixation. Subchondral drilling is an option for a stable but symptomatic lesion.

The International Cartilage Repair Society (ICRS) scale of OCD lesions is based on the arthroscopic assessment:

Type I: Stable lesion with a continuous but softened area covered by intact articular cartilage.

Type II: Lesion with partial articular cartilage discontinuity, stable when probed.

Type III: Lesion with complete articular cartilage discontinuity, but no dislocation.

Type IV: Empty defect, or defect with a dislocated fragment or loose fragment within the bed.

23. Answer E. **The posterior condylar axis is more reliable than the transepicondylar axis for setting the correct femoral component rotation**

Valgus knee deformity is defined by a tibiofemoral angle of greater than 10°.

The posterior femoral condyle on the lateral side can be deficient in a valgus knee. Relying on the posterior condylar axis in lateral femoral condyle hypoplasia can result in internal rotation of the femoral component. The anteroposterior (AP) and the transepicondylar axis are more reliable reference lines to achieve appropriate femoral component rotation.

Popliteus release can be considered in knees that are tight laterally in flexion but not in extension. Iliotibial band release can be considered in knees that are tight laterally in extension but not in flexion. Knees that are tight laterally in flexion and extension have popliteus tendon or LCL release (or both).

Lange J, Haas SB. Correcting severe valgus deformity: taking out the knock. *Bone Joint J.* 2017;**99-B**(1 Suppl. A):60–64.

Whiteside LA. Selective ligament release in total knee arthroplasty of the knee in valgus. *Clin Orthop Relat Res.* 1999;**367**:130–140.

24. Answer D. **Reduces risk of future knee arthritis**
There is some controversy about conservative versus surgical management of ACL reconstruction. While a structured rehabilitation programme may be suitable for some patients, ACL reconstruction has been shown to improve knee stability and thereby decrease the risk of further meniscal injuries. There is no significant evidence to suggest that an ACL reconstruction protects against future development of knee arthritis. Repair of meniscal tear is more likely to be successful if an associated ACL deficiency is managed surgically.

25. Answer D. **Sulcus angle of less than 140° may suggest trochlear dysplasia**
TT-TG distance measures the distance between two perpendicular lines from the posterior cortex to the tibial tubercle and the trochlear groove; a value of greater than 20mm is usually considered abnormal.

Sulcus angle is used to evaluate trochlear dysplasia; an angle of more than 140° may indicate suspicion of dysplasia. The Insall–Salvati method helps to assess patellar height. Normal value is between 0.8 and 1.2.

The lateral patellofemoral angle is a measurement of the patellar tilt; it is the angle between the line across femoral condyles and a second line along the lateral patellar facet.

The Q angle is the angle between the line joining the anterior superior iliac spine and the centre of the patella and the second line joining the centre of the patella to the tibial tubercle. It can be measured both at flexion (15–20°) and extension; however, it may not be accurate in extension due to lateral patellar displacement. Traditionally measured with the patient supine and quadriceps relaxed, there has not yet been a standardisation of the position and state of muscle contraction while measuring the Q angle. It is an indicator of the net lateral force exerted on the patella by the quadriceps and the patellar tendon.

Dejour H, Walch G, Nove-Josserand L, Guier C. Factors of patellar instability: an anatomic radiographic study. *Knee Surg Sports Traumatol Arthrosc.* 1994;**2**:19–26.

26. Answer C. **Medial and anterior displacement of tibial tubercle**
Distal patellar realignment procedures are used to help with patella compression syndrome. They can be classed as tibial tubercle anteriorisation (Maquet procedure), medialisation (Elmslie–Trillat procedure) or a combination (anteriorisation and medialisation, as with Fulkerson procedure). Elmslie–Trillat is contraindicated with medial patella facet arthritis.

27. Answer D. **Raised joint line with decreased posterior condylar offset**
The joint line is inadvertently raised due to proximal displacement of the femoral component if the distal femoral bone loss is not taken into consideration. This causes joint line elevation and potentially a smaller revision femoral component being used. A common surgical mistake is to use a thicker insert as the extension gap is too large, but this raises the joint line. Undersizing of the femoral component causes decreased posterior condylar offset, which is a cause of flexion instability. Posterior condylar offset is the maximum thickness of posterior condyles; some authors measure this as a ratio. Posterior condylar offset ratio is defined by Johal

et al. (2012) as the 'maximal thickness of the posterior condyle projecting posteriorly to a straight line drawn as the extension of the posterior femoral shaft cortex, divided by the maximal thickness of the posterior condyle projecting posterior to a straight line drawn as the extension of the anterior femoral shaft cortex on a true lateral radiograph of the distal quarter of the femur'.

Restoring joint line is another important consideration in revision knee arthroplasty. Some landmarks for joint line are previous meniscal scar, 10–15mm proximal to the tip of fibular styloid, 25mm distal to the sulcus of the medial epicondyle and 20mm from lateral epicondyle.

Clement ND, MacDonald DJ, Hamilton DF, Burnett R. Posterior condylar offset is an independent predictor of functional outcome after revision total knee arthroplasty. *Bone Joint Res.* 2017;**6**:172–178.

Johal P, Hassaballa MA, Eldridge JD, Porteous AJ. The posterior condylar offset ratio. *Knee* 2012;**19**:843–845.

28. Answer D. **Open chain (e.g. seated leg extension) exercises**
Post-operative ACL rehabilitation is goal based rather than time based. Open chain and isokinetic exercises should be avoided in the first few weeks for ACL post-operative rehabilitation. Closed chain knee exercises are those that are performed with the foot in contact with the ground or a machine. Closed chain exercises tend to cause compression of joints, which helps stabilise the joint. Open chain exercises tend to involve more shearing force across the joint; this may risk putting undue stretch on the graft.

There are some differences in a hamstring (HS) versus bone–patella–tendon–bone (BPTB) graft on how open chain exercises can be delivered. For BPTB graft, open chain exercises can be started from 4 weeks post-operative in a restricted ROM of 90–45°, and extra resistance is allowed, for example, at a leg extension machine. For HS graft, open chain exercises can also be started from 4 weeks post-operative in a restricted ROM of 90–45°, but no extra weight should be added in the first 12 weeks to prevent graft elongation.

van Melick N et al. Evidence-based clinical practice update: practice guidelines for anterior cruciate ligament rehabilitation based on a systematic review and multidisciplinary consensus. *Br J Sports Med.* 2016;**50**:1506–1515.

29. Answer D. **There is higher rate of failure in allograft compared with autograft use in ACL reconstruction**
The transtibial technique involves femoral tunnel drilling through the tibial tunnel; hence the tibia is prepared first. The anteromedial technique of femoral tunnel placement is independent of the tibial tunnel. The anteromedial technique has been shown to be more reliable in appropriate femoral tunnel position compared with transtibial technique, thereby there is better functional outcome.

There is no donor site morbidity with use of allograft but it has the disadvantage of higher failure rate. The incidence of anterior knee pain and difficulty in kneeling is more common with the patellar tendon (BPTB) autograft.

30. Answer E. **Soft tissue grafts are better for transphyseal technique**
There are increasing literature reports about the risks of delaying surgery in symptomatic knees for the skeletally immature; this has the risk of meniscal and chondral injuries. Both transphyseal- and physeal-sparing techniques have been shown to have similar and low risk of growth disturbance in skeletally immature patients. The risk factors for growth disturbance involve high-speed drilling, use of interference screws, over-tension of graft, large tunnel size and oblique tunnel position. Soft tissue grafts with slightly more vertical tunnels in the transphyseal technique reduce the risk of growth disturbance.

31. Answer E. **Vertical incision has higher risk of injury compared with oblique incision**
The saphenous nerve is the longest sensory branch of the femoral nerve (L1, L2, L3), supplying sensation to the medial aspect of the leg and foot. Injury to the IPBSN in ACL reconstruction is not related to age, gender or physique. An oblique incision has been shown to reduce the risk of injury to the IPBSN (Figure 8.8).

Table 8.1 Biomechanics properties of ACL grafts

Tissue	Ultimate Tensile Load (Newton)	Stiffness (N/mm)	Cross-sectional area (mm^2)
Intact ACL	2160	242	44
Bone-patella-tendon-bone	2977	620	35
Quadrupled hamstring	4090	776	53
Quadriceps tendon (10mm)	2352	463	62
Patella tendon allograft	1403	224	
Achilles allograft	1189	74111	105

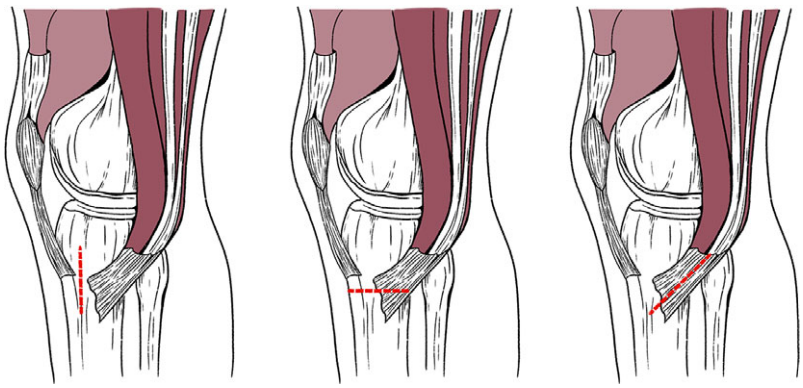


Figure 8.8 Knee arthroscopy incisions

Henry BM et al. Oblique incisions in hamstring tendon harvesting reduce iatrogenic injuries to the infrapatellar branch of the saphenous nerve. *Knee Surg Sports Traumat Arthrosc.* 2018;**26**:1197–1203.

Sanders B, Rolf R, McClelland W, Xerogeanes J. Prevalence of saphenous nerve injury after autogenous hamstring harvest: an anatomic and clinical study of sartorial branch injury. *Arthroscopy* 2007;**23**:956–963.

32. Answer D. **Irradiated allografts have no donor site morbidity but are more likely to fail**
A BPTB graft has high donor site morbidity with anterior knee pain being a common problem. Most autografts have a higher tensile strength than an intact native ACL. Allografts have the lowest tensile strength but no donor site morbidity. Hamstring graft is commonly used for double bundle ACL reconstruction. Allografts are useful for multi-ligament reconstruction. A hamstring graft takes a longer time for bone-graft integration.

33. Answer A. **Acute 'killer turn' of the graft is encountered in transtibial technique**
The transtibial tunnel technique is the most prevalent fixation method for the tibial side of the graft tendon. However, the biggest drawback of this method is the formation of a severe acute angle in the posterior tibia, in which this acute angle could decrease the thickness of graft tendon, leading to permanent graft elongation and ineffective graft pretension, resulting in increased posterior knee laxity. The more acute the 'killer turn' for the graft emerging into the joint from a tibial tunnel, the higher risk of abrasion against the anterior 'lip' of the internal tibial tunnel aperture, leading to the enlargement of the tunnel inlet and attenuation of the graft.

Therefore, the tibial inlay technique through the direct posterior approach has been introduced to prevent frictional loss of the graft tendon. However, there has been debate over the comparison of the outcome between the transtibial tunnel technique and the tibial inlay

Table 8.2 Advantages and disadvantages of various ACL grafts

Graft	Advantages	Disadvantages
BPTB	• Excellent tensile strength • Good bone integration • Good return to preoperative condition	• Extensor mechanism morbidity • Quadriceps weakening • Anterior knee pain
Hamstrings	• Good tensile strength • Good return to preoperative condition • Larger graft diameter • Integrity of the extensor mechanism	• Longer recovery time • Lower mechanical strength • Longer time for bone-graft integration
Quadriceps	• Low patellar tendon morbidity • No damage to the infra-patellar branch of the saphenous nerve • Lower incidence of anterior knee pain	• Poor mechanical strength • Lack of long-term follow up studies • Lack of meta-analysis
Allograft	• Reduction of surgical time • Lack of donor site morbidity • Less post-operative pain	• Infection risk • Immune reaction risk • Delayed bone integration
I.A.B. (Intra-articular brace)	• Reduction of surgical time • Lack of donor site morbidity • Less post-operative pain • Quicker recovery	• Delayed bone integration • Immune reaction risk • Only for selected patients (>40 years, motivated, symptomatic, needing quick recovery)

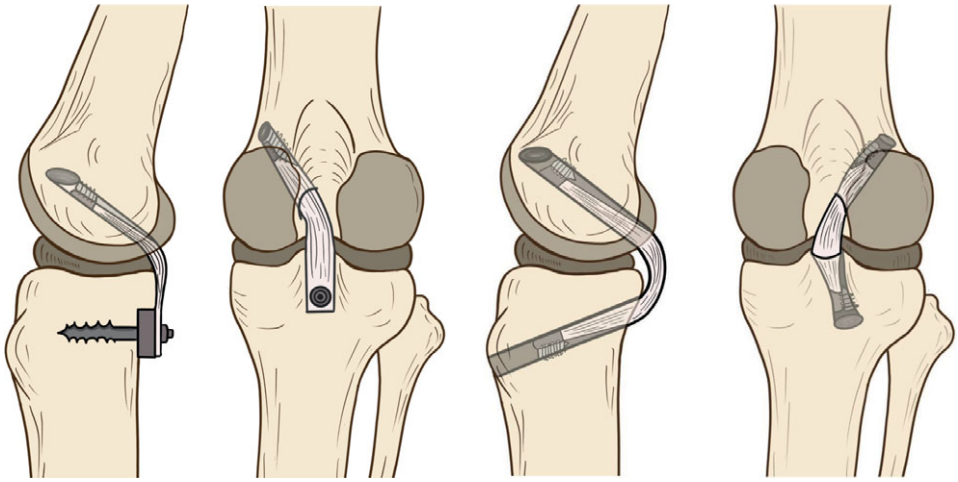


Figure 8.9 PCL reconstruction. (a) The tibial-inlay technique tries to avoid an acute turn with a bone plug in the extremity of the graft, securing bone-to-bone tibial attachment with an anchor or screw. Femoral fixation is accomplished through 2 bone tunnels placed at the 1 o'clock position and 3 o'clock position. Both strands are fixed at 90° of knee flexion. (b) The transtibial tunnel technique aims to simulate the tibial and femoral anterolateral bundles' (ALB) origins PCL

technique. Single bundle PCL reconstruction is tensioned at 90° of flexion (Figure 8.9).

Owing to the anatomy of the PCL and the complex nature of PCL injuries, there is no consensus for a specific operative technique when considering PCL reconstruction. Variations between the different reconstructive techniques depend primarily on tunnel

placement, graft choice, graft positioning and fixation, and the choice of an arthroscopic or open surgical approach.

Winkler PW et al. Evolving evidence in the treatment of primary and recurrent posterior cruciate ligament injuries, part 2: surgical techniques, outcomes and rehabilitation. *Knee Surg Sports Trauma Arthrosc.* 2021;**29**:682–693.

Zhang X et al. Evaluation of the theoretical optimal angle of the tibial tunnel in transtibial anatomic posterior cruciate ligament reconstruction by computed tomography. *BMC Musculoskelet Disord.* 2018;**19**:436.

34. Answer E. **Range of movement knee exercise in a supine position in early stages**
Hamstring exercises should be avoided in the early stage to prevent increased posterior translation of the tibia.

Range of motion exercises initially should be performed in the prone position to avoid stressing the healing ligament from hamstring activation causing posterior translation of the tibia.

Agolley D, Gabr A, Benjamin-Laing H, Haddad FS. Successful return to sports in athletes following non-operative management of acute isolated posterior cruciate ligament injuries: medium-term follow-up. *Bone Joint J.* 2017;**99-B**:774–778.

Wang D, Graziano J, Williams RJ 3rd, Jones KJ. Nonoperative treatment of PCL injuries: goals of rehabilitation and the natural history of conservative care. *Curr Rev Musculoskelet Med.* 2018;**11**:290–297.

35. Answer D. **Histology shows haemosiderin stained multinucleated giant cells**
The MRI shows PVNS which is characterised by an exuberant proliferation of synovial villi and nodules. Haemosiderin disposition in the synovium gives the classic MRI appearance. It can be a localised or diffuse presentation. Both male and females are affected equally. Arthroscopic synovectomy gives good clearance of tissue in local PVNS but not in the diffuse form. Local recurrence is common. External beam radiation is sometimes used to reduce recurrence. Total joint arthroplasty is useful in advanced degenerative changes. Histology reveals mononuclear stromal cells infiltrating the synovium, highly vascular villi, haemosiderin stained multinucleated giant cells and pigmented foam cells (histiocytes). Metastasis of PVNS, both malignant and benign, is extremely rare. However, there have been documented cases of metastasis to the lung, muscles and lymph nodes. The synovial proliferation of PVNS begins as a focal mass. The abnormal synovium is prone to haemorrhage with minor trauma, resulting in haemorrhagic effusions. Thus, radiographs or MRI of early disease may show only a focal mass and a joint effusion. The classic MRI finding is of large effusion and synovial masses with variably low signal intensity on all MRI sequences because of haemosiderin deposition related to prior haemorrhage. The differential diagnosis includes infection and other monoarticular arthritides such as gout, amyloidosis, nodular synovitis, haemophilic arthropathy and synovial chondromatosis.

Tan YC, Tan JY, Tsitskaris K. Systematic review: total knee arthroplasty (TKA) in patients with pigmented villonodular synovitis (PVNS). *Knee Surg Relat Res.* 2021;**33**:6.

36. Answer C. **Posterior condylar axis**
The valgus knee is different from the varus knee because bone loss occurs on the lateral femur (in contrast to varus knee that shows anteriormedial tibial bone loss). The posterior condylar axis taken alone as a reference is unreliable as the lateral femoral condyle can be significantly hypoplastic. Whiteside or transepicondylar axis is more reliable but usually it is a combination of multiple reference points used in a valgus knee.

This is important to identify if the surgeon is measuring femoral rotation by posterior referencing, which typically adds 3° to compensate for the difference in sizes between the medial and lateral femoral condyle. In the case of a hypoplastic LFC, the posterior referencing system may need to dial in 5° or more to prevent internal rotation of the femoral component. Additionally, if there is more than 5mm of deficient bone on the posterior or distal femoral cut, augments should be considered because a cement mantle this large will lead to early loosening.

In a gap balancing technique, the tibial cut is made first; this then acts as guide to plan the cuts for the distal femur and posterior femur.

Computer navigation allows a more consistent tibial cut and also assures a neutral leg alignment.

Grifka J, Baier C, Maderbacher G. Improved femoral component rotation in total knee arthroplasty: an anatomical study with optimized gap balancing. *Arch Orthop Trauma Surg.* 2021;**141**:1669–1675.

37. **Answer E: Pie-crusting to release the MCL**
The pie-crust technique involves repetitive puncturing with a spinal needle on the medial aspect of the knee. This allows for partial release of the MCL thereby increasing the medial space to allow safe passage of arthroscopic instruments. This is done using an 18-gauge needle and by making multiple puncture holes just proximal to the joint line.

Bert JM. First, do no harm: protect the articular cartilage when performing arthroscopic knee surgery! *Arthroscopy* 2016;**32**:2169–2174.

Figure 8.10 Pie-crusting technique

38. Answer E. **Smaller size femoral cutting block with posterior referencing**
The benefit of anterior referencing is that it reduces the risk of anterior femoral notching but the disadvantage is the risk of flexion instability. The benefit of posterior referencing is that it helps to recreate the posterior condylar offset but it has the disadvantages of an increased risk of femoral notching or overstuffing of the anterior compartment.

39. Answer D. **Outside-in meniscal repair**
Inside-out technique has the strongest repair (was first described by Henning), this is considered the gold standard for meniscal repair.

Outside-in technique – passing sutures were passed through the previously passed two spinal needles from the meniscal rim to the meniscal body across the meniscal tear. The two ends of the passing sutures were tied onto the capsule, under direct vision. The improper apposition of the ends of the meniscal tear is an important disadvantage of this technique. This technique is useful for an anterior horn tear.

All-inside technique has been an increasingly used method for most meniscal tears due to its advantages: avoidance of opening accessory portals and additional incisions, easy applicability, use of bio-absorbable implants and relatively less risk for injury to posterior neurovascular structures.

To enhance healing after meniscal repair, a variety of augmentation techniques and biological products have been introduced: needling, trephination, platelet-rich plasma, bone marrow aspirate, hyaluronan-collagen scaffold, fibrin clot, fibrin glue, mesenchymal stem cells and growth factors.

Doral MN, Bilge O, Huri G, Turhan E, Verdonk R. Modern treatment of meniscal tears. *EFORT Open Rev.* 2018;**3**:260–268.

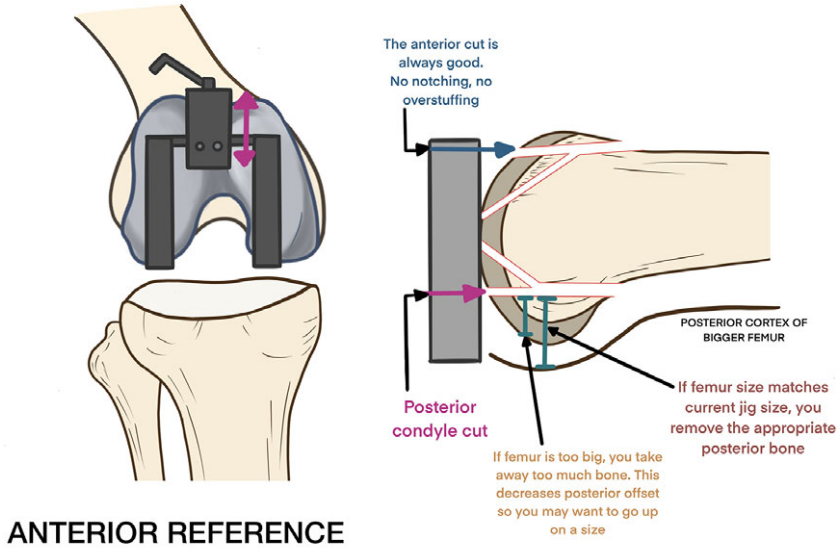
40. Answer C. **More distal femoral resection**
Symmetric gap issues:

Addressed with proximal tibia. Resecting more proximal tibia helps with tight extension and flexion.

Using a thicker insert or tibial augmentation helps, if loose in extension and flexion.

Asymmetric gap issues:

- Extension good and loose in flexion can be addressed with an increase in the size of the femoral component; other options are to translate the femoral component posteriorly or to use a thicker insert followed by addressing tight extension gap.
- Extension tight and flexion good can be addressed by either more distal femoral resection or posterior capsule release.
- Extension good and tight in flexion can be addressed by decreasing the size of the femoral component. Other options are to recess PCL and address posterior slope of tibia if needed.
- Extension loose and flexion good can be addressed with distal femoral augmentation.



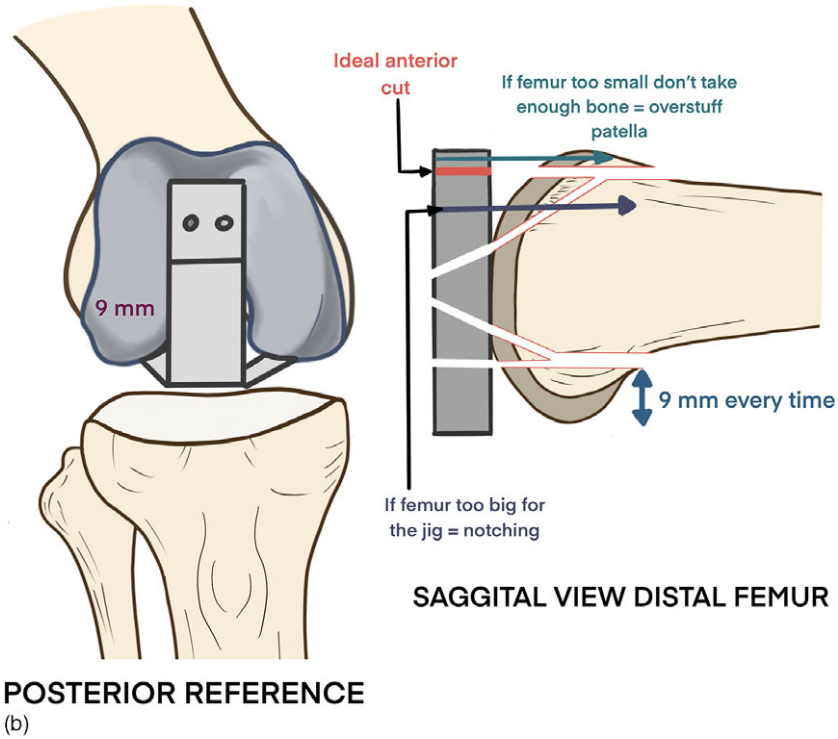


Figure 8.11 Anterior and posterior knee referencing. (a) Anterior referencing device uses a boom to sit on the anterior cortex and the cut is 5 mm below. The posterior cortex is not involved in determining the posterior condyle cut. (b) Posterior referencing device has two legs that sit under the posterior condyles. It measures 9 mm up from condyles. This is where the cut will occur.

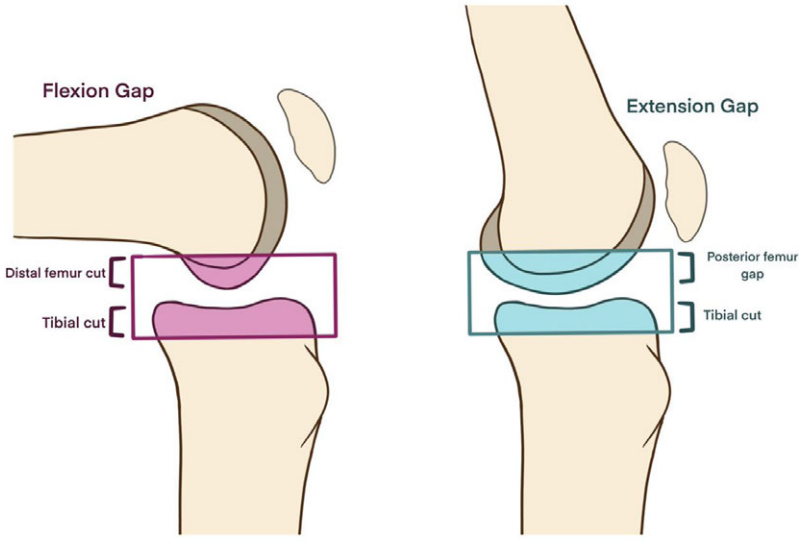


Figure 8.12 Flexion/extension gap knee

Other options are to use a thicker insert followed by addressing tight flexion gap.

Changing the femoral component size only affects the flexion gap, not the extension.

Joint line is influenced by the distal femoral cut, but not proximal tibia cut.

41. Answer A. **Eccentric exercises**

The patient has typical features of chronic patella tendinitis. The clinical presentation is variable: often characterised by pain in the front part of the knee which initially does not prevent activity but over time, if not diagnosed and treated, progresses so that the pain is incapacitating, continues after exercise, and may even cause difficulties in everyday activities, for example causing pain when walking, going downstairs, sitting, etc.

There are a wide range of possible treatment options including shockwaves, low-intensity laser, splints, injections (corticoids, heparin, dextrose, glycosaminoglycan polysulphates (GAGPS), autologous growth factors (platelet-rich plasma), etc.) cryotherapy, stretches, ultrasound.

It has been shown that eccentric exercises are the preferred initial treatment in the rehabilitation of patellar tendinopathy, given that they increase the tendon's resistance to traction, producing an elongation of the tendinous muscle unit, meaning the tendon bears less tension. Some of the physiological effects of the exercises on the tendon have been proven. They are effective in encouraging the formation of tendon collagen fibres, improving its remodelling, and requiring less oxygen consumption, greater muscle tension and less energy expenditure.

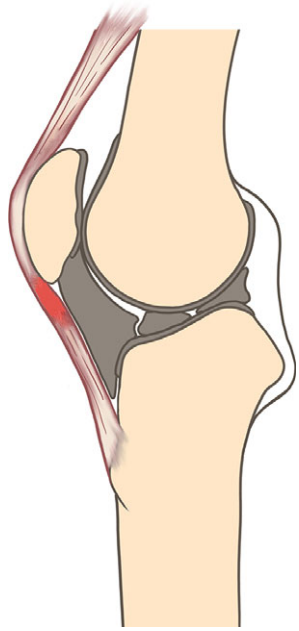


Figure 8.13 The patella tendon should be palpated in full extension and then tested in 90° of flexion. In chronic patella tendinosis, tenderness in the proximal tendon is more noticeable in extension (Bassett's sign) compared with flexion. In flexion, the normal superficial fibres cover the damaged deep fibres, resulting in less pain on palpation

42. Answer D. **Rotating on a 20° flexed knee whilst weight bearing on that side**

Explanation:

- A is the Appley grind test.

- B is McMurray's test.
- D is Thessaly's test – the most sensitive test for meniscal pathology.
- E is also a test for meniscal pathology. But this is not sensitive. Squat and walk like a duck! Childress' test.

The diagnosis of a meniscal tear is usually from the history and the presence of joint line tenderness. Meniscal stimulation tests have a wide-ranging sensitivity and specificity (the absence of positive signs does not rule out a meniscal tear).

The following clinical tests are infrequently performed in a clinical setting, but the Thessaly test has the highest accuracy in detecting a meniscal tear with 94% for medial meniscal and 96% for lateral meniscal tears (Karachalios et al. 2005).

The **Appley grind test** is historical and involves forcing the tibiofemoral surfaces together to 'catch' the meniscus. In this test the patient is prone with the knee flexed to 90° and the examiner pushes downwards on the foot and rotates the leg.

McMurray's test was used to recreate displacement of a meniscal tear which is painful and probably not in the patient's best interests. A modification of this is a compression test to produce discomfort along the joint line, which may indicate pathology in the medial or lateral compartment. The patient is supine with the knee flexed. The examiner places one hand on the top of the knee with the fingers and thumbs positioned to palpate the joint line and the other under the heel. The examiner can then compress the joint by pushing down on the top hand while the lower hand controls flexion and can also rotate the leg thereby stressing each compartment in varying degrees of flexion. This test is most specific for a tear of the posterior horn of the medial meniscus.

Thessaly's test. Here the patient is asked to stand on one leg at a time. First, the unaffected leg as a trial, then the affected leg (Figure 8.14). The examiner holds the patient's hands to prevent them overbalancing. The patient flexes their knee to 5° and then internally rotates and externally rotates their knee and body three times. This is repeated with the knee flexed to 20°.

Figure 8.14 Thessaly test. (a) The patient is supported and asked to stand on one leg in turn. The leg to be examined is flexed 5° and the patient is asked to rotate 3 times. This is then repeated at 20°. (b) The patient should twist their body with the standing knee in either internal or external rotation.

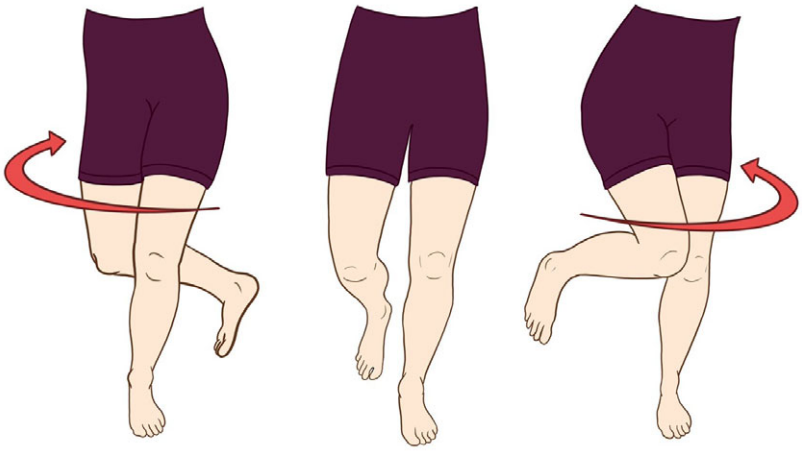


Figure 8.15

Pain, locking or catching represents a positive result. The test is more sensitive at 20° compared with 5°.

Childress' test. Another less specific test is to ask the patient to fully squat, and if possible, duck walk. This action compresses the posterior horns of the menisci but can also cause patello-femoral pain.

Karachalios T et al. Diagnostic accuracy of a new clinical test (the Thessaly test) for early detection of meniscal tears. *J Bone Joint Surg Am.* 2005;**87**:955–962.

Chapter 9

Foot and Ankle I Structured SBA

Gavin Heyes and Lyndon Mason

FOOT AND ANKLE I STRUCTURED SBA QUESTIONS

Anatomy and Biomechanics

1. **From the options listed below, please choose the most appropriate description of the anatomy of the spring ligament.**
   - A. Originates on the lateral malleolus and inserts onto the lateral aspect of the talus
   - B. Originates on the medial malleolus and inserts onto the medial wall of the calcaneum
   - C. Originates on the medial malleolus and inserts onto the medial aspect of the talus
   - C. Originates on the navicular and inserts onto the medial cuneiform
   - E. Originates on the sustentaculum tali and inserts onto the navicular

2. **From the options listed below, please choose the most appropriate anatomical structure to occur in the third layer of the foot.**
   - A. Abductor digiti minimi
   - B. Adductor hallucis
   - C. Peroneus longus
   - D. Plantar interossei
   - E. Quadratus plantae

3. **From the options listed below, please choose the most appropriate muscle that plantar flexes the 1st metatarsal.**
   - A. Flexor hallucis brevis
   - B. Flexor hallucis longus
   - C. Peroneus longus
   - D. Tibialis anterior
   - E. Tibialis posterior

4. **From the options listed in the next column, please choose the most appropriate description of the anatomy of the Lisfranc ligament.**
   - A. Dorsal ligament between the medial cuneiform and the 2nd metatarsal
   - B. Interosseous ligament between the medial cuneiform and the 2nd metatarsal
   - C. Plantar ligament between the 2nd metatarsal and 5th metatarsal
   - D. Plantar ligament between the intermediate cuneiform and the 2nd metatarsal base
   - E. Plantar ligament between the medial cuneiform and the 2nd metatarsal

5. **What structure attaches to the plantar surface of the hallucal sesamoids?**
   - A. Abductor hallucis
   - B. Adductor hallucis
   - C. Flexor hallucis brevis
   - D. Lateral sesamoid ligament
   - E. Medial sesamoid ligament

6. **What is the main blood supply of the talar body?**
   - A. Anterior tibia artery
   - B. Artery of the sinus tarsi
   - C. Perforator artery
   - D. Peroneal artery
   - E. Posterior tibial artery

7. **Which muscle contracts eccentrically during the heel strike phase of the gait cycle?**
   - A. Extensor hallucis longus
   - B. Lateral head of gastrocnemius
   - C. Medial head of gastrocnemius
   - D. Tibialis anterior
   - E. Tibialis posterior

8. **What nerve supplies adductor hallucis?**
   - A. Baxter's nerve
   - B. Deep peroneal nerve
   - C. Lateral plantar nerve
   - D. Medial plantar nerve
   - E. Superficial peroneal nerve

Achilles and Heel

9. **What is the most common aetiological factor for plantar fasciopathy?**
   A. Calf tightness
   B. Depression
   C. Job requiring standing
   D. Obesity
   E. Smoking

10. **Which of the following best describes the reactive phase of Achilles tendinopathy?**
   A. Cell death, minimal fibrillar collagen
   B. Collagen fibre dysrepair, increased chondrocytic cellularity
   C. Increased production of large proteoglycans, which bind with large amounts of water
   D. Ingrowth of neovessels
   E. Production of type III collagen

11. **What is the most likely diagnosis with pain occurring on calcaneal squeeze test?**
   A. Calcaneal fracture
   B. Flexor hallucis longus tendinopathy
   C. Plantar fasciopathy
   D. Radiculopathy
   E. Tarsal tunnel syndrome

12. **What is the first-line treatment of plantar fasciopathy?**
   A. Laser therapy
   B. Mechanical overload reduction
   C. Physiotherapy
   D. Shockwave therapy
   E. Ultrasound-guided pulse radiofrequency

13. **What statement is true in regard to Achilles tendon ruptures?**
   A. Functional rehabilitation is equal to surgical treatment regarding the incidence of re-rupture
   B. Immobilisation increases load to failure
   C. In the acute phase, collagen type I is the first collagen that is layered down
   D. Use extrinsic healing with passive motion
   E. Use of heel wedges in functional rehabilitation works by shortening tendon

Midfoot

14. **Which statement is true in regard to Lisfranc injuries?**
   A. A tightrope controls axial movement
   B. Fusion improves functional outcome as compared to fixation
   C. MRI is indicated when radiographs show diastasis
   D. Quality of anatomical reduction is the best predictor of functional outcomes
   E. Transarticular screws reduce movement at the tarsometatarsal joint as compared with bridge plate

15. **'Too many toes' sign would most likely be seen in which case?**
   A. Charcot–Marie–Tooth disease
   B. Fibular hemimelia
   C. Iselin's disease
   D. Stage IIA tibialis posterior tendon dysfunction
   E. Stage IIB tibialis posterior tendon dysfunction

16. **At the level of the navicular, when harvesting flexor digitorum longus for tibialis posterior tendon reconstruction, what structure lies immediately dorsal or deep to it?**
   A. Adductor hallucis
   B. Baxter's nerve
   C. Flexor hallucis longus
   D. Lumbricals
   E. Plantar fascia

17. A 53-year-old is currently being operated on for a fixed flat foot deformity. The surgeon has just completed preparation of the hindfoot for fusion, reduced it and held it with guidewires.
   The surgeon notes a forefoot deformity that will require intervention. What is the deformity likely to be?
   A. Abduction and pronation deformity
   B. Adduction deformity
   C. Adduction and pronation deformity
   D. Supination deformity
   E. Valgus deformity

18. A patient attends clinic for the results of an excision biopsy performed from a discrete firm lesion in the foot. The histopathology report included no cell atypia, myofibroblast proliferation and collagen proliferation of type III collagen more so than type I collagen.
What is the likely diagnosis?
A. Fibromyxoma
B. Gardner's disease
C. Ledderhose disease
D. Lipoma
E. Synovial sarcoma

Forefoot

19. A 42-year-old female attends with a painful bunion she has had for the past 2 years. She has failed conservative measures. On examination, there is no first ray instability or pain on grind test. Her radiographs reveal a hallux valgus angle of 25° and intermetatarsal angle of 12°.
What is the most appropriate surgical intervention?
A. Basal osteotomy
B. Distal chevron osteotomy
C. Lapidus fusion
D. Moberg osteotomy
E. Proximal phalanx osteotomy

20. A 42-year-female with a bunion presents with gradual onset pain on shod weight bearing originating under the 2nd and 3rd metatarsal heads. The patient had a negative Mulders Click test.
Which of the following is the most likely diagnosis?
A. Freiberg's disease
B. Mallet toe
C. Morton's neuroma
D. MTP joint synovitis
E. Plantar plate rupture

21. A 23-year-old professional footballer sustains an undisplaced metadiaphyseal proximal 5th metatarsal fracture during training after a few weeks of grumbling about foot pain.
What is the most appropriate treatment?
A. Cast immobilisation and non-weight bearing
B. Internal fixation
C. Metatarsal strapping and full weight bearing
D. Metatarsal strapping and non-weight bearing
E. Stiff shoe

22. **What is the most frequent iatrogenic complication of excision of both tibial and fibular sesamoids of the hallux?**
A. Flexor hallucis longus tendonitis
B. Hallux valgus
C. Hallux varus
D. Intractable keratosis
E. Weakness on tip toe stance

23. **Floating toe is an iatrogenic complication most frequently associated with which procedure?**
A. Keller's resection arthroplasty
B. Kidner's procedure
C. Morton's neuroma excision
D. Stainsby procedure
E. Weil metatarsal osteotomy

24. **What force on the proximal phalanx is created by the abductor hallucis in a hallux valgus deformity?**
A. Adduction
B. Adduction and supination
C. Dorsiflexion and pronation
D. Plantar flexion
E. Plantar flexion and pronation

25. A fit and healthy 75-year-old presents to clinic with pain, stiffness, swelling, erythema over her left 1st metatarsal phalangeal joint (MTPJ) following a silastic 1st MTPJ arthroplasty performed 12 years ago. Radiographs demonstrate osteolysis around the component and a valgus deformity. Blood tests are normal with regard to full blood picture, erythrocyte sedimentation rate and C-reactive protein.
What is the appropriate treatment?
A. First stage of two-stage 1st MTPJ fusion
B. Revision to 1st MTPJ fusion with inlay bone graft
C. Revision to excision arthroplasty
D. Revision to silastic arthroplasty
E. Steroid injection

26. An 18-year-old young woman presents with forefoot pain and stiffness of the 2nd metatarsal phalangeal joint. Pain worsened on axial loading of the joint. Radiographs demonstrate arthrosis and flattening of the metatarsal head.

What is the likely diagnosis?

A. Freiberg's disease
B. Kohler's disease
C. Mueller–Weiss syndrome
D. Sever's disease
E. Turf toe

27. A 1-year-old female infant is brought into your clinic. Her mother is concerned about her 4th toes bilaterally. They appear to be shortened and overlapping the 5th toes. Radiographs demonstrate disruption of Maestro's parabola and premature closure of the 4th metatarsal physis. You also notice the child to be smaller than average, with a short, webbed neck.

What condition could this child have?

A. Klippel–Feil syndrome
B. Poland syndrome
C. Sprengel deformity
D. Trisomy 21
E. Turner's syndrome

28. An 83-year-old nursing home patient presents with pain over 2nd toe, inability to fit into shoes, chronic paronychia and an ulcer over the 2nd toe proximal interphalangeal joint (PIPJ). The PIPJ is fixed in flexion, the metatarsal phalangeal joint (MTPJ) is slightly extended and the distal interphalangeal joint (DIPJ) is hyperextended and flexible.

What is the most appropriate treatment?

A. Amputation through proximal one-third of proximal phalanx
B. MTPJ release + DIPJ fusion
C. MTPJ release + flexor to extensor transfer + temporary K-wire fixation
D. MTPJ release + MTPJ replacement
E. MTPJ release + PIPJ fusion + temporary K-wire fixation

29. A 46-year-old man presents with pain in the right 1st metatarsal phalangeal joint (MTPJ). He recalls a rugby injury to the joint 20 years ago. On examination he has moderate pain on end range of motion, reduced range of motion (10° dorsiflexion, 50° plantar flexion) and pain on axial loading of the 1st MTPJ. Radiographs demonstrate around 40% joint space narrowing with dorsal osteophyte on the metatarsal and phalanx. He has failed conservative treatment and still wishes to play rugby.

What is the most appropriate treatment?

A. Dorsal cheilectomy
B. Keller's procedure
C. MTPJ arthrodesis
D. MTPJ arthroplasty
E. Synovectomy

30. When performing a scarf osteotomy in an otherwise normally aligned foot, to avoid shortening or lengthening the 1st metatarsal, what landmark or reference point should be used for your distal transverse cut?

A. Parallel to proximal phalanx base joint surface
B. Parallel with the 5th metatarsal phalangeal (MTP) joint
C. Perpendicular to 1st metatarsal
D. Perpendicular to 2nd metatarsal
E. Perpendicular to cut surface after removing medial eminence

31. An 18-month-old presents to your clinic with bilateral deformities of their 4th and 5th toes. On examination, there is a flexion and varus deformity to all toes.

What is the likely cause of the deformities?

A. Absence of extensor digitorum
B. Central nervous system lesion
C. Congenital bands around toes
D. Contracture of flexor digitorum longus and/or brevis
E. Delta phalanx

Ankle

32. A 28-year-old man is seen in a nurse-led dressings clinic 2 weeks after arthroscopic ankle surgery. He is complaining of persistent numbness over the dorsum of his foot but not in the first web space.

What is the most likely cause of this complication?

A. Anterocentral portal placement
B. Anterolateral portal placement
C. Anteromedial portal placement
D. Posterolateral portal placement
E. Posteromedial portal placement

33. A normally fit and well 32-year-old woman is taken to theatre for examination under anaesthesia for chronic ankle instability despite several courses of physiotherapy. On the lateral image, 10mm of forward shift is demonstrated during an anterior drawer test compared with the unaffected ankle.

Which ligament is most likely damaged?

A. Anterior inferior tibiofibular ligament
B. Anterior talar fibular ligament
C. Calcaneofibular ligament
D. Posterior inferior tibiofibular ligament
E. Posterior talar fibular ligament

34. A 43-year-old man sustains a pronation external rotation injury to his left ankle while playing football. Initial radiographs show increased tibio-fibular clear space.

Which of these is the correct group of ligaments which form the structure that is injured, resulting in the increased tibiofibular clear space?

A. AITFL, ATFL, PITFL
B. AITFL, IOL, CFL
C. AITFL, IOL, PITFL
D. PITFL, CFL, ATFL
E. PITFL, IOL, ATFL

35. A patient is brought into the ED after sustaining an ankle injury while playing basketball. The ankle is grossly swollen and tender. Radiographs show a pronation external rotation injury pattern.

Which answer best describes the sequence of injury?

A. ATFL disruption, oblique fibula fracture at the level of the syndesmosis, PITFL disruption or posterior malleolus fracture, transverse medial malleolus fracture or deltoid ligament injury
B. Medial malleolus transverse fracture or deltoid disruption, ATFL disruption, lateral short oblique fracture or spiral fracture of the fibula above the syndesmosis, PITFL avulsion or posterior malleolus fracture
C. Medial malleolus transverse fracture or deltoid disruption, ATFL disruption, lateral short oblique/spiral fracture of the fibula below the syndesmosis, PITFL avulsion or posterior malleolus fracture
D. Medial malleolus transverse fracture or deltoid disruption, ATFL disruption, transverse or comminuted fibula fracture above the level of the syndesmosis
E. Vertical medial malleolus fracture, ATFL disruption or fibula fracture below the joint line

36. A 30-year-old keen cross-country runner presents to a foot and ankle clinic with non-specific ankle pain and occasional swelling. They describe a couple of episodes of mild ankle sprains over the past couple of years. An osteochondral defect of the talus is suspected.

What is the most common location for these injuries on the talus?

A. Anterior lateral talar dome
B. Central anterior talar dome
C. Central lateral talar dome
D. Central medial talar dome
E. Posterior medial talar dome

37. A 70-year-old man presents to an elective foot and ankle clinic with pain in his right ankle. He had an ankle injury 30 years ago, which he was told could not be operated on at the time and was managed in a cast. Weight bearing ankle radiographs show end stage ankle arthritis. The patient has decided on an ankle arthrodesis for treatment.

During ankle arthrodesis surgery, what is the ideal position of the ankle?

A. 10° dorsiflexion, 10° external rotation, 5° hindfoot valgus
B. 10° dorsiflexion, neutral external rotation, 5° hindfoot valgus
C. Neutral dorsiflexion, 10° external rotation, 5° hindfoot valgus
D. Neutral dorsiflexion, 10° external rotation, 5° hindfoot varus
E. Neutral dorsiflexion, neutral external rotation, 5° hindfoot valgus

38. **What ankle position at the time of sustaining a Pilon fracture results in the worst outcomes?**
    A. Dorsiflexion
    B. Neutral
    C. Plantar flexion
    D. Valgus
    E. Varus

39. **What is the most common malignancy of the foot?**
    A. Ewing's sarcoma
    B. Liposarcoma
    C. Metastasis
    D. Osteosarcoma
    E. Synovial sarcoma

Diabetes

40. A patient with diabetes type 2 develops a midfoot collapse with ulceration. A tissue viability nurse describes the ulcer as grade 2. The radiographs are reported as a 'rocker bottom deformity with osseous fragmentation'.
    What is the most appropriate management?
    A. Exostectomy
    B. Midfoot plantar flexion osteotomy and fixation with a mega construct
    C. Negative pressure dressing and an ankle–foot orthosis
    D. Range of motion walker
    E. Total contact casting

41. A 49-year-old male patient with a history of type 2 diabetes, neuropathy and retinopathy presents to the diabetic foot and ankle MDT clinic with a chronic foot ulcer.
    Which of the following is a negative predictor for diabetic ulcer wound healing?
    A. Arterial brachial pressure index ratio of 0.5
    B. Inability to feel a 5.07 Semmes–Weinstein monofilament around the ulcerated area
    C. Serum albumin 2.9g/dL
    D. Total lymphocyte count 2.8 ($\times$109/L)
    E. Transcutaneous oxygen pressure 41mm Hg

General

42. A patient presents to you with a Hallux valgus deformity with HVA of 35° and IMA of 12°. Operative treatment is undertaken. During the surgical approach, an osteotomy is performed. On follow up, it is noted that the metatarsal head has undergone avascular necrosis.
    What factor is most likely to cause iatrogenic avascular necrosis?
    A. Akin osteotomy
    B. Distal short Chevron osteotomy
    C. Proximal dome osteotomy
    D. Scarf osteotomy
    E. Single medial incision

43. **What is true of posterior malleolar fractures of the ankle?**
    A. All posterior malleolar fractures should be fixed through a posterolateral approach
    B. Morphology of fracture determines functional outcome in fixed posterior malleolar fractures
    C. Percentage of joint involved should dictate surgical treatment
    D. Plain radiographs are accurate at estimation of the size of the posterior malleolar fracture fragment
    E. Posterior malleolar fracture fixation negates the need for syndesmosis fixation

44. **During a Morton's neuroma excision in the 3rd webspace, what ligament must be cut to visualise the neuroma from a dorsal approach?**
    A. Intermetatarsal ligament
    B. Interphalangeal ligament
    C. Lisfranc ligament
    D. Metatarsophalangeal ligament
    E. Transverse metatarsal ligament

45. A 14-year-old female hockey player presents to you with pain for 2 weeks over the 2nd MT head. On X-ray, you find that the 1st MT is shorter than the second and the 2nd MTPJ space is increased. She complains of sustaining an injury to the hindfoot of the same side 2 months prior which settled in a week and she resumed her sporting activities.
    What is the best treatment for her condition?
    A. Ankle brace
    B. Dorsal closing wedge osteotomy
    C. Extensor digitorum arthrodesis

D. Injection into the 2nd MTPJ
E. Orthosis with a metatarsal bar

46. A 25-year-old female presents with diffuse pain and stiffness in her right foot. She struggles with walking in the forest when she goes for hikes.

The radiograph reveals the following (Figure 9.1).

Figure 9.1
Internally rotated oblique radiograph. This view is best used to image the cubocalcaneal, cubocuneiform and cubometatarsal joints which are seen in profile

What is the initial treatment that should be offered to the patient?
A. Accommodative orthotics
B. Corrective orthotics
C. Subtalar fusion
D. Talanavicular fusion
E. Tarsal bar resection

47. A 62-year-old male presents with pain in his left ankle. He is a builder and owns his own business. He says he had an ankle injury many years ago. The X-ray is as shown in Figure 9.2. He wants to improve his pain but still wants to work. He has exhausted conservative management and wants surgery.

Figure 9.2
Oblique ankle radiograph

What surgery would be most appropriate?
A. Distal tibial osteotomy
B. Distraction arthrodesis
C. Tibiotalar calcaneal fusion
D. Total ankle fusion
E. Total ankle replacement

48. A 49-year-old woman with chronic plantar medial pain in the region of the head of the 1st metatarsal. She undergoes corrective surgery for the same in the form of a medial sesamoidectomy. This relieves her symptoms temporarily but the patient presents back to your clinic in 2 years with redness and pain over the medial aspect of the head of the 1st metatarsal and difficulty in wearing heels.

What is the patient's most likely aetiology?
A. Bunionnette
B. Hallux valgus
C. Hallux varus
D. Metatarsus adductus
E. Metatarsus varus

49. A 19-year-old patient presents with a painful pes planus. Jack's test was abnormal. Radiographs are shown in Figure 9.3.

The radiograph shows what radiographic sign?
A. Anteater's sign
B. C sign

Figure 9.3 Lateral radiograph left foot.

C. Fleck sign
D. Rocker bottom
E. Too many toes sign

50. A 1.5-month-old baby is brought by a very concerned mother to your clinic with complaints of toes turned in. Father is unavailable. Examination – bilateral metatarsus adductus and heel bisector through the 3rd toe. No medial crease noted and deformity is correctable at this point.

What should the advice to the mother be?

A. Passive stretching
B. Reverse lateral shoes
C. Serial casting
D. Serial casting as per Ponsetti technique and then TA tenotomy
E. Tarsometatarsal osteotomy at 1 year of age

51. A 34-year-old male presents to you with pain on the lateral aspect of his foot and on clinical examination you notice he has increased medial longitudinal arches. He also has a callosity on the base of the 1st metatarsal head. The patient has tried non-operative treatment in the form of shoe modifications and orthotics. You use a board and ask the patient to rest the lateral board over it with the hallux and metatarsal head off to check for hindfoot alignment with the ankle.

The basis of this test lies in?

A. Confirming normal heel varus in toe rise
B. Elevating the medial arch in a cavovarus foot
C. Eliminating the effect of first ray plantar flexion
D. Locking the transverse tarsal joint to form a rigid lever
E. Placing the hindfoot into an equinus posture

52. A 25-year-old male presents to the foot and ankle clinic and is found to have long-standing pain localised to a tendon pathology. This tendon contracts concentrically during terminal stance and pre-swing phase of the gait cycle. It is also primarily involved in the pathology that leads to the 'too many toes' sign.

From what structure does the muscle originate?

A. Distal femur and proximal tibia
B. Fibula only
C. Interosseous membrane
D. Tibia and fibula
E. Tibia only

53. A patient presents with an acute onset of pain under the 2nd metatarsal head 4 weeks ago. The patient then developed the diffuse callosity under the metatarsal head as seen in Figure 9.4.

What is the most likely diagnosis?

Figure 9.4 Clinical picture sole foot

A. Bursitis
B. Intractable plantar keratosis
C. Mallet toe
D. Morton's neuroma
E. Plantar plate rupture

54. A 66-year-old patient presents with 2 months of right ankle pain after having a total ankle replacement 5 years ago. On workup – his blood investigations are normal with a marginally raised ESR. Aspiration reveals a <50% count of neutrophils and no pus or organisms on culture. The wound is well healed, no redness and no fever or chills.

What is the next step in the management in this patient?

A. Arthrodesis of the ankle
B. CT scan with metal reduction artefact
C. MRI of the ankle joint
D. Repeat aspiration
E. Revision TAR

55. A 52-year-old woman presents with an acute onset positional change to her foot where the foot has become supinated and adducted (Figure 9.5a). She has a history of complex regional pain syndrome. She complains of pain along the medial arch. An examination under anaesthetic as per images, shows a complete

Figure 9.5 Clinical picture foot and ankle. (a) Supinated and adducted right foot. (b) Examination under anaesthetic

Figure 9.6 (a) Anteroposterior (AP) and (b) lateral radiographs

correction of her deformity on giving muscle relaxation (Figure 9.5b).

What is the most likely diagnosis?

A. Dystonia
B. L5 nerve root palsy
C. Peroneus brevis rupture
D. Tibial posterior tendon entrapment
E. Tibialis anterior rupture

56. A 35-year-old female presents with medial arch pain and has noted her foot has become flat. On examination, the patient is unable to do a single leg heel raise on the affected side. The posture of the foot is of a flattened medial longitudinal arch, which is passively correctable. The patient has 'too many toes sign' when viewed from behind. She exhausts conservative measures and wants surgery.

What is the most appropriate surgical intervention?

A. Talanavicular and subtalar joint fusion
B. Tibialis posterior reconstruction and gastrocnemius slide
C. Tibialis posterior reconstruction and medialising calcaneal osteotomy
D. Tibialis posterior reconstruction, medialising calcaneal osteotomy, gastrocnemius slide, Cotton osteotomy
E. Tibialis posterior reconstruction, medialising calcaneal osteotomy, gastrocnemius slide, spring ligament reconstruction

FOOT AND ANKLE I STRUCTURED SBA ANSWERS

Anatomy and Biomechanics

1. Answer E. **Originates on the sustentaculum tali and inserts onto the navicular**
   Otherwise known as the plantar calcaneonavicular ligamentous complex, it is a broad and thick band with three constituent ligaments that connect the anterior margin of the sustentaculum tali of the calcaneus to the plantar surface of the navicular. Its individual components are the superomedial, intermedial (medioplantar) and lateral (inferoplantar) ligaments, which fan out and attach to the navicular bone at three separate locations. The ligament combines with the superficial and deep deltoid to provide the ligamentous support to the proximal aspect of the medial longitudinal arch. The distal aspect of the medial longitudinal arch is supported by the navicularcuneiform ligament.

   Campbell KJ et al. The ligament anatomy of the deltoid complex of the ankle: a qualitative and quantitative anatomical study. *J Bone Joint Surg Am.* 2014;**96**:e62.

   Swanton E, Fisher L, Fisher A, Molloy A, Mason L. An anatomic study of the naviculocuneiform ligament and its possible role maintaining the medial longitudinal arch. *Foot Ankle Int.* 2019;**40**:352–355.

   Taniguchi A, Tanaka Y, Takakura Y. Anatomy of the spring ligament. *J Bone Joint Surg Am.* 2003;**85**:2174–2178.

2. Answer B. **Adductor hallucis**
   - First layer: three short muscles. Flexor digitorum brevis is central; abductor digiti minimi laterally and abductor hallucis medially.
   - Second layer contains two muscles and the two longus tendons: flexor hallucis longus and flexor digitorum longus. The four lumbrical muscles arise from the tendons of flexor digitorum longus. The second muscle is the quadratus plantae.
   - Third layer: three muscles, with two acting on the great toe and one on the little. Flexor hallucis brevis, adductor hallucis and flexor digiti minimi brevis.
   - Fourth layer consists of two muscle groups and two tendons: the plantar and dorsal interossei, and the tendons of peroneus longus and tibialis posterior.

3. Answer C. **Peroneus longus**
   Peroneus longus – The peroneus longus inserts onto the 1st metatarsal base and to a lesser extent the medial cuneiform, traversing the plantar aspect of the foot from lateral to medial. The action is to plantar flex the 1st metatarsal, and participate in the eversion of the foot. In non-bipedal apes, the peroneus longus lateralised the first ray, which was used for grasping.

   Flexor hallucis longus – This muscle inserts onto the base of the distal phalanx of the hallux. It acts to flex all joints of the hallux and, to a lesser extent, plantar flex the ankle joint.

   Flexor hallucis brevis – This muscle inserts on the medial and lateral sides of the proximal phalanx, comprising a component of the hallucal sesamoid complex. It flexes the hallux along with the flexor hallucis longus muscle.

   Tibialis anterior – This muscle inserts onto the dorsal and medial aspect of the medial cuneiform and 1st metatarsal. Its function is to dorsiflex and invert the foot.

   Tibialis posterior – This muscle inserts onto the navicular and medial cuneiform, and in a variable nature onto the other cuneiforms. It acts to invert the foot and plantar flex the foot at the ankle.

4. Answer B. **Interosseous ligament between the medial cuneiform and the 2nd metatarsal**
   The ligaments at the 2nd metatarsal base have a unique arrangement in that there is no intermetatarsal ligament between the 1st and 2nd metatarsals. Instead, in addition to the dorsal ligaments, there are two ligaments between the medial cuneiform and 2nd metatarsal base. These two large ligaments maintain the relationship of the 2nd metatarsal base to the medial cuneiform. The interosseous ligament, also called the Lisfranc ligament, attaches to the lateral aspect of the medial cuneiform and the medial aspect of the 2nd metatarsal base. The plantar ligament attaches to the lateral aspect of the medial cuneiform and the plantar aspect of the base of the 2nd and 3rd metatarsals.

   There are three dorsal ligaments attached to the 2nd metatarsal base, one from each of the first three cuneiforms.

Solan et al. (2001) showed that on biomechanical testing the plantar and Lisfranc ligaments were significantly stiffer and stronger than the dorsal ligament, and the Lisfranc ligament was significantly stronger and stiffer than the plantar ligament.

Panchbhavi VK, Molina D 4th, Villarreal J, Curry MC, Andersen CR. Three-dimensional, digital, and gross anatomy of the Lisfranc ligament. *Foot Ankle Int.* 2013;**34**:876–880.

Solan MC, Moorman CT 3rd, Miyamoto RG, Jasper LE, Belkoff SM. Ligamentous restraints of the second tarsometatarsal joint: a biomechanical evaluation. *Foot Ankle Int*. 2001;**22**:637–641.

5. Answer C. **Flexor hallucis brevis**
The sesamoids are closely connected with the fibrous layer of the joint capsule as well as with the medial and lateral sesamoid ligaments that are blended with the capsule. Sharpey's fibres from the sesamoid ligaments penetrate the sesamoids on their capsular side. Anterior to the medial and lateral sesamoid ligaments are the collateral ligaments that fan out distally and plantarward, connecting to the base of the proximal phalanx. The dense, fibrous plantar pad enshrouds the plantar aspect of the sesamoids and anchors the sesamoid complex to the base of the proximal phalanx. The tendons of the flexor hallucis brevis are attached to the plantar surface of the sesamoids. However, the tendons of the adductor and abductor hallucis mainly bypass the sesamoids. The intersesamoid ligament connects the sesamoids. The flexor hallucis longus nestles on the plantar aspect between the sesamoids with the inter-sesamoid ligament, blending with its synovial tendon.

6. Answer E. **Posterior tibial artery**
The talus is 60% covered by articular cartilage. Blood vessels enter the talus via capsular and ligamentous attachments, limiting the arterial entry sites to the talar neck, the medial surface of the body below the medial malleolus, the sinus tarsi and the posterior tubercle.

Earlier studies (Phemister 1940) seemed to confirm that the main blood supply was from the anterior tibial artery, providing branches to the superior surface of the body and neck of the talus.

Gelberman and Mortensen's work (1938) changed the consensus to the posterior tibial artery as the main blood supply, along with its anastomotic network to the sinus tarsi artery, allowing only retrograde blood flow to the talar body from the talar neck.

Miller et al. (2011) used a gadolinium-enhanced MRI study and found the posterior tibial artery to be the main contributor, like Gelberman and Mortensen's initial findings. However, they found an entry point not only at the talar neck but also an antegrade flow entry point at the posterior tubercle.

Gelberman RH, Mortensen WW. The arterial anatomy of the talus. *Foot Ankle* 1983;**4**:64–72.

Miller AN, Prasarn ML, Dyke JP, Helfet DL, Lorich DG. Quantitative assessment of the vascularity of the talus with gadolinium-enhanced magnetic resonance imaging. *J Bone Joint Surg Am*. 2011;**93**:1116–1121.

Phemister DB. Changes in bones and joints resulting from interruption of circulation: I. General considerations and changes resulting from injuries. *Arch Surg*. 1940;**41**:436–472.

7. Answer D. **Tibialis anterior**
The tibialis anterior contracts eccentrically during heel strike; thus, it acts to help control the lowering of the foot onto the ground. Injury to the tibialis anterior or to the motor nerve supply (deep peroneal nerve) will mean that the foot will slap onto the ground during initial contact. The tibialis anterior will contract concentrically during the initial and mid-swing phases of the gait cycle. If the tibialis anterior is weak during these phases, then clearance of the foot becomes a problem, which can lead to a compensatory high-stepping gait.

Bland DC, Prosser LA, Bellini LA, Alter KE, Damiano DL. Tibialis anterior architecture, strength, and gait in individuals with cerebral palsy. *Muscle Nerve* 2011;**44**:509–517.

Brunner R, Rutz E. Biomechanics and muscle function during gait. *J Child Orthop*. 2013;**7**:367–371.

8. Answer C. **Lateral plantar nerve**
Five main nerves innervate the foot (Table 9.1).

Achilles and Heel

9. Answer A. **Calf tightness**
Individuals with calf tightness, defined as less than 0° of ankle dorsiflexion, are 23 times more likely

Table 9.1 Nerve anatomy of the foot

Nerve	Motor function in the foot	Sensory function
Lateral plantar nerve	Adductor hallucis Quadratus plantae Lumbricals 4–5 Interossei	Plantar foot + lateral 1½ digits
Medial plantar nerve	Flexor hallucis brevis Flexor digitorum brevis Lumbricals 2–3 Abductor hallucis	Plantar foot + medial 3½ digits
Baxter's nerve (first branch of lateral plantar)	Abductor digiti minimus	
Deep peroneal nerve	Extensor hallucis brevis Extensor digitorum brevis	1st web space (dorsal)
Superficial peroneal nerve	-	Medial branch – dorsomedial hallux Lateral branch – dorsum foot

to have plantar heel pain. Obesity (BMI greater than 30) are 2.9 times more likely to have plantar heel pain. Those with jobs involving standing are 3.6 times more likely to have plantar heel pain if they stand for long periods throughout the day. This is because peak forces for walking and running occur at 60% of stance, with the plantar fascia taking 1.8 body weight during walking and 3.7 body weight during running.

Obesity does not only affect the plantar fascia due to weight. Tenocyte inhibition, weaker collagen and cytokines occur with obesity. Hypercholesterolaemia is also associated with Achilles tendon ruptures.

For every 1 unit increase in depression, anxiety or stress (in the DASS subscales), the odds ratios for having plantar heel pain are increased by 1.3.

10. Answer C. **Increased production of large proteoglycans, which bind with large amounts of water**

It is important to understand the pathophysiology and 'patient-specific' risk factors to individualise tendinopathy treatment and develop sound treatment theory where evidence is lacking.

The continuum model proposed by Cook and Purdam is well established. They proposed that the cell response is the initial trigger in tendinopathy and not collagen breakdown. The continuum contains three phases: reactive, dysrepair and degeneration.

Tenocytes manufacture components of extracellular matrix. The extracellular matrix's main component is tightly packed collagen. Proteoglycans in tendons are typically small.

Phases

Reactive – The tenocyte responds to acute overload by increasing the production of large proteoglycans, which bind with large amounts of water. The tendon therefore swells homogeneously (fusiform), which serves to increase cross-sectional area. This increase in cross-sectional area reduces strain. The response takes minutes to a few days. No collagen damage or neovessels occur. The goal of treatment in this phase is to reduce tenocyte activation/response. So, the swelling associated with the reactive phase is not inflammation.

Dysrepair – The ongoing reaction to inappropriate loading leads eventually to collagen fibre dysrepair, increased chondrocytic cellularity and proteins with the production of weak type III collagen. Disorganisation leads to early ingrowth of neovessels. Clinically, it can be difficult to distinguish this stage, but it can be picked up on imaging. Changes remain reversible.

Degeneration – This is typified by areas of cell death, minimal fibrillar collagen and the ingrowth of neovessels. In tendon matrix heterogeneity, the tendon becomes knobbly due to fibrotic thickening. Irreversible changes occur within those areas, but this does not necessarily mean clinical benefit cannot be achieved. Treatment requires stimulation of cell response.

Cook JL, Purdam CR. Is tendon pathology a continuum? A pathology model to explain the clinical presentation of load-induced tendinopathy. *Br J Sports Med.* 2009;**43**:409–416.

11. Answer A. **Calcaneal fracture**
The following tests are described for the diagnosis of the cause of heel pain:

Heel squeeze test – Calcaneal stress fracture is typically painful by squeezing the calcaneum from both sides.

Silfverskiöld test – Passive ankle dorsiflexion with the knee flexed to 90°. Abnormal if when going from extension to flexion, there is an increase in passive dorsiflexion of the ankle. This diagnoses a tight gastrocnemius complex.

Passive toe dorsiflexion (plantar fasciopathy) – Tightens the windlass mechanism and exacerbates pain.

Dorsiflexion-eversion test (tarsal tunnel syndrome) – Tibial nerve is compressed.

12. Answer C. **Physiotherapy**
In the majority of cases, plantar fasciopathy is a self-limiting problem. If you do nothing, then 90% will resolve by 10 months. Mechanical overload reduction includes focused calf stretches, weight loss and activity modification amongst other measures. Until recently this was the preferred first-line treatment for plantar fasciopathy. New up to date evidence suggests that physiotherapy is now the preferred option in the initial phase of the condition. All other conservative measures have been investigated quite extensively with level 1 evidence. A summary of the conclusions from a level 1 meta-analysis by Savioli et al. (2017) showed no intervention had a clinical improvement compared with placebo on the visual analogue scale (VAS) (Table 9.2).

Table 9.2 Effectiveness of treatment options for plantar fasciopathy compared with placebo

Intervention	Improvement as compared with placebo	Improvement VAS clinically better than placebo
Ultrasound-guided pulsed radiofrequency	High	No
Low-level laser therapy	Moderate	No
Dry needling	Moderate	No
Calcaneal taping	Moderate	No
Shockwave therapy	Low	No
Orthotic	Low	No
Calf muscle stretching	No	No
Plantar fascia stretching	No	No
Low-dye taping	No	No
Pulsed radiofrequency electromagnetic field	No	No

Salvioli S, Guidi M, Marcotulli G. The effectiveness of conservative, non-pharmacological treatment, of plantar heel pain: a systematic review with meta-analysis. *Foot* 2017;**33**:57–67.

13. Answer A. **Functional rehabilitation is equal to surgical treatment regarding the incidence of re-rupture**
In the initial phase of tendon healing, collagen type III is the initial collagen layered down. After 3 days, type I collagen production increases from 15- to 22-fold. After 2 weeks, a fibrous bridge consisting of fibroblasts and collagen fibres fuses the tendon. Between 3 and 4 weeks, the collagen fibres begin to organise longitudinally, a process that continues for a number of months. Collagen fibril crosslinking improves with applied stress.

Healing tendons undergoing passive motion will undergo intrinsic healing from tendon cells from the epitenon. If immobilised, the tendon heals predominately by granulation tissue from

the endotenon. Prolonged immobilisation causes decreased fibrillogenesis, and collagen and elastic fibres are less organised. Protective passive mobilisation has been shown to increase load to failure significantly when compared with immobilisation.

The most recent meta-analysis by Zhang et al. (2015) included a total of nine meta-analyses. When functional rehabilitation was used, conservative intervention was equal to surgical treatment regarding the incidence of re-rupture, range of motion, calf circumference and functional outcomes while reducing the incidence of other complications. Where functional rehabilitation was not performed, conservative intervention could significantly increase re-rupture rate. Critical to using a functional walking orthosis for an Achilles tendon rupture is ensuring the orthosis achieves the required equinus. Ellison et al. (2017) showed that using heel wedges causes the foot to flex at the midfoot and the Achilles does not shorten.

Ellison P, Molloy A, Mason LW. Early protected weightbearing for acute ruptures of the Achilles tendon: do commonly used orthoses produce the required equinus? *J Foot Ankle Surg*. 2017;**56**:960–963.

Zhang H et al. Surgical versus conservative intervention for acute Achilles tendon rupture: a PRISMA-compliant systematic review of overlapping meta-analyses. *Medicine (Balt.)* 2015;**94**:e1951.

Midfoot

14. Answer D. **Quality of anatomical reduction is the best predictor of functional outcomes**
Most studies agree that the quality of anatomical reduction is the best predictor of functional outcomes. Smith et al. (2018) performed a meta-analysis on fixation vs fusion, where three trials met criteria for inclusion. There was no difference in PROMs or alignment; the only difference was hardware removal. In a biomechanical study, transarticular screws and dorsal plates showed similar ability to reduce the first and second TMT joints after TMT and Lisfranc ligament transection and to resist TMT joint displacement with weight bearing load (Alberta et al. 2005). In regard to the use of tightrope, biomechanical studies have shown this can control translation, but there is no axial control; therefore, this is often combined with bridge plating (Ahmed et al. 2010).

Ahmed S, Bolt B, McBryde A. Comparison of standard screw fixation versus suture button fixation in Lisfranc ligament injuries. *Foot Ankle Int*. 2010;**31**:892–896.

Alberta FG et al. Ligamentous Lisfranc joint injuries: a biomechanical comparison of dorsal plate and transarticular screw fixation. *Foot Ankle Int*. 2005;**26**:462–473.

Smith N, Stone C, Furey A. Does open reduction and internal fixation versus primary arthrodesis improve patient outcomes for Lisfranc trauma? A systematic review and meta-analysis. *Clin Orthop Relat Res*. 2016;**474**:1445–1452.

15. Answer E. **Stage IIB tibialis posterior tendon dysfunction**
This sign is indicative of forefoot abduction. This may be seen following clinical examination and would most likely be seen in stage IIB tibialis posterior tendon dysfunction. This sign is caused by forefoot abduction; it would be seen in association with talonavicular uncoverage >40%. Stage IIA does not have significant talonavicular uncoverage and thus no 'too many toes' sign (Table 9.3). Fibular hemimelia is associated with

Table 9.3 Myerson modification of Johnson and Strom classification of adult acquired flat foot deformity

Stage	Description
I	Mild medial pain and swelling with no deformity, can perform heel-rise test but demonstrates weakness on repetition, tenosynovitis on pathology with normal tendon length
II	Moderate pain with or without lateral pain, flexible deformity, unable to perform heel-rise test, elongated tendon with longitudinal tears
IIA	<30% talar head uncoverage
IIB	>30% talar head uncoverage
III	Severe pain, fixed deformity, unable to perform heel-rise test, visible tears on pathology
IV	Lateral talar tilt
IVA	Flexible ankle valgus without severe arthritis
IVB	Fixed ankle valgus with or without arthritis

a ball and socket ankle and tarsal coalition. In more severe cases, the lateral rays are also deficient, and therefore will not have 'too many toes'. Charcot–Marie–Tooth disease would be associated with pes cavus and forefoot adductus. Iselin's disease is an apophysitis of the base of the 5th metatarsal.

Johnson KA, Strom DE. Tibialis posterior tendon dysfunction. *Clin Orthop Relat Res.* 1989;**239**:196–206.

Myerson MS. Adult acquired flatfoot deformity: treatment of dysfunction of the posterior tibial tendon. *Instr Course Lect.* 1997;**46**:393–405.

16. Answer C. **Flexor hallucis longus**
Flexor hallucis longus (FHL) runs with flexor digitorum longus (FDL) and intersects at the knot of Henry. Distal to the knot of Henry there are often multiple other connections between the two tendons, allowing the harvesting of the tendon with minimal functional loss. Baxter's nerve, the first branch of the lateral plantar nerve, turns medially around the calcaneus to travel laterally, sending the branch to the abductor digiti quinti (ADQ). The plantar fascia is plantar and superficial to FDL. Adductor hallucis is deeper and more laterally located and does not become accessible until further distal. Lumbricals are further deep and dorsal.

17. Answer E. **Supination deformity**
The deformity most commonly encountered is a supination deformity. It develops as part of an adaptive mechanism to re-establish the columns of the foot while in pes planus. The forefoot abnormalities will require derotation through the Chopart joints. It may also require a Cotton osteotomy to plantar flex the first ray. Prior to reduction of the hindfoot, the forefoot would be expected to show an abduction deformity. With coverage of the talar head, the abduction deformity should be corrected; however, the rotation may not have been fully appreciated. This would typically manifest itself as a persistent supination deformity of the forefoot.

18. Answer C. **Ledderhose disease**
Ledderhose disease, or plantar fibromatosis, is the correct diagnosis. The disease is named after Dr Georg Ledderhose, a German surgeon who described the condition in 1894. It is a similar disease to Dupuytren's disease. As in most forms of fibromatosis, it is usually benign. The nodules are typically slow growing and most often found in the central and medial portions of the plantar fascia. Options for intervention include radiation therapy, cryosurgery, treatment with collagenase clostridium histolyticum or surgical removal only if discomfort hinders walking.

In synovial sarcoma, histopathology would show a high histological grade, including cell atypia and the presence of poorly differentiated epithelial and spindle cells. For a lipoma, histological analysis demonstrates acellular stroma and lack of atypia. Fibromyxomas typically occur in the sub or periungual region, and histological analysis would show poor margins, spindle- and stellate-shaped cells, eosinophilic cytoplasm, fibrous and myxoid stroma and infrequent mitotic and minimal atypia. Gardner's syndrome is a variant of familial adenomatous polyposis and is associated with multiple tumours of soft tissue, skin and osteomas.

Forefoot

19. Answer B. **Distal chevron osteotomy**
The patient has acquired hallux valgus deformity, and on radiographs this has been described as mild (Table 9.4). Therefore, a basal osteotomy would be too powerful for this correction. The examination shows no instability of the first ray, ruling out the Lapidus fusion (fusion of the 1st tarsometatarsal joint), and no arthritis (negative grind test), ruling out the 1st metatarsal phalangeal joint fusion. The Moberg osteotomy is a dorsiflexion osteotomy usually preserved for arthritis to allow range of motion. The proximal phalanx osteotomy is primarily used to correct a hallux interphalangeus deformity (delta phalanx) or to supplement a 1st metatarsal osteotomy. The

Table 9.4 Classification of severity of hallux valgus based on the hallux valgus and intermetatarsal angles

Hallux valgus angle		Intermetatarsal angle
Mild	<30°	<13°
Moderate	30–40°	13–20°
Severe	>40°	>20°

distal chevron osteotomy is the most appropriate treatment.

20. Answer D. **MTP joint synovitis**
With the presence of a bunion deformity, the metatarsal head is often elevated. This can frequently lead to transfer metatarsalgia to the lesser metatarsals. Commonly, this leads to synovitis and pain of the 2nd and possibly 3rd MTP joint. Certainly, this is far more common than other causes of 2nd and 3rd MTP joint pain, Freiberg's disease, plantar plate rupture and Morton's neuroma. Freiberg's disease only usually affects one metatarsal and occurs most commonly in adolescents. A mallet toe occurs at the distal interphalangeal joint and is unlikely to cause pain under the metatarsal head.

Morton's neuroma is common in middle-aged (average 50 years old) women, and the incidence is at least 4–15 times higher in females. Clinically, there may be tenderness and a dorsal bulging may be found. It may also be present as an enlargement of the interdigital space. When pressure is applied axially to the intermetatarsal space, acute pain is induced. The pressure can be exerted while tightening the metatarsals with the other hand, and this may be associated with a painful and palpable clicking sensation (Mulder's click). Mulder's click demonstrates a 61% sensitivity and 62% accuracy. It most commonly occurs in the third intermetatarsal space, which it is theorised is due to the anastomosis of the medial and lateral plantar nerves, making it stiffer and more prone to injury.

21. Answer B. **Internal fixation**
Jones (1902) described a fracture in the proximal three-quarter segment of the shaft distal to the styloid. The Jones fracture was later defined by Stewart (1960) as a transverse fracture at the junction of the diaphysis and metaphysis without extension into the 4th and 5th intermetatarsal articulation. Dameron (1975) defined the proximal 5th metatarsal as having three zones: zone 1 – styloid process; zone 2 – meta-diaphyseal area; zone 3 – proximal diaphysis.

Ekrol and Court-Brown (2004) further differentiated fractures of zone 1 and explained their differences due to muscle insertion at the base of the 5th metatarsal.

For treatment, zone 1 injuries have been shown to be easily treated with symptomatic measures, with this no different to cast immobilisation at 4 weeks and 3 months (Akimau et al. 2016). A boot, however, is preferred to a sandal, as it results in significantly lower peak pressure at the 5th metatarsal during walking (Hunt et al. 2014).

In zone 2 and 3 injuries, biomechanical testing has shown fracture gapping during weight bearing (Morris et al. 2015). Zone 2 and 3 fractures are also at a watershed area, with the retrograde nutrient artery being damaged during fracture.

What is described in this clinical scenario is a zone 3 fracture, probably secondary to a stress fracture. It has been shown in an operative vs non-operative study that the operative treatment group demonstrated a reduced time to return to sport and faster clinical union by almost 50% compared with the non-operative group (Mologne et al. 2005). In this patient, therefore, surgery would be offered. In the non-athletic group, conservative management is commonly offered first (non-weight bearing cast); however, there is still a 30% non-union risk and a 30% refracture risk (Quill 1995).

Akimau PI et al. Symptomatic treatment or cast immobilisation for avulsion fractures of the base of the fifth metatarsal: a prospective, randomised, single- blinded non-inferiority controlled trial. *J Bone Joint Surg Br*. 2016;**98**:806–811.

Dameron JT. Fractures and anatomical variations of the proximal portion of the fifth metatarsal. *J Bone Joint Surg Am*. 1975;**57**:788–792.

Ekrol I, Court-Brown CM. Fractures of the base of the 5th metatarsal. *Foot* 2004;**14**:96–98.

Hunt KJ et al. Site-specific loading at the fifth metatarsal base in rehabilitative devices: implications for Jones fracture treatment. *PM&R*. 2014;**6**:1022–1029.

Jones RI. Fracture of the base of the fifth metatarsal bone by indirect violence. *Ann Surg*. 1902;**35**:697.

Mologne TS, Lundeen JM, Clapper MF, O'Brien TJ. Early screw fixation versus casting in the treatment of acute Jones fractures. *Am J Sports Med*. 2005;**33**:970–975.

Morris PM, Francois AG, Marcus RE, Farrow LD. The effect of peroneus brevis tendon

anatomy on the stability of fractures at the fifth metatarsal base. *Foot Ankle Int*. 2015;**36**:579–584.

Stewart IM. Jones's fracture: fracture of base of fifth metatarsal. *Clin Orthop*. 1960;**16**:190–198.

Quill Jr GE. Fractures of the proximal fifth metatarsal. *Orthop Clin N Am*. 1995;**26**:353–362.

22. Answer E. **Weakness on tip toe stance**
Excision of both sesamoids should be avoided if at all possible. Excision of both sesamoids relatively lengthens the flexor hallucis brevis and decreases its moment arm at the metatarsal phalangeal joint, essentially defunctioning it. It has been shown biomechanically that decreases in the effective tendon moment arm of the flexor hallucis longus tendon occurred with resection of both the medial and lateral sesamoids. One of the largest series of sesamoidectomy showed a 30% extreme difficulty or an inability to stand on tip toe (Lee et al. 2005).

The most recent systematic review on sesamoidectomy showed that most did well, with 94.4% of patients returning to sports, with 90.0% returning to their previous level, at a mean of 11.8±1.8 weeks. The overall complication rate, however, was 22.5% and the revision rate was 3.0%. The complications varied but included hallux valgus (medial sesamoidectomy), hallux varus (lateral sesamoidectomy), loss of range of motion of the 1st metatarsophalangeal joint, weakness of plantar flexion strength and transfer metatarsalgia. It was difficult to clearly divide the complications; however, the alteration in mechanical loading after sesamoidectomy appears to cause complications that include transfer metatarsalgia, neuroma, stress fracture of the metatarsals and lateral sesamoiditis (Shimozono et al. 2018).

Lee S, James WC, Cohen BE, Davis WH, Anderson RB. Evaluation of hallux alignment and functional outcome after isolated tibial sesamoidectomy. *Foot Ankle Int.* 2005;**26**:803–809.

Shimozono Y, Hurley ET, Brown AJ, Kennedy JG. Sesamoidectomy for hallux sesamoid disorders: a systematic review. *J Foot Ankle Surg*. 2018;**57**:1186–1190.

23. Answer E. **Weil metatarsal osteotomy**
Weil metatarsal osteotomy involves a near-horizontal osteotomy at the metatarsal head and neck. The most frequent complication reported is a floating toe. Morton's neuroma excision complications do not typically include mechanical toe deformities. Complications may include stump neuroma and painful or sensitive scar. Stainsby procedure is used in toe clawing to reduce the plantar plate to its correct position under the metatarsal head. It is performed by excising the proximal one-third to one-half of the proximal phalanx and suturing the proximal end of the extensors to the flexors. Loss of function of the toe is the most important problem. Keller's excision arthroplasty is performed on the hallux with complications including weakness on push off and cock-up deformity. Kidner's procedure involves resection of a symptomatic accessory navicular and reconstruction of the tibialis posterior.

Trnka H, Schuh R. Strategies for managing complications of osteotomies of the lesser metatarsals. In *Advanced Reconstruction Foot and Ankle 2*, eds Alexander I, Blumen E, Greisberg J. Rosemont, IL: American Academy of Orthopaedic Surgeons; 2015.

Migues A, Slullitel G, Bilbao F, Carrasco M, Solari G. Floating-toe deformity as a complication of the Weil osteotomy. *Foot Ankle Int.* 2004;**25**:609–613.

24. Answer E. **Plantar flexion and pronation**
Hallux valgus is a rotational and lateralising deformity of the hallux. The phalanx deviates into valgus and the metatarsal into varus. As the metatarsal migrates medially, the flexor hallucis brevis (sesamoids contained within) remains in place, becoming a valgus force to the phalanx as well as a flexor. This initiates rotation; the abductor hallucis becomes a plantar flexor and pronator of the hallucis as it moves plantarward and medially relative to its usual line of pull.

25. Answer B. **Revision to 1st MTPJ fusion with inlay bone graft**
Improvements in AOFAS score to 74.9 can be achieved with fusion, although one should be aware that they unite slower, have a significantly higher reoperation rate and have lower AOFAS scores than primary fusions (Baumhauer and Giovanni 2003; Gross et al. 2013). There is no

strong evidence for revision to a further silastic implant. Given there is osteolysis around the primary component, revision is likely to be technically challenging and will have a high probability of instability.

Baumhauer JF, DiGiovanni BF. Salvage of first metatarsalphalangeal joint arthroplasty complications. *Foot Ankle Clin N Am.* 2003;**8**:37–48.

Gross CE, Hsu AR, Holmes GB, Lee S. Revision MTP arthrodesis for failed MTP arthroplasty. *Foot Ankle Spec.* 2013;**6**:471–478.

26. Answer A. **Freiberg's disease**
The history is typical for a presentation of Freiberg's disease. The radiograph description is indicative of avascular necrosis of part of the metatarsal head. The condition was first described by Dr Alfred H. Freiberg in 1914. It is an uncommon condition, occurring most often in young women, athletes and those with abnormally long metatarsals.

Kohler's disease is osteochondritis of the navicular, typically affecting children between 5 and 10 years and affects boys more often than girls. Sever's disease is calcaneal apophysitis. Mueller–Weiss syndrome is adult-onset avascular necrosis of the navicular. Turf toe is a sprain of varying grades affecting the big toe.

27. Answer E. **Turner's syndrome**
Turner's syndrome is characterised by brachymetatarsia (described in the question), down-slanting eyes, droopy eyelids, short, webbed neck, teeth crowding, broad (Shield) chest, short carrying angle and short fingers and occurs in females. Klippel–Feil syndrome is a congenital condition characterised by fusion of at least two cervical vertebrae, a short neck, low hairline, scoliosis and Sprengel deformity and may also have cardiac and pulmonary abnormalities. Poland syndrome is a congenital disorder characterised by underdeveloped chest muscle and short, webbed fingers on one side. Trisomy 21 (Down's syndrome) is a congenital disorder characterised by mild to moderate developmental delay, poor immune function, heart defects, epilepsy, thyroid disorder, micrognathia, slanted eyes, macroglossia, short neck, large space between 1st and 2nd toes and shortened metatarsals 3–5. Sprengel deformity is characterised by malposition and hypoplasia of the scapula.

28. Answer A. **Amputation through proximal one-third of proximal phalanx**
In a low-demand nursing home patient with chronic infection and ulceration, an amputation would have the least complications. In the absence of infection and in a higher-demand patient, option E would address all the involved joints.

29. Answer A. **Dorsal cheilectomy**
This describes a grade 2 hallux rigidis (Coughlin and Shurnas Classification, Table 9.5). A Dorsal cheilectomy is the accepted procedure for a grade 2 as it will allow a greater range of motion. Synovectomy alone would not provide sustainable pain relief or range of motion required for this gentleman. Keller's procedure would leave him with functional loss, weakness and increased complications. Arthrodesis would provide pain relief but adversely affect function, it would also not be necessary in a grade 2 hallux rigidus although is often utilised if a cheilectomy were to fail. There is no great evidence for arthroplasty in active patients with grade 2 hallux rigidis and should not be considered in the first instance.

Coughlin MJ, Shurnas PS. Hallux rigidus: grading and long-term results of operative treatment. *J Bone Joint Surg Am.* 2003;**85-A**:2072–2088.

30. Answer D. **Perpendicular to 2nd metatarsal**
The goal in a conventionally shaped foot is to maintain length in the 1st metatarsal. Lengthening it could lead to significant 1st MTP stiffness and pain. Shortening the 1st metatarsal risks transfer metatarsalgia. Option D should not lengthen the metatarsal, as the 2nd metatarsal normally is in parallel with the longitudinal axis of the foot. Option C would lengthen the metatarsal, as the osteotomy would slide the metatarsal head distally as it is reduced. Options A and B would likely shorten and E may lengthen the metatarsal through the same mechanisms as previously discussed.

31. Answer D. **Contracture of flexor digitorum longus and/or brevis**
What is described is 'curly toes'. This is a congenital abnormality usually caused by a contracture of one or both of the flexors. It is not

Table 9.5 Coughlin and Shurnas classification of hallux rigidus

Grade	Dorsiflexion	Radiographic findings	Clinical findings
0	40°–60° +/– or 10–20% loss compared to other side	Normal	Stiffness
1	30°–40° +/– or 20–50% loss compared to other side	Dorsal osteophyte. Minimal joint space narrowing, flattening of metatarsal head and periarticular sclerosis	Stiffness and mild pain on end range of motion
2	10°–30° +/– or 50–70% loss compared with other side	Dorsal, lateral +/– medial osteophyte. Flattening metatarsal head with >1/4 dorsal joint involvement. Mild to moderate joint space narrowing	Stiffness. Moderate to severe pain, occurring just before end range of motion
3	<10° +/– or 75–100% loss compared to other side. <10° plantar flexion	Grade 2 + substantial joint space narrowing +/– periarticular cystic change. >1/4 dorsal joint space involvement. Sesamoid enlargement/ cystic change	Stiffness and constant pain except mid-range motion
4	Grade 3	Grade 3	Grade 3 BUT mid-range pain on passive motion

associated with any bony abnormalities. It is often bilateral and involves 1–3 of the lateral 3 digits. Treatment initially involves observation and some passive stretching; in severe cases, flexor tenotomy can be performed.

Ankle

32. Answer B. **Anterolateral portal placement**
Anterolateral portal placement is recommended to be sited after anteromedial portal placement. This is due to the risk of injury to the superficial peroneal nerve during portal placement. The portal is sited lateral to the peroneus tertius tendon and medial to the lateral malleolus at the level of the tibiotalar joint. The risk of injury is reduced by illuminating the portal site from internally, as the nerve can often be seen as a shadow.

The anterocentral portal is not commonly used due to risk of injury to the anterior tibial artery and deep peroneal nerve, which, if injured, would only give rise to numbness in the first dorsal web space. The anteromedial portal is sited medial to the tibialis anterior tendon and anterior to the long saphenous vein. The saphenous nerve is at risk of injury, and injury will lead to minor altered sensation on the medial aspect of the foot. With the posterolateral portal, the sural nerve, which provides sensation to the lateral border of the foot, is at risk of injury. With the posteromedial portal, the tibial nerve is at risk of injury. This will cause sensation loss to the plantar aspect of the foot.

Tonogai I, Hayashi F, Tsuruo Y, Sairyo K. Anatomic study of anterior and posterior ankle portal sites for ankle arthroscopy in plantarflexion and dorsiflexion: a cadaveric study in the Japanese population. *J Foot Ankle Surg.* 2018;**57**:537–542.

Yammine K, Assi C. Neurovascular and tendon injuries due to ankle arthroscopy portals: a meta-analysis of interventional cadaveric studies. **Surg Radiol Anat.** 2018;**40**:489–497.

33. Answer B. **Anterior talar fibular ligament**
The anterior drawer test is carried out with the foot in 20° of plantar flexion. It is considered to be positive for injury to the anterior talar fibular ligament (ATFL) if there is more than 8mm of forward shift on lateral view. Injury to the ATFL shown with a positive anterior drawer test and symptomatic ankle instability in an otherwise healthy adult suggests that the patient would benefit from surgical management if physiotherapy had failed. Surgery for ankle instability can be described as either anatomical or non-anatomical. A modified Brostrom–Gould is one of the most common anatomical repairs carried

out. It is an operation which Brostrom originally described as direct ligament repair to the ATFL and which was later modified by Gould to include detaching, shortening and reattaching the ATFL and then including the inferior extensor retinaculum into the repair to strengthen it. This has been further modified by Molloy to include bone anchors.

Croy T, Koppenhaver S, Saliba S, Hertel J. Anterior talocrural joint laxity: diagnostic accuracy of the anterior drawer test of the ankle. *J Orthop Sports Phys Ther.* 2013;**43**:911–919.

Karlsson J, Eriksson BI, Bergsten T, Rudholm O, Sward L. Comparison of two anatomic reconstructions for chronic lateral instability of the ankle joint. *Am J Sports Med.* 1997;**25**:48–53.

Orr JD, Robbins J, Waterman BR. Management of chronic lateral ankle instability in military service members. *Clin Sports Med.* 2014;**33**:675–692.

34. Answer C. **AITFL, IOL, PITFL**

The tibial (or tibiofibular) clear space is defined as the horizontal distance between the lateral border of the posterior tibial malleolus (the incisura fibularis) and the medial border of the fibula at the point where the posterior malleolus is widest on an AP radiograph. Tibiofibular distance should be 3.7mm ± 0.5mm, 1cm above the joint. Ostrum et al. (1995) found gender differences – normal tibial clear space should be less than 5.2mm in women and less than 6.5mm in men. Increased tibiofibular clear space is a radiographic finding that can be used to help diagnose injuries to the distal tibiofibular syndesmosis. The syndesmosis has three main ligaments: the anterior-inferior tibiofibular ligament (AITFL), the interosseous ligament (IOL) and the posterior-inferior tibiofibular ligament (PITFL). The presence of a fourth ligament, the transverse ligament, is disputed in the literature, with some authors detailing it as deep fibres of the PITFL and others detailing it as a separate ligament and thus this was not part of the answers given. The intermalleolar ligament is a secondary stabiliser.

The tibiofibular overlap is another measure for syndesmosis injury. On an AP radiograph, tibiofibular overlap should be measured from the medial edge of the fibula to the lateral border of the tibia, and it should exceed 6mm. The anterior tubercle of tibia should overlap the fibula more than 5.2mm in women and more than 6.5mm in men (Ostrum et al. 1995). Some of the older literature states this to be more than 1cm.

Ostrum RF, De Meo P, Subramanian R. A critical analysis of the anterior-posterior radiographic anatomy of the ankle syndesmosis. *Foot Ankle Int.* 1995;**16**:128–131.

35. Answer B. **Medial malleolus transverse fracture or deltoid disruption, ATFL disruption, lateral short oblique fracture or spiral fracture of the fibula above the syndesmosis, PITFL avulsion or posterior malleolus fracture**

The injury described was a pronation external rotation injury (Lauge-Hansen 1950). Pronation injuries start with medial-sided injuries first. As the injury progresses, the external rotation moment of the talus then leads to ATFL disruption or Wagstaff (avulsion of the AITFL from the fibular) type fractures. The intraosseous part of the syndesmosis is ruptured, and the injury progresses to a short oblique type of fracture of the fibula above the syndesmosis. As the external rotation moment continues, the PITFL is disrupted, either an avulsion or posterior malleolus fracture. This renders the syndesmosis unstable and can lead to ankle diastasis.

Supination injuries start on the anterolateral aspect of the ankle.

Vertical medial malleolus fractures are seen in supination adduction injury patterns and occur after the lateral side has been injured.

Lauge-Hansen N. Fractures of the ankle. II. Combined experimental-surgical and experimental-roentgenologic investigations. *Arch Surg.* 1950;**60**:957–985.

36. Answer D. **Central medial talar dome**

In an MRI-based study of 424 osteochondral lesions, Elias et al. (2007) described a 9-zone grid map of the talar dome, with zone 1 being anterior medial and zone 9 being posterior lateral. Zone 4 is described as being central and medial and was seen in 227 (53%) cases. Central lateral was the second most frequent, with 110 (25.7%) cases. Overall medial injuries were more common (63%), with lateral injuries following

(33%) and the remaining (4%) in the midline. Most medial injuries will describe a history of an injury.

Elias I et al. Osteochondral lesions of the talus: localization and morphologic data from 424 patients using a novel anatomical grid scheme. *Foot Ankle Int.* 2007;**28**:154–161.

Looze CA et al. Evaluation and management of osteochondral lesions of the talus. *Cartilage* 2017;**8**:19–30.

37. Answer C. **Neutral dorsiflexion, 10° external rotation, 5° hindfoot valgus**
The optimal position for the ankle for ankle arthrodesis is neutral dorsiflexion, 10° external rotation and 5° hindfoot valgus. This was shown in a biomechanical gait analysis by Buck et al. (1987). They demonstrated that this positioning of the ankle allows the greatest compensatory motion at the foot and places the least strain on the knee.

Buck P, Morrey BF, Chao EY. The optimum position of arthrodesis of the ankle: a gait study of the knee and ankle. *J Bone Joint Surg Am.* 1987;**69**:1052–1062.

38. Answer B. **Neutral**
Wei et al. (2014) undertook a study where patients were categorised into groups based on ankle position at the time of the injury: Group I (varus), Group II (valgus), Group III (dorsi-flexion), Group IV (plantar flexion) and Group V (neutral). More than 90% of participants in Groups I–IV as well as 57.2% of participants in Group V had anatomical/good fracture reduction, respectively. Fracture healing/union was significantly slower in Group V vs Groups I, III and IV, and in Group II vs Group IV. AOFAS scores were significantly higher ($P < 0.005$) in Groups III (96) and IV (95.0, IQR: 90.0e100.0) vs Groups II (86.9, IQR: 75.0e90.0) and V (83.0, IQR: 73.0e86.0).

Wei SJ, Han F, Lan SH, Cai XH. Surgical treatment of Pilon fracture based on ankle position at the time of injury/initial direction of fracture displacement: a prospective cohort study. *Int J Surg.* 2014;**12**:418–425.

This study equates to the fact that the neutral position causes a full Pilon rather than the partial articular fractures in other types. The eponymous Gosselin fracture is a neutral Pilon fracture where a V-shaped fracture is formed from the anterior and posterior fragments.

39. Answer E. **Synovial sarcoma**
Synovial sarcoma is the most common sarcoma of the foot, it affects males more than females and it is associated with metastasis in approximately one-third of patients. Sites of metastasis may also include lymphatics, which is rare for soft tissue sarcoma. The other answers are less common in the foot, with metastasis the lowest at approximately 0.01%.

Herzog CE. Overview of sarcomas in the adolescent and young adult population. *J Pediatr Hematol Oncol.* 2005;**27**:215–218.

Maheshwari AV, Chiappetta G, Kugler CD, Pitcher D, Temple HT. Metastatic skeletal disease of the foot: case reports and literature review. *Foot Ankle Int.* 2008;**29**:699–710.

Diabetes

40. Answer E. **Total contact casting**
The history describes a grade 2 ulcer with active Charcot, Eichenholtz Stage I. Although this patient may at some point require an exostectomy, or midfoot reconstruction, in the presence of an acute Charcot process and ulceration, an attempt should be made to offload the ulcer and contain the involved joints during the active phase. The Eichenholtz stages are:

Stage I – Developmental (Acute)
- Hyperaemia due to autonomic neuropathy weakens bone and ligaments.
- Diffuse swelling, joint laxity, subluxation, frank dislocation, fine periarticular fragmentation, debris formation.

Stage II – Coalescence (Quiescent)
- Absorption of osseous debris, fusion of larger fragments.
- Dramatic sclerosis.
- Joints become less mobile and more stable.
- The 'hypertrophic' or 'subacute' phase of Charcot.

Stage III – Consolidation (Resolution)
- Osseous remodelling.

Eichenholtz SN. *Charcot Joints.* Springfield, IL: Charles C. Thomas; 1966.

41. Answer C. **Serum albumin 2.9g/dL**
Ankle–brachial pressure index of <0.45 or transcutaneous oxygen pressure <30mm Hg is a negative predictor of wound or ulcer healing. Laboratory tests that assess nutrition and ability to mount an immune response are also of value in assessing ulcer healing potential. An albumin of <3.0g/dL or a white cell count of <1.5 ($\times 10^9$/L) are negative predictors of diabetic ulcer healing.

Transcutaneous oxygen pressures ($TcPO_2$)

- Considered gold standard to assess wound healing potential.
- Between 30 and 40mmHg is considered the 'grey zone' and concerning.
- <20 has high rate of wound infections.
- >40mmHg is a good sign of healing potential.

Ankle–brachial pressure and ischaemic index

- Calcification in the arteries can result in inaccurate Doppler flow readings
- Calcifications falsely elevate the ABIs due to decreased compliance of the calcified vessels.
- Ratio of ankle to brachial pressures (<0.6 is abnormal and concerning).
- Index of 0.6, absolute ankle pressure of >40mmHg and absolute toe pressure of 40mm Hg or more are good indicators that a diabetic ulcer will heal.
- Index of <0.45 is associated with poor wound healing.

Serum albumin

- <3.5 g/dL indicates malnourishment and is a poor indicator of wound healing.

Total lymphocyte count

- <1,500/mm^3 indicates immune deficiency and is a poor indicator of wound healing.

A 5.07 Semmes–Weinstein monofilament at 10 sites (9 plantar and 1 dorsal) is the most reproducible and valid test for checking protective foot sensation.

General

42. Answer B. **Distal short Chevron osteotomy**
Specific components of the Chevron procedure have been identified as being linked to the development of post-operative AVN. Factors such as positioning of the osteotomy cuts wholly within the joint capsule; overzealous use of the saw in the intermetatarsal space whilst performing the transverse cuts and using a separate intermetatarsal incision for the release of the adductor hallucis tendon, have all been cited as increasing the risk of post-operative AVN.

M Rothwell, Pickard J. The chevron osteotomy and avascular necrosis. *Foot (Edinburgh)* 2013;**23**:34–38.

43. Answer B. **Morphology of fracture determines functional outcome in fixed posterior malleolar fractures**
There have been nine publications showing the estimation of posterior malleolar fracture size to be very poor on plain radiographs. The position of the X-ray source and its orientation to the sagittal fracture line determines the fragment size you can see. Any posteromedial involvement has a high chance of not being seen as the fracture line is not orientated correctly to be visible. Meijer et al. (2015) found that the accuracy of measurement of posterior malleolar fracture size on lateral radiograph was only 22%.

In 2016 and 2018, two systematic reviews were undertaken looking at the outcomes of posterior malleolar fractures treated by traditional means (fixation only occurred if greater than a third of the articular surface) (Odak et al. 2016; Verhage et al. 2018). Both concluded that articular percentage involved had no relevance to outcome. More recently, a paper by Patel et al. (2022) reviewed all posterior malleolar fracture fixation literature, finding that morphology of fracture dictated the functional outcome.

Although there are both clinical and anatomical studies showing that fixation of a posterior malleolar fracture increases syndesmosis stability, not all posterior malleolar fractures have syndesmosis instability and not all syndesmosis injuries with posterior malleolar fractures have just posterior injuries (Jayatilaka et al. 2019). In high fibular fractures, injury to the AITFL means that just posterior malleolar fracture fixation is not enough to stabilise the syndesmosis.

Multiple studies have shown that posterolateral approach would not be recommended for treatment of a posterior malleolar fracture in cases of a high fibular fracture, comminuted fibular fracture (where a direct lateral fibular

approach is recommended), Mason and Molloy type 2B fracture (with medial fragment requiring a medial posteromedial approach) or where access to a die punch fragment is required (Gandham et al. 2020).

Gandham S, Millward G, Molloy AP, Mason LW. Posterior malleolar fractures: a CT guided incision analysis. *Foot (Edinburgh)* 2020;**43**:101662.

Jayatilaka MLT et al. Anatomy of the insertion of the posterior inferior tibiofibular ligament and the posterior malleolar fracture. *Foot Ankle Int.* 2019;**40**:1319–1324.

Kohler FC et al. The role of the posterior malleolus in the treatment of unstable upper ankle joint injuries: a biomechanical study. *Foot Ankle Surg.* 2022;**28**:979–985.

Meijer DT et al. Guesstimation of posterior malleolar fractures on lateral plain radiographs. *Injury* 2015;**46**:2024–2029.

Odak S, Ahluwalia R, Unnikrishnan P, Hennessy M, Platt S. Management of posterior malleolar fractures: a systematic review. *J Foot Ankle Surg.* 2016;**55**:140–145.

Patel S, Baburaj V, Sharma S, Mason LW, Dhillon MS. Influence of posterior malleolar fragment morphology on the outcomes of trimalleolar fractures: a systematic review and meta-analysis. *Foot Ankle Surg.* 2022; S1268–7731(22)00116-3.

Verhage SM, Hoogendoorn JM, Krijnen P, Schipper IB. When and how to operate the posterior malleolus fragment in trimalleolar fractures: a systematic literature review. *Arch Orthopaed Trauma Surg.* 2018;**138**:1213–1222.

44. Answer A. **Intermetatarsal ligament**
During a Morton's neuroma excision through a dorsal approach, the intermetatarsal tissues are dissected and the deep transverse intermetatarsal ligament is visualised and incised parallel to the metatarsals. A laminar spreader can be inserted between the metatarsal heads. The nerve is then dissected first distally, until the bifurcation of the two digital branches becomes apparent. The distal nerve branches are cut distally, and proximal dissection on the plantar aspect of the nerve is performed.

Adnan AF, Acuth H. The outcome after using two different approaches for excision of Morton's neuroma. *Chin Med J.* 2010;**123**:2195–2198.

45. Answer E. **Orthosis with a metatarsal bar**
The age and the clinical presentation points towards Freiberg's disease. It is characterised by infarction and fracture of the metatarsal head. Diagnosis is made radiographically with plain radiographs showing subchondral sclerosis, flattening of the involved MT head and eventual joint destruction in advance disease. MRI studies may be needed to detect early disease. Treatment is activity modification and NSAIDs in early disease. Surgical management is indicated for progressive pain, joint destruction, and joint deformity. First-line treatment in early stage of the disease is by short leg walking cast or boot for 4-6 weeks or still-soled shoes with MT bars or pads.

Carmont MR, Rees RJ, Blundell CM. 2009. Current concepts review: Freiberg's disease. *Foot Ankle Int.* 2009;**30**:167–176.

46. Answer A. **Accommodative orthotics**
Tarsal coalition is a common congenital condition caused by failure of embryonic segmentation leading to abnormal coalition of two or more of the tarsal bones. The condition is usually asymptomatic but may present with a flatfoot deformity or recurrent ankle sprains. Diagnosis is made with plain radiographs of the foot and ankle showing a coalition, most commonly a calcaneonavicular or talocalcaneous coalition. Treatment is initially accommodative orthotics as this is a fixed case of pes planus and will not correct passively. Surgical coalition resection or joint arthrodesis is indicated for patients with persistent symptoms who fail conservative management although studies are small. Fusion is often preferred to excision in the adult population.

47. Answer D. **Total ankle fusion**
The radiograph shows end stage arthritis to an ankle with maintained subtalar joint. He is very active and want to remain active. The option of TTC fusion is not desirable as we would want to maintain the subtalar motion. Distraction arthroesis and distal tibial osteotomy are options in younger patients with moderate arthritis. There

is currently no difference in outcomes between total ankle replacement and total ankle fusion in the literature in ankles of minimal deformity. Ankle replacements in deformities greater than 15° will require adjuncts such as calcaneal or tibial osteotomies, which are not given as options.

48. Answer B. **Hallux valgus**
Sesamoid injuries of the hallux consist of a constellation of injuries to the sesamoid complex consisting of fractures, tendonitis and ligamentous injuries. Diagnosis is suspected with hallux pain that is worse with hyperextension and can be confirmed with MRI studies. Treatment depends on the specific injury to the sesamoid complex, chronicity and patient activity demands. Hallux valgus is a complication because of tibial sesamoid excision.

Shimozono Y, Hurley ET, Brown AJ, Kennedy JG. Sesamoidectomy for hallux sesamoid disorders: a systematic review. *J Foot Ankle Surg.* 2018;**57**:1186–1190.

49. Answer B. **C Sign**
The abnormal Jack's test indicates a fixed pes planus deformity.

The C sign is seen on a lateral radiograph of the ankle in those with the talocalcaneal subtype of tarsal coalition. It can be seen in both osseous and non-osseous coalition. A continuous C-shaped arc on a lateral ankle radiograph is formed by the medial outline of the talar dome and posteroinferior aspect of the sustentaculum tali due to their bridging.

An anteater sign is formed from an elongated anterior process of calcaneus in a calcaneonavicular coalition.

The fleck sign is a small bony fragment seen in the space between the base of the 1st and 2nd metatarsal associated with avulsion of the Lisfranc ligament.

A rocker bottom foot (also known as a congenital vertical talus) is a congenital anomaly of the foot characterised by a prominent calcaneus/heel and a convexly rounded sole. A similar appearance can also occur in a Charcot neuropathy patient with midfoot destruction and tight triceps surae.

'Too many toes' signs is a clinical sign not radiographic, where forefoot abduction reveals more toes than would be expected, when the foot is viewed from behind.

50. Answer A. **Passive stretching**
Metatarsus adductus is a common congenital condition in infants that is thought to be caused by intrauterine positioning that leads to abnormal adduction of the forefoot at the tarsometatarsal joint.

Diagnosis is made clinically with medial deviation of the forefoot with normal alignment of the hindfoot. Treatment is generally non-operative with stretching if the deformity can be passively corrected, and with casting if the deformity is rigid. Surgical management is indicated for patients with progressive deformities who fail non-operative management.

Bleck EE. Metatarsus adductus: classification and relationship to outcomes of treatment. *J Pediatr Orthop*. 1983;**3**:149–159.

51. Answer C. **Eliminating the effect of first ray plantar flexion**
Coleman block test evaluates hindfoot flexibility and pronation of forefoot. The initial deformity is in the forefoot followed by subsequent changes in the hindfoot. The test is performed by placing the patient's foot on a wood block, 2–4 cm thick, with the heel and lateral border of foot on the block and bearing full weight while the 1st, 2nd and 3rd metatarsals are allowed to hang freely into plantar flexion and pronation.

Interpretation:

- test is based on premise that there is fixed flexion of 1st metatarsal; this test negates effect that forefoot (1st metatarsal in plantar flexion) may have on the hindfoot in stance
- if heel varus corrects while the patient is standing on the block, hindfoot is considered flexible
- if subtalar joint is supple and corrects with block test, then surgical procedures may be directed to correcting forefoot pronation, which is usually due to plantar flexion of 1st metatarsal
- if hindfoot is rigid, then surgical correction of both the forefoot and hindfoot are required.

Paulos L, Coleman SS, Samuelson KM. Pes cavovarus: review of a surgical approach using

selective soft-tissue procedures. *J Bone Joint Surg Am.* 1980;**62**:942–953.

52. Answer D. **Tibia and fibula**
The muscle in discussion is the tibialis posterior. Adult acquired flatfoot deformity is generally associated with a collapsing medial longitudinal arch and a progressive loss of strength of the posterior tibial tendon (PTT). This condition is commonly associated with PTT dysfunction or rupture, which can have an arthritic or a traumatic aetiology.

The tibialis posterior muscle is contained within the deep posterior compartment of the lower limb, arising from the adjacent posterior surfaces of the tibia, fibula and interosseus membrane. The TP tendon has multiple insertions within the foot, dividing into three main components: (i) anterior; (ii) middle; and (iii) posterior. The anterior component is the largest and extends to the navicular tuberosity; it is reported to contain a fibrocartilaginous or bony sesamoid at this site. The sesamoid functions to provide a pressure absorbing or gliding mechanism. The middle and posterior components extend to the remaining tarsal bones, the middle three metatarsals and the flexor hallucis brevis muscle.

Guelfi M et al. 2017. Anatomy, pathophysiology, and classification of posterior tibial tendon dysfunction. *Eur Rev Med Pharmacol Sci.* 2017;**21**:13–19.

53. Answer E. **Plantar plate rupture**
The history of an acute event is much more likely to represent a plantar plate rupture. The plantar plate of the toe is a rectangular structure with a stout distal insertion and relatively flimsy proximal origin. The anatomical relationships to adjacent structures and composition are similar between the volar plates of the fingers and plantar plates of the toes, however the weight bearing nature of the foot and forces imposed by toe-off may create chronic hyperextension of the metatarsophalangeal joint and predispose the plantar plate to attenuation or rupture and can lead to instability of the metatarsophalangeal joint. As the toe has then clawed, the metatarsal head moves plantarward, ultimately causing the callosity. The callosity represented is a mixture of a second rocker and third rocker callosity, being both prominent on stance phase and propulsive phase of gait.

An intractable plantar keratosis is a focused, painful lesion that commonly takes the form of a discrete, focused callus, usually about 1cm, on the plantar aspect of the forefoot. The other options will not give rise to the callosity presented.

Lucas DE, Philbin T, Hatic S 2nd. The plantar plate of the first metatarsophalangeal joint: an anatomical study. *Foot Ankle Spec.* 2014;**7**:108–112.

54. Answer B. **CT scan with metal reduction artefact**
The most common reported event was aseptic loosening (19.3%) followed by infection (18.2%) and alignment/mechanical issues (16.5%). The above-described scenario brings the question of ascertaining whether this is loosening or infection. The clinical and biochemical work-up points in the direction that infection is unlikely in this case and therefore it is safe to assume that the most common cause here is aseptic loosening. A CT is required to look at bone stock prior to consideration of surgical management.

Glazebrook MA, Arsenault K, Dunbar M. Evidence-based classification of complications in total ankle arthroplasty. *Foot Ankle Int.* 2009;**30**:945–949.

55. Answer A. **Dystonia**
This clinical picture represents dystonia. The foot corrects during muscle relaxant showing that muscle activity is involved. Dystonia is a movement disorder in which a person's muscles in the affected body part contract involuntarily, resulting in abnormal postures, repetitive movements, or both. Many people with functional dystonia report that the problem is triggered by an event, often an injury, an operation, or a physical illness, with a background of stress and psychological difficulty.

Functional dystonia can be subdivided into the two postural types: functional fixed dystonia and functional paroxysmal dystonia. A coexisting diagnosis of chronic regional pain syndrome (CRPS) is also common in patients with a fixed functional dystonia, and severe pain frequently accompanies the deformity.

Gray J, Welck M, Cullen NP, Singh D. Functional dystonia in the foot and ankle. *Bone Joint J.* 2021;**103-B**:1127–1132.

56. Answer E. **Tibialis posterior reconstruction, medialising calcaneal osteotomy, gastrocnemius slide, spring ligament reconstruction**
The clinical history and examination illustrate a progressive flat foot deformity, or what is sometimes described as a Johnson and Strom type 2B deformity (flexible flat foot with forefoot abduction). As such, correcting the tibialis posterior tendon alone, or with combined triceps surae contracture correction (additional gastrocnemius slide or medialising calcaneal osteotomy) will not correct the forefoot abduction. Therefore, either a medial column ligamentous repair (spring ligament reconstruction) or lateral column lengthening is needed to correct the forefoot.

Only the spring ligament option is given in this case. A Cotton osteotomy is used to correct metatarsal elevation if a flat foot reconstruction has resulted in a compensatory supination of the first ray on correction. A medial double fusion (talanavicular and subtalar joint fusion) is often preserved for fixed/arthritic deformities or in older patients. The corrected case can be seen in Figure 9.7.

Heyes G, Swanton E, Vosoughi AR, Mason LW, Molloy AP. Comparative study of spring ligament reconstructions using either hamstring allograft or synthetic ligament augmentation. *Foot Ankle Int.* 2020;**41**:803–810.

Myerson MS et al. Classification and nomenclature: progressive collapsing foot deformity. *Foot Ankle Int.* 2020;**41**:1271–1276.

Figure 9.7 Anteroposterior (AP) and lateral radiographs of correction flat foot deformity

Chapter 10

Foot and Ankle II Structured SBA

Andrea Nicolas and Simon Chambers

FOOT AND ANKLE II STRUCTURED SBA QUESTIONS

Anatomy and Biomechanics

1. **During the gate cycle?**
   - A. At toe-off, the gastrocnemius and soleus complex is eccentric contracting
   - B. During heel strike iliopsoas is concentrically contracted
   - C. Gastrocnemius and soleus complex concentrically contract during midstance
   - D. Hamstrings are concentrically contracted during pre-swing phase
   - E. Tibialis anterior eccentrically contracts after heel strike

2. **Regarding the anatomy of the medial longitudinal arch?**
   - A. During mid-stance, the medial longitudinal arch contracts due to pronation of the forefoot
   - B. The deltoid and spring ligaments are the primary restraints against pronation and valgus deformity of the foot and preserve the medial arch
   - C. The medial arch reaches its maximal length during the toe off phase
   - D. The medial longitudinal arch is formed by two pillars. The medial two metatarsal heads comprise the anterior pillar, and the posterior pillar is made up of the medial third of the navicular bone
   - E. The posterior tibial tendon has a primary role in plantar arch maintenance

3. **Which of the following statements regarding the nerve supply to the foot is correct?**
   - A. The lateral plantar nerve innervates the abductor and flexor digiti minimi, the abductor hallucis and the interossei muscles
   - B. The medial and lateral plantar nerves are sensory branches that provide sensation to the sole of the foot
   - C. The sural nerve is formed from branches of both the tibial and common peroneal nerves, and supplies sensation to the medial foot
   - D. The tibial nerve divides into the two calcaneal branches and medial and lateral plantar nerve at the level of the tarsal tunnel
   - E. The tibial nerve innervates the gastrocnemius plantaris, soleus, popliteus, posterior tibialis, extensor digitorum longus and extensor hallucis longus muscles

4. **What structure attaches to the medial cuneiform?**
   - A. Extensor hallucis longus
   - B. Flexor digitorum
   - C. Peroneus brevis
   - D. Tibialis anterior
   - E. Tibialis posterior

5. **What is the antagonist muscle of tibialis anterior?**
   - A. Extensor hallucis longus
   - B. Flexor hallucis longus
   - C. Peroneus brevis
   - D. Peroneus longus
   - E. Tibialis posterior

6. **What best describes the contents of the tarsal tunnel from anteromedial to posterolateral?**
   - A. The flexor digitorum longus tendon, posterior tibial tendon, the posterior tibial artery and veins, the posterior tibial nerve and the flexor hallucis tendon
   - B. The flexor hallucis tendon, the posterior tibial tendon, the flexor digitorum longus tendon, the posterior tibial nerve and the posterior tibial artery and veins

C. The posterior tibial nerve, the posterior tibial artery, the posterior tibial veins, the posterior tibial tendon, the flexor digitorum longus tendon and the flexor hallucis tendon
D. The posterior tibial tendon, the flexor digitorum longus tendon, the posterior tibial artery and veins, the posterior tibial nerve and the flexor hallucis tendon
E. The posterior tibial tendon, the flexor digitorum longus tendon, the flexor hallucis tendon, the posterior tibial nerve and the posterior tibial artery and veins

7. **What nerve supplies the flexor hallucis brevis?**
   A. Deep peroneal nerve
   B. Lateral calcaneal nerve
   C. Lateral plantar nerve
   D. Medial plantar nerve
   E. Superficial peroneal nerve

8. **Which statement is not true in regard to the Lisfranc joint complex?**
   A. Lisfranc joint complex is inherently stable with little motion due to stable osseous architecture (keystone configuration and strong ligamentous restrain)
   B. Lisfranc ligament tightens with pronation and abduction of forefoot
   C. The dorsal tarsometatarsal ligaments are weaker and therefore bony displacement with injury is often dorsal
   D. The intermetatarsal ligaments are located between first and fifth metatarsal bases
   E. The Lisfranc ligament. It is an interosseous ligament that originates from medial cuneiform to base of 2nd metatarsal on plantar surface

Trauma

9. A 45-year-old male sustained a right talus fracture following a RTA. He was treated conservatively in a below knee non-weight bearing cast. Radiograph at 8 weeks demonstrated subchondral radiolucent band in the talar dome.
   What is the most appropriate next step?
   A. Arrange CT scan
   B. Arrange MRI
   C. Continue non-weight bearing cast for a further 6 weeks
   D. Plan for core decompression
   E. To commence mobilisation in a moonboot

10. A 34-year-old man fell off a ladder and sustained a closed, intra-articular fracture of right calcaneus. He is otherwise fit and well, he is a non-smoker.
    What is the most appropriate management?
    A. Close reduction and external fixation
    B. Conservative management in a below knee cast
    C. Open reduction and internal fixation using a minimally invasive approach
    D. Open reduction and internal fixation using an extended lateral approach
    E. Percutaneous fixation

11. An 88-year-old woman tripped and fell in the garden. Her radiographs are shown in Figure 10.1.
    What would be the most appropriate definitive management for this patient?
    A. Application of circular frame
    B. Close contact cast

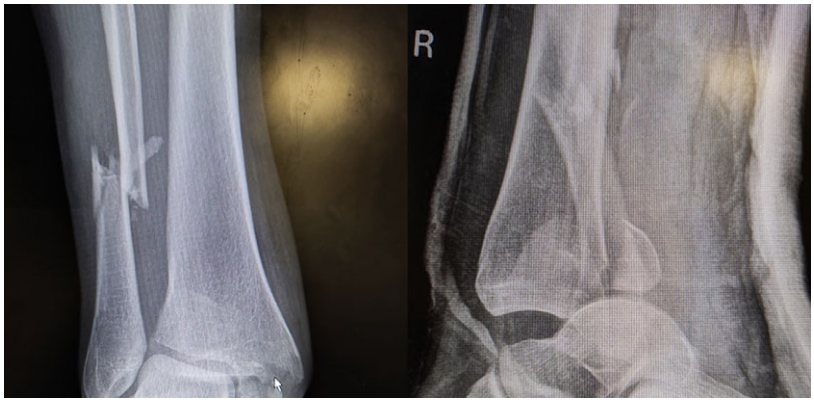


Figure 10.1 Anteroposterior (AP) and lateral radiographs ankle

C. Open reduction and internal fixation of lateral malleolus through a direct lateral approach
D. Open reduction and internal fixation of lateral, medial and posterior malleolus through a posterolateral and direct medial approach
E. Open reduction and internal fixation of lateral, medial and posterior malleolus through a posteromedial and direct lateral approach

12. A 25-year-old male sustained a fracture dislocation of the talus with subtalar and tibiotalar dislocation.
According to Hawkins classification this is?
A. Hawkins I
B. Hawkins II
C. Hawkins III
D. Hawkins IV
E. Hawkins V

13. A 24-year-old female fell 3 steps and sustained an injury to her left foot. At presentation she has a grossly swollen foot with plantar ecchymosis. Initial X-rays in ED do not demonstrate any obvious injury.
What is the next step in managing this patient?
A. Moonboot and review in fracture clinic in 4 weeks
B. Moonboot, advice and discharge to physiotherapy
C. MRI
D. Stress view X-rays
E. Weight-bearing X-rays

Ankle

14. A 25-year-old fit and well woman presents 3 months following inversion injury while walking up a steep hill. She describes instability symptoms.
What is most likely ligament injured?
A. Anterior inferior tibiofibular ligament
B. Anterior talar fibular ligament
C. Calcaneofibular ligament
D. Posterior inferior tibiofibular ligament
E. Posterior talar fibular ligament

15. A 47-year-old male presents to the ED with difficulty walking. He describes an injury while playing tennis 2 months ago with pain and difficulty walking on the right side. On examination he mobilises with a limp, he has a wasted right calf and squeeze calf test elicits minimal ankle plantarflexion.
What would be the most appropriate next step?
A. MRI scan
B. Physiotherapy
C. Plain radiographs
D. Referral to foot and ankle surgeon for surgical repair
E. Ultrasound scan

16. A 34-year-old male presents to the clinic with a chronic (3 months) history of an Achilles tendon rupture. Ultrasound scan has confirmed an 8cm gap between the edges. He is keen to resume sporting activities.
The most appropriate management would be?
A. Direct surgical repair
B. Functional orthotic treatment
C. Reconstruction with ipsilateral flexor hallucis longus
D. Reconstruction with ipsilateral hamstring autograft
E. Reconstruction with V to Y advancement

17. A 68-year-old male presents to clinic complaining of severe left ankle pain. It is limiting his ability to walk more than 200 yards. He is a retired policeman who enjoys gardening and walks. He suffers from mild asthma, hypertension and hypercholesterolaemia. Radiographs are shown in Figure 10.2.
What is the most appropriate treatment?
A. Analgesia and physiotherapy
B. Ankle arthrodesis
C. Ankle arthroscopy
D. Fixed bearing total ankle arthroplasty
E. Mobile bearing total ankle arthroplasty

18. A 22-year-old man sustained an inversion injury to his right ankle in dorsiflexion with axial loading while playing football. He complains of ankle pain and swelling but is able to weight bear. X-rays show no obvious fracture.
The most likely pathology would be?
A. Osteochondral lesion of the lateral distal tibia
B. Osteochondral lesion of the lateral talus
C. Osteochondral lesion of the medial distal tibia
D. Osteochondral lesion of the medial talus
E. Osteochondral lesion of the posterior talus

Figure 10.2
Anteroposterior (AP) radiograph ankle

19. **During the anterior approach to the ankle**
    A. Careful dissection must be taken to avoid damage of the deep peroneal nerve at the distal end of the incision
    B. Careful dissection must be taken to avoid damage of the superficial peroneal nerve at the distal end of the incision
    C. Deep dissection is between tibialis anterior and FHL to avoid damage to the neurovascular bundle
    D. Deep dissection is taken through the sheath of FHL to avoid damage to the neurovascular bundle
    E. The incision is made lateral to EDL tendon

Hindfoot and Forefoot

20. A 45-year-old female presents with pain on both feet when walking, left worse than right. She states she has to change shoes regularly as she wears off the lateral side of the shoe. Her mother had similar problems.
    What would be the most appropriate clinical test to be performed in clinic to aid management?
    A. Anterior drawer test
    B. Coleman block test
    C. Nerve conductive studies
    D. Silfverskiöld test
    E. Single heel raise

21. A 45-year-old female presents for the first time to an elective foot and ankle clinic complaining of pain over the medial aspect of the right foot. On clinical examination she has a valgus deformity of the hindfoot, medial longitudinal arch collapse and abduction of the midfoot.
    According to Johnson and Strom classification this patient is?
    A. Stage I
    B. Stage IIA
    C. Stage IIB
    D. Stage IVA
    E. Stage IVB

22. A 67-year-old female presents to your clinic. You observe she is wearing insoles (Figure 10.3).

Figure 10.3
Insoles

    What is the most likely diagnosis?
    A. Flexible cavovarus foot
    B. Hallux rigidus
    C. Hallux valgus
    D. Plantar fasciitis
    E. Stage 1 posterior tibial tendon insufficiency

23. **From the options listed below please choose the one that best describes a claw toe.**
    A. Lesser toe deformity characterised by MTP flexion with PIP hyperextension and DIP flexion

B. Lesser toe deformity characterised by PIP flexion, DIP flexion and MTP flexion
C. Lesser toe deformity characterised by hyperflexion of the DIP joint with a normal MTPJ and PIP
D. Lesser toe deformity characterised by MTP hyperextension with PIP and DIP flexion
E. Lesser toe deformity characterised by PIP flexion, DIP extension and MTP slight extension

24. A 32-year-old female presents complaining of pain and burning sensation over the third and fourth toes.

What is the most appropriate management?

A. Corticosteroid injection in clinic
B. Metatarsal bar
C. Physiotherapy
D. Surgical excision
E. Ultrasound guided injection

25. What is the optimal position for first MTPJ arthrodesis?

A. 0° of valgus and 15° of dorsiflexion with neutral rotation
B. 0° of valgus and dorsiflexion
C. 10–15° of valgus and neutral dorsiflexion and rotation
D. 10–15° of valgus, 15° of dorsiflexion and neutral rotation
E. 10–15° of varus and 15° of dorsiflexion and neutral rotation

26. A 46-year-old female presents with pain at the first MTPJ. She has difficulty finding appropriate shoe wear and the pain is affecting her mobility. Weight bearing X-rays reveal a distal articular metatarsal angle of 8°, an intermetatarsal angle of 14° and a hallux valgus angle of 36°.

What is the most appropriate management?

A. Chevron osteotomy +/− Akin osteotomy
B. Lapidus procedure
C. Modified McBride and medial eminence resection
D. Scarf osteotomy +/− Akin osteotomy
E. Shoe modification and orthoses

27. The Hallux valgus angle is:

A. The angle created between the lines that longitudinally bisect the proximal phalanx of the first metatarsal and the proximal phalanx of the second metatarsal
B. The angle created between the lines that longitudinally bisect the proximal phalanx and the first metatarsal
C. The angle drawn between the first and second metatarsal shaft on an axial view of the foot
D. The angle drawn between the long axis of the distal phalanx and proximal phalanx
E. The angle drawn between the longitudinal axis and the articular surface of the first metatarsophalangeal joint

Diabetes

28. A 46-year-old male presents to diabetic clinic with a 4-month history of a plantar foot ulcer. He has a good palpable pulse but no sensation to the sole of the foot. He is systemically well, denies fevers. Bloods taken on admission showed a CRP of 4 and WCC of 11.

What is the most appropriate management?

A. Charcot restrain orthotic walker
B. Close contact cast
C. Six weeks of broad-spectrum antibiotics and close contact cast
D. Surgical debridement, regular dressings and prolonged course of antibiotics
E. Surgical debridement, tissue samples and targeted antibiotics

29. A 56-year-old diabetic male presents to clinic with a warm, swollen and erythematous left foot.

X-rays demonstrated multiple joint dislocations on the midfoot.

A. Stage 1 Fragmentation
B. Stage 2 Coalescence
C. Stage 2 Fragmentation
D. Stage 3 Coalescence
E. Stage 3 Reconstruction

30. A 62-year-old male has been referred for vascular assessment.

Regarding the ankle brachial index:

A. It consists of the ratio between the diastolic blood pressure of the lower extremity, specifically the ankle, and the upper extremity. Normal value is between 0.9–1.4

B. It consists of the ratio between the diastolic blood pressure of the lower extremity, specifically the ankle, and the upper extremity. Normal value is <0.9
C. It consists of the ratio between the systolic blood pressure of the lower extremity, specifically the ankle, and the upper extremity. Normal value is <0.9
D. It consists of the ratio between the systolic blood pressure of the lower extremity, specifically the ankle, and the upper extremity. Normal value is >1.4
E. It consists of the ratio between the systolic blood pressure of the lower extremity, specifically the ankle, and the upper extremity. Normal value is between 0.9–1.4

31. A 29-year-old female presents to ED with a painful swollen right foot. She is a type 1 diabetic. Bloods reveal a CRP 211, WCC 16. She has a large ulcer on the dorsum of her foot with significant cellulitis up to the mid calf. She is very tender. Radiographs confirmed osteomyelitis on the cuboid and 5th metatarsal. She has a temperature of 38.7°.

What is the most appropriate next step?

A. Below knee amputation
B. IV antibiotics
C. Oral antibiotics and urgent referral to the diabetic foot clinic
D. Radical debridement
E. Urgent podiatry review

32. A 48-year-old female presents to an elective foot and ankle clinic complaining of pain over the medial aspect of the right foot. On clinical examination she has a valgus deformity of the hindfoot, medial longitudinal arch collapse and abduction of the midfoot.

What would be the most appropriate management for the patient?

A. Conservative management with orthoses
B. Medial calcaneal osteotomy, FDL tendon transfer and spring ligament reconstruction
C. Medial calcaneal osteotomy, gastrocnemius recession, FDL tendon transfer, spring ligament reconstruction and opening wedge medial cuneiform osteotomy (Cotton osteotomy)
D. Medial calcaneal osteotomy, tibialis posterior tendon transfer and spring ligament reconstruction
E. Triple arthrodesis

FOOT AND ANKLE II STRUCTURED SBA ANSWERS

Anatomy and Biomechanics

1. Answer E. **Tibialis anterior eccentrically contracts after heel strike**
   In midstance the amount of forward movement is restrained by eccentric contraction of the gastrocnemius soleus complex

   During heel strike iliopsoas is inactive, hamstrings are inactive during pre-swing phase. Immediately after heel-strike, the dorsiflexors 'pay out' eccentrically to lower the rest of the foot to the ground.

   At toe-off, the gastrocnemius and soleus complex is concentrically contracting.

   With the third rocker the heel begins to lift under the powerful concentric contraction of the gastrocnemius soleus complex.

   When a muscle contracts concentrically, the muscle–tendon unit shortens and kinetic energy is released. When contracting eccentrically the overall unit lengthens and energy is stored.

2. Answer B. **The deltoid and spring ligaments are the primary restraints against pronation and valgus deformity of the foot and preserve the medial arch**
   The medial longitudinal arch is formed by two pillars (anterior and posterior pillars). The anterior pillar is formed by the medial three metatarsal heads, and the posterior pillar comprises the calcaneal tuberosity. The deltoid and spring ligaments are the primary restraints against pronation and valgus deformity of the foot and preserve the medial arch. The posterior tibial tendon has a secondary role.

   Babu D, Bordoni B. *Anatomy, Bony Pelvis and Lower Limb, Medial Longitudinal Arch of the Foot.* Treasure Island (FL): StatPearls Publishing; 2022.

3. Answer D. **The tibial nerve divides into the two calcaneal branches and medial and lateral plantar nerve at the level of the tarsal tunnel**
   The tibial nerve is one of the two main terminal branches of the sciatic nerve. It originates from the lumbo-sacral plexus. It travels in the posterior compartment of the leg and innervates gastrocnemius plantaris, soleus, popliteus, posterior tibialis, flexor digitorum longus, and flexor hallucis longus muscles. It travels along the medial aspect of the Achilles tendon and passes under the flexor retinaculum into the tarsal tunnel, where it divides into its terminal branches: the calcaneal nerve branches that provide sensory innervation to the heel, and the medial and lateral plantar nerves. The medial plantar nerve innervates the abductor hallucis, flexor digitorum brevis, and flexor hallucis brevis muscles. The lateral plantar nerve innervates the abductor and flexor digiti minimi, the adductor hallucis, and the interossei muscles. Both branches also provide sensory innervation to the sole of the foot. The sural nerve is formed from branches of both the tibial and common peroneal nerves, and supplies sensation to the lateral foot.

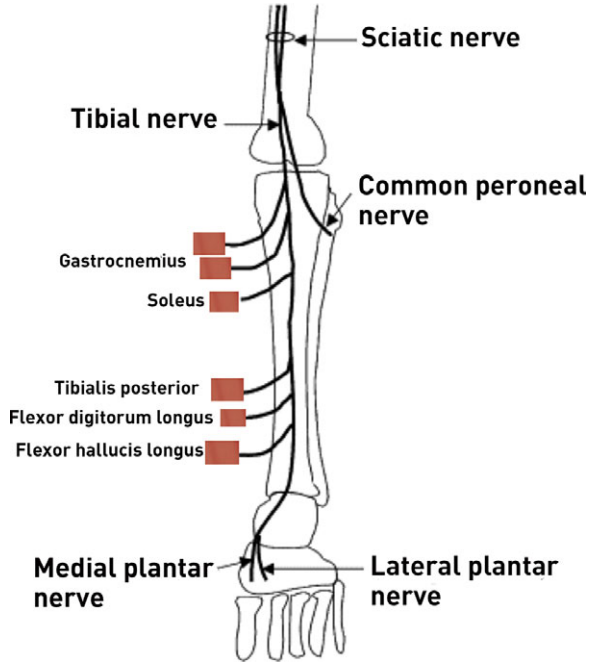


Figure 10.4 Anatomy of the tibial nerve

4. Answer D. **Tibialis anterior**
   The tibialis anterior attaches to the medial cuneiform. Tibialis anterior muscle is the primary ankle dorsiflexor. It originates on the proximal two-thirds of the lateral surface of the tibia and attaches to the medial cuneiform and base of the first metatarsal. It is the most medial tendon of the foot and ankle. It plays a critical role during the

swing phase on the gate cycle, as dorsiflexion is essential to safely clear the foot during this phase.

Olewnik Ł, Podgórski M, Polguj M, Topol M. A cadaveric and sonographic study of the morphology of the tibialis anterior tendon – a proposal for a new classification. *J Foot Ankle Res.* 2019;**12**. doi: 10.1186/s13047-019-0319-0.

Thielen M, Waible D, Krautwurst BK, Wolf SI, Dreher T. Effects of artificially induced bilateral internal rotation gait on gait kinematics and kinetics. *Gait Posture* 2022;**95**:204–209.

5. Answer C. **Peroneus brevis**
The tibialis posterior muscle, originates from the posterior aspect of the proximal tibia and fibula and the interosseous membrane. It is the deepest muscle of the deep posterior compartment of the lower leg. It inserts on the navicular tuberosity, cuneiforms, cuboid, 2–4 metatarsals, and sustentaculum tali of calcaneus. Its main function is inversion of the foot and adduction of the forefoot. Its principal antagonist is the peroneus brevis, which normally everts the subtalar joint and abducts the forefoot.

6. Answer D. **The posterior tibial tendon, the flexor digitorum longus tendon, the posterior tibial artery and veins, the posterior tibial nerve and the flexor hallucis tendon**
The boundaries of the tarsal tunnel: the superior border is formed by the medial malleolus, the anterior border is the tibia, the posterior process of the talus forms the posterior border, the calcaneus forms the lateral border, the inferior border is formed by the abductor hallucis and the flexor retinaculum which extends from the medial malleolus to the medial calcaneus and prevents medial displacement of its contents.

Yang Y et al. Fine dissection of the tarsal tunnel in 60 cases. *Sci Rep.* 2017;7:46351. doi:10.1038/srep46351. Erratum in: *Sci Rep.* 2021;**11**.

Porter DA, Schon LC. Functional nerve disorders and plantar heel pain. In *Baxter's The Foot and Ankle in Sport*, 3rd Ed., 224–229. Elsevier; 2020.

7. Answer D. **Medial plantar nerve**
The medial plantar nerve innervates the flexor hallucis brevis, the flexor digitorum brevis, the abductor hallucis and the second and third lumbrical. It also supplies the sensation of the three and a half digits of the sole of the foot and the medial part of the sole, excluding the heel pad (innervated by medial calcaneal nerve, a branch of the tibial nerve).

8. Answer C. **The dorsal tarsometatarsal ligaments are weaker and therefore bony displacement with injury is often dorsal**
The statement 'the intermetatarsal ligaments are located between first and fifth metatarsal bases' is not true. The intermetatarsal ligaments run between the first and fifth metatarsal base. There is no intermetatarsal ligamentous attachment between the first and second metatarsal. The dorsal ligament is the smallest with the plantar ligament being twice as large. Being the smallest, it is also the most common ligament damaged during injury with subsequent dorsal bony displacement. The intermetatarsal ligament is the largest, with the greatest height, width and cross-sectional area.

Johnson A, Hill K, Ward J, Ficke J. Anatomy of the lisfranc ligament. *Foot Ankle Spec.* 2008;**1**:19–23.

Mason L et al. Anatomy of the lateral plantar ligaments of the transverse metatarsal arch. *Foot Ankle Int.* 2020;**41**:109–114. doi:10.1177/1071100719873971.

Moracia-Ochagavía I, Rodríguez-Merchán EC. Lisfranc fracture-dislocations: current management. *EFORT Open Rev.* 2019;**4**:430–444.

de Palma L, Santucci A, Sabetta SP, Rapali S. Anatomy of the Lisfranc joint complex. *Foot Ankle Int.* 1997;**18**:356–364.

Trauma

9. Answer E. **To commence mobilisation in a moonboot**
This SBA deals with Hawkins sign and AVN. When the Hawkins sign (subchondral radiolucent band in the talar dome) is present on AP radiographs at 6–8 weeks, this suggests that the blood supply to the talus had been preserved and avascular necrosis is unlikely to develop (Donelly 1999). The radiolucent band resulted from increased bone resorption relative to bone formation and it manifests with active hyperaemia of the bone.

Tezval et al. (2007) reported that the Hawkins sign was a good indicator of talus vascularity following fracture. If a full or partial positive Hawkins sign was detected, it was unlikely that AVN would develop at a later stage after injury.

Chen et al. (2014) found the Hawkins sign to be a reliable predictor of AVN development and suggested that MRI at 12 weeks might be valuable to identify early AVN in patients who have a negative Hawkins sign.

The Hawkins classification of talar neck fractures is based on the amount of displacement and the associated dislocations or subluxations.

- Type 1: Undisplaced fracture with no associated joint dislocation is associated with less than 15% risk of AVN.
- Type 2: Talar neck fracture with associated dislocation or subluxation of the subtalar joint. Risk of AVN is 42%.
- Type 3: Talar neck fracture with dislocation of the talar body from both the ankle and subtalar joints. Risk of AVN is 91%.
- Type 4: The classification was later modified by Canale and Kelly (1978) (not included in Hawkin's original paper). Type 4 implies associated dislocation not only of the tibiotalar and subtalar joints but also dislocation of the talar head from the talonavicular joint. The rate of AVN is quoted at 100%.

Lack of Hawkins sign with sclerosis is indicative of AVN. In clinical practice, the Hawkins sign is strongly predictive of the absence of AVN. However, the sign has high sensitivity and low specificity, so that its absence does not universally predict AVN.

Five major vessel sources enter the talus in the area of the talar neck. The extraosseous blood supply comes from three arteries: the posterior tibial artery, the anterior tibial artery and the perforating peroneal artery. The main artery supplying blood to the body of the talus is the artery of the tarsal canal. An anastomotic ring around the inferior neck of the talus is formed by the artery of the tarsal canal and the artery of the tarsal sinus, but the body of the talus tends to have limited intraosseous anastomosis so that interruption of any vessel may lead to areas of bone necrosis in the distribution of that vessel.

Canale ST, Kelly FB Jr. Fractures of the neck of the talus: long-term evaluation of seventy-one cases. *J Bone Joint Surg Am.* 1978;**60**:143–156.

Chen H, Liu W, Deng L, Song W. The prognostic value of the Hawkins sign and diagnostic value of MRI after talar neck fractures. *Foot Ankle Int.* 2014;**35**:1255–1261.

Donnelly EF. The Hawkins sign. *Radiology* 1999;**210**:195–196.

Tezval M, Dumont C, Stürmer KM. Prognostic reliability of the Hawkins sign in fractures of the talus. *J Orthop Trauma.* 2007;**21**:538–543.

10. Answer B. **Conservative management in a below knee cast**

A multicentre randomised controlled trial of 151 patients comparing surgical and non-surgical management of displaced, closed intraarticular fractures of calcaneus demonstrated a similar functional and symptomatic outcome between both groups but a higher risk of complication following operative fixation. Therefore, surgical fixation it is not recommended for such fractures.

Griffin D et al.; UK Heel Fracture Trial Investigators. Operative versus non-operative treatment for closed, displaced, intra-articular fractures of the calcaneus: randomised controlled trial. *Br Med J* 2014;**349**:g4483.

11. Answer B. **Close contact cast**

The AIM trial, a multicentre randomised controlled trial comparing close contact cast vs open reduction and internal fixation in the management of unstable ankle fracture in adults over 60 years of age, demonstrated clinical equivalent outcomes of close contact cast and ORIF but at a reduction in cost. The ORIF group had a higher incidence of infection and return to theatre while the CCC group had a higher incidence of malunion and non-union of the medial malleolus.

12. Answer C. **Hawkins III**

The Hawkins classification is still one of the most widely used and accepted classifications for talar neck fractures (Hawkins 1970). It is based on displacement and dislocation, and therefore, presumed damage to the blood supply of the talus.

Table 10.1 Hawkins Classification

Type	Description
Hawkins I	Undisplaced
Hawkins II	Subtalar dislocation
Hawkins III	Subtalar and tibiotalar dislocation
Hawkins IV	Subtalar, tibiotalar and talonavicular dislocation

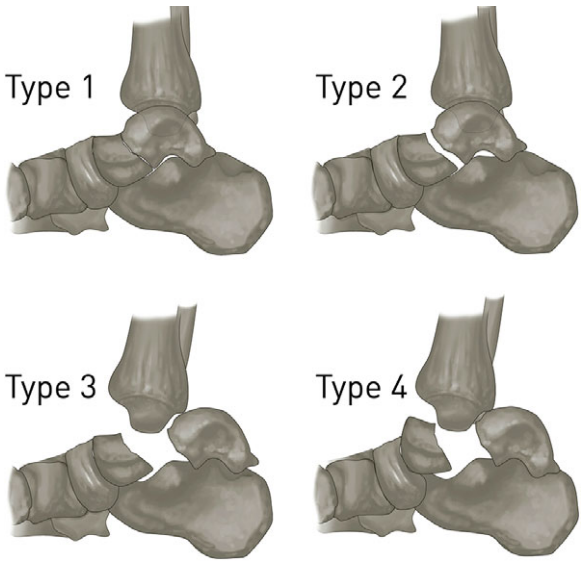


Figure 10.5 Hawkins classification of talar neck fractures

This classification was further expanded 8 years later by Canale and Kelly (1978) who added the type IV category).

The rate of AVN of the talus as reported in subsequent studies has been 0–24% after Hawkins Type I, 0–50% after Hawkins Type II and 33–100% after Hawkins Type III and IV fractures (Metzger et al. 1999).

Patients with talus fractures of Hawkins Type I and II had considerably better outcomes (with 95% being excellent or good) compared with individuals suffering dislocated fractures with involvement of the articulating surface which had 70% good results in Hawkins Type III and 10% good results in Hawkins Type IV fractures (Alton et al. 2015).

Alton T, Patton DJ, Gee AO. Classifications in brief: the Hawkins classification for talus fractures. *Clin Orthop Relat Res.* 2015;**473**:3046–3049.

Canale ST, Kelly FB Jr. Fractures of the neck of the talus: long-term evaluation of seventy-one cases. *J Bone Joint Surg Am.* 1978;**60**:143–156.

Hawkins LG. Fractures of the neck of the talus. *J Bone Joint Surg Am.* 1970;**52**:991–1002.

Metzger MJ, Levin JS, Clancy JT. Talar neck fractures and rates of avascular necrosis. *J Foot Ankle Surg.* 1999;**38**:154–162.

13. Answer E. **Weight bearing X-rays**

Low energy Lisfranc injuries are challenging to diagnose. Most units will do non-weight bearing radiographs and subtle Lisfranc injuries can be missed. Patients may present with pain and swelling without any obvious deformity and in some cases are able to weight bear. Clinicians should have a high index of suspicion if patients present with plantar equimosis, altered sensation in the first web space secondary to post-traumatic neuropathy of the medial terminal branch of the deep peroneal nerve and hypermobility of a metatarsal head ('piano key sign'). In those cases, further investigation with weight bearing radiographs is needed.

Weight bearing radiographs are superior to the radiographs performed under stress manoeuvres, in which the applied force is limited compared with that of the entire weight of the body.

A computed tomography (CT) scan allows a more accurate assessment of the Lisfranc joint. It allows the diagnosis of more subtle fractures and subluxations that are not observed in simple radiographs. The CT scan is generally used for surgical planning.

Magnetic resonance imaging (MRI) is very useful for detecting soft-tissue injuries and ligamentous injuries. It presents a sensitivity and predictive value of up to 94% in determining instability of the Lisfranc joint and can therefore be useful for the diagnosis of the subtle Lisfranc injury.

A CT or more preferably an MRI scan would be indicated if weight bearing radiographs are negative but there is still a high index of suspicion for a Lisfranc injury.

Moracia-Ochagavía I, Rodríguez-Merchán EC. Lisfranc fracture-dislocations: current management. *EFORT Open Rev.* 2019;**4**:430–444.

Ankle

14. **Answer C. Calcaneofibular ligament**
The lateral ligamentous complex is formed by the anterior talar fibular ligament (ATFL), the calcaneofibular ligament (CFL) and the posterior talar fibular ligament. Damage to the lateral ligamentous complex often occurs because of ankle inversion injuries. The ATFL is the most common injured structure of the complex followed by a combined injury to ATFL and CFL. The ATFL is more vulnerable when the ankle is in a plantarflexed position and undergoes supination and adduction forces. It originates at the anterior aspect of the lateral malleolus and inserts on the anterolateral aspect of the talus, therefore with the ankle in plantar flexion it is vertically orientated and becomes taut. The CFL originates from the anterior-inferior aspect of the lateral malleolus inferior to the origin of the ATFL. It runs postero-inferiorly and inserts on the lateral calcaneus. Isolated injuries to the CFL are rare but can occur with inversion injuries with the ankle in dorsiflexion where the CFL is taut and the ATFL is lax.

The load to failure of the CFL is approximately 2–3.5 times greater than the load to failure of the ATFL. The CFL is the primary constraint to talar inversion when the ankle is dorsiflexed, and in plantarflexion, it resists inversion in conjunction with the ATFL.

Hur ES, Bohl DD, Lee S. Lateral ligament instability: review of pathology and diagnosis. *Curr Rev Musculoskelet Med.* 2020;**13**:494–500.

15. Answer D. **Referral to foot and ankle surgeon for surgical repair**
This patient has a chronic Achilles tendon rupture. The diagnosis of chronic Achilles tendon ruptures can be challenging. There may not be a palpable gap due to fibrous tissue and the Simmonds (squeeze calf) test may be inconclusive. Active plantar flexion of the foot can be preserved because of the action of tibialis posterior, the toe flexor and the peroneal tendons. MRI or USS can aid with the diagnosis but clinical examination remains the gold standard.

Maffulli N, Via AG, Oliva F. Chronic Achilles tendon rupture. *Open Orthop J.* 2017;**11**:660–669.

16. Answer D. **Reconstruction with ipsilateral hamstring autograft**
There are multiple surgical options for the management of chronic Achilles tendon rupture. For those patients with a gap <2cm, primary repair can be attempted. With gaps of 2–5cm V-Y advancement is recommended. For gaps of >5cm tendon transfer with FHL or peroneus previs with or without V-Y advancement is recommended. For larger gaps >6cm despite maximal plantarflexion of ankle, ipsilateral hamstring tendon graft is indicated.

Arshad Z, Lau EJS, Leow SH, Bhatia M. Management of chronic Achilles ruptures: a scoping review. *Int Orthop.* 2021;**45**:2543–2559.

Maffulli N, Via AG, Oliva F. Chronic Achilles tendon rupture. *Open Orthop J.* 2017;**11**:660–669.

17. Answer D. **Fixed bearing total ankle arthroplasty**
The anteroposterior (AP) radiograph demonstrates end stage OA of the ankle. A recent randomised controlled trial published in 2022 of 281 patients demonstrated that both total ankle arthroplasty (TAR) and ankle fusion (AF) have similar post-operative scores and complication rates. TAR had higher nerve damage and healing complications, while AF patients had higher thromboembolic events and a non-union rate of 7%.

TAR surgeons in the UK involved in the trail used both a 2-component, fixed-bearing and a 3-component, mobile-bearing implant.

When a fixed bearing TAR was looked at separately, this showed a significant improvement in clinical scores and quality of life over AF.

A post hoc analysis suggested superiority of fixed-bearing total ankle arthroplasty over ankle arthrodesis.

The SBA is assuming that the patient is suitable for either TAR or ankle fusion considering patient characteristics such as deformity, sources of pain, adjacent joints, stability, bone quality, soft tissue envelope and neurovascular status.

Goldberg AJ et al. Total ankle replacement versus arthrodesis for end-stage ankle osteoarthritis: a randomized controlled trial. *Ann Intern Med.* 2022;**175**:1648–1657.

18. Answer B. **Osteochondral lesion of the lateral talus**
Osteochondral lesions of the talus are common injuries that affect a wide variety of active

patients. Many of these lesions are associated with ankle sprains and fractures.

Most patients are 20– 40 years old, with men being more commonly affected than women (1.6:1). Typically, patients will present with non-specific ankle pain that may or may not correspond to the location of the lesion. Additionally, they will often complain of swelling and occasional joint instability.

Most osteochondral lesions occur in the centromedial and centrolateral area of the talus. In a large study of 500 patients, it was identified that 98% of the lateral lesions were associated with injuries (most commonly ankle sprains). The mechanism of injury of lateral osteochondral lesions is a shearing force on the talar dome when the ankle is in a dorsiflexed and inverted position. On the other hand, the medial lesions are associated with an axial load while the ankle is forced into a plantarflexed and inverted position.

Elias I et al. Osteochondral lesions of the talus: change in MRI findings over time in talar lesions without operative intervention and implications for staging systems. *Foot Ankle Int.* 2006;**27**:157–166.

Looze CA et al. Evaluation and management of osteochondral lesions of the talus. *Cartilage* 2017;**8**:19–30.

19. Answer B. **Careful dissection must be taken to avoid damage of the superficial peroneal nerve at the distal end of the incision**
During the anterior approach to the ankle, a longitudinal incision is made immediately lateral to the anterior tibial tendon extending distally to the level of the talonavicular joint. Special care is taken at the distal end of the incision to avoid damage to the superficial peroneal nerve. Deep dissection can be taken either through the tibialis anterior sheath or through the extensor hallucis longus but one must be aware that the neurovascular bundle lies just behind the EHL tendon at the level of the ankle joint.

Dekker RG 2nd, Kadakia AR. Anterior approach for ankle arthrodesis. *JBJS Essent Surg Tech.* 2017;**7**:e10.

Hindfoot and Forefoot

20. Answer B. **Coleman block test**
The patient suffers from Charcot-Marie-Tooth disease and cavovarus foot. Patients with CMT disease develop hindfoot varus, pes cavus, clawing of the toes and hands and plantarflexion of the first ray. Asymmetrical cavovarus deformities are more typical of spinal dysraphism.

Although nerve conductive studies are necessary for the diagnosis of CMT this cannot be performed in clinic.

Silfverskiöld test will give an indication of a tight gastrocnemius and although this is often present in cavovarus disease it is not specific for this pathology. It is important to assess for Achilles shortening when planning any hindfoot deformity correction as Achilles tendon lengthening may be required.

Coleman block test evaluates the flexibility of the hindfoot (flexible or fixed) and pronation. The test is based on premise that the first metatarsal is plantarflexed. The test is performed by placing the patient's weight bearing foot on a block, with the heel and lateral border of foot on the block and the first metatarsal off the block. It eliminates contribution of the plantarflexed first ray and forefoot pronation to the hindfoot deformity.

Single heel raise is performed to assess tibialis posterior power.

Anterior drawer test is performed to test ankle stability and the anterior tibio-fibular ligament.

Coleman SS, Chesnut WJ. A simple test for hindfoot flexibility in the cavovarus foot. *Clin Orthop Relat Res.* 1977;**123**:60–62.

Kovaleski JE, Norrell PM, Heitman RJ, Hollis JM, Pearsall AW. Knee and ankle position, anterior drawer laxity, and stiffness of the ankle complex. *J Athl Train.* 2008;**43**:242–248.

21. Answer C. **Stage IIB**
The original classification described by Johnson and Strom in 1989 describes three stages of tibialis posterior tendon dysfunction (Johnson & Strom 1989). In 1997, this was revised by Myerson to include a fourth stage.
- Stage I – Tenosynovitis of tibialis posterior tendon without arch collapse.
- Stage II is subdivided.
    - Stage IIa – Arch collapse with valgus hindfoot deformity but normal midfoot alignment.

Table 10.2 Staging of the adult acquired flatfoot deformity as proposed by Johnson and Strom, later modified by Myerson

	Stage I	Stage II	Stage III	Stage IV
Posterior tibial tendon	Tenosynovitis, degeneration or both	Elongation and degeneration	Elongation and degeneration	Elongation and degeneration
Deformity	Absent	Flexible, reducible pes planovalgus deformity with hindfoot held in equines	Fixed, irreducible pes planovalgus deformity	Fixed, irreducible pes planovalgus deformity
Pain	Medial	Medial, lateral or both	Medial, lateral or both	Medial, lateral or both
Single limb heel rise	Mild weakness, hindfoot inverts normally	Marked weakness, no or weak inversion of hindfoot	Unable to perform test, no inversion of hindfoot	Unable to perform test, no inversion of hindfoot
Too many toes sign	Negative	Positive	Positive	Positive
Valgus deformity and ankle arthritis	No	No	No	Yes

  - Stage IIb – Arch collapse with valgus hindfoot deformity and midfoot abduction.

- Stage III – Fixed valgus deformity and midfoot abduction.
- Stage IV – Fixed valgus deformity and midfoot abduction and associated valgus ankle deformity secondary to deltoid ligament insufficiency.
  - Stage IVA – Flexible ankle valgus deformity.
  - Stage IVB – Fixed ankle valgus deformity.

Abousayed MM, Tartaglione JP, Rosenbaum AJ, Dipreta JA. Classifications in brief: Johnson and Strom classification of adult-acquired flatfoot deformity. *Clin Orthop Relat Res.* 2016;**474**:588–593.

Johnson KA, Strom DE. Tibialis posterior tendon dysfunction. *Clin Orthop Relat Res.* 1989;**239**:196–206.

Myerson MS. Adult acquired flatfoot deformity: treatment of dysfunction of the posterior tibial tendon. *Instr Course Lect.* 1997;**46**:393–405.

22. Answer B. **Hallux rigidus**

Although conservative treatment does not prevent progression of hallux rigidus it has a role in symptom control for patients with early disease. Insoles with a first ray extension (Morton's extension) have been used for the conservative management of hallux rigidus. These are semi-rigid insoles with a first toe extension made of carbon graphite or spring stele. It works by minimising the movement of the metatarsophalangeal joint and therefore reducing pain as well as decreasing the forces across the midfoot and forefoot.

Colò G et al. The efficacy of shoe modifications and foot orthoses in treating patients with hallux rigidus: a comprehensive review of literature. *Acta Biomed.* 2020;**91**(14-S):e2020016.

Sánchez-Gómez R et al. Morton's extension on hallux rigidus pathology. *Prosthesis* 2023;**5**:251–263.

23. Answer D. **Lesser toe deformity characterised by MTP hyperextension with PIP and DIP flexion**

Hammer toe is defined as a primary flexion deformity of the PIPJ, with or without

hyperextension at the MTPJ, but with a neutral or hyperextended DIPJ.

A mallet toe deformity is a DIPJ flexion deformity. This may occur due to direct pressure from a shoe and eventually the FDL tightens resulting in a fixed deformity. This may gradually cause callosities at the tip of the toe and pressure on the nail.

A claw toe initially presents with hyperextension at the MTPJ. When the MTPJ becomes chronically hyperextended, the intrinsics shorten, the flexors are pulled taut and flex the IPJs. Initially this clawing may be flexible and dynamic but gradually as the plantar plate ruptures, the MTPJ subluxes and the deformity becomes rigid. This is commonly seen in neuromuscular disorders.

24. Answer B. **Metatarsal bar**
Morton's neuroma is a thickening of the digital nerve commonly caused by pressure or repetitive trauma. The most commonly affected location is the third intermetatarsal space. Conservative management is the first line of treatment. Wide toe shoes and metatarsal bar. The metatarsal bar is an insole that relieves the pressure of the metatarsal head and therefore relieves pressure on the neuroma, improving symptoms. If simple orthotics fail, the next step will be a corticosteroid injection. Surgical excision (more commonly done through a dorsal approach) can be considered if conservative measures fail.

Table 10.3 Common toe conditions

	MTP	PIP	DIP
Claw toe	Hyperextension	Flexion	Flexion
Hammer toe	Slight extension	Flexion	Extension
Mallet toe	Normal	Normal	Flexion

Bhatia M, Thomson L. Morton's neuroma – current concepts review. *J Clin Orthop Trauma.* 2020;**11**:406–409.

25. Answer D. **10–15° of valgus, 15° of dorsiflexion and neutral rotation**
The first MTP joint is positioned in a way that allows the pulp of the great toe to rest 5–10 mm above the flat surface with weight bearing.

Positioning of the hallux is of paramount importance to obtain proper foot function and optimal shoe fit. Malunion can occur in one or more of the sagittal, frontal and transverse planes.

Sagittal plane malposition, especially excessive dorsiflexion is poorly tolerated by the patient due to increased plantar pressure at the first MTP joint and concomitant abutment of the hallux against the shoe wear, whereas excessive plantarflexion significantly increases pressure on the big toe during heel off. Malrotation may also represent a problem as it causes painful callosities as well as painful nail deformities. Finally, malunion in the transverse plane, namely varus malposition, usually causes painful abutment of the medial aspect of the hallux against the shoe. Excessive valgus alignment of the hallux will result in abutment with the second toe and the potential for the crossover second toe deformity.

Wagner E, Wagner P, Ortiz C. Arthrodesis of the hallux metatarsophalangeal joint. *JBJS Essent Surg Tech.* 2015;**5**:e20.

26. Answer D. **Scarf osteotomy +/− Akin osteotomy**
The intermetatarsal angle (IMA) rather than the hallux valgus angle is the more important angle that determines the type of surgery required (Table 10.4).

Table 10.4 Radiographic angular measurements in hallux valgus

Deformity	Hallux valgus angle (HVA)	Intermetatarsal angle (IMA)	Management
Normal	<15°	<9°	None
Mild	<20°	9–11°	Distal osteotomy +/− soft tissue procedures
Moderate	20–40°	11–16°	Proximal osteotomy +/− soft tissue procedure
Severe	>40°	>16°	Proximal osteotomy or first tarsometatarsal arthrodesis +/− soft tissue procedure

Coughlin MJ, Jones CP. Hallux valgus: demographics, aetiology, and radiographic assessment. *Foot Ankle Int.* 2007;**28**:759–777.

Ray JJ et al. Hallux valgus. *Foot Ankle Orthop.* 2019;**4**:2473011419838500.

27. Answer B. **The angle created between the lines that longitudinally bisect the proximal phalanx and the first metatarsal**

The angle drawn between the first and second metatarsal shaft on an axial view of the foot is the Intermetatarsal Angle (IMA).

The angle drawn between the longitudinal axis and the articular surface of the first metatarsophalangeal joint is Distal Metatarsal Articular Angle (DMAA).

The angle drawn between the long axis of the distal phalanx and proximal phalanx is the Hallux Valgus Interphalangeus Angle (HVIA).

Ray JJ et al. Hallux valgus. *Foot Ankle Orthop.* 2019;**4**:2473011419838500.

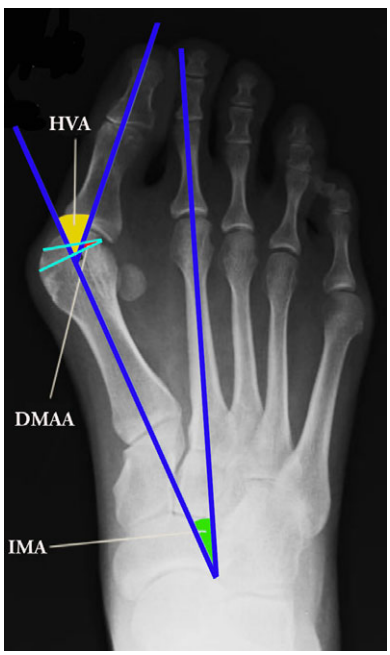


Figure 10.6 Hallux valgus radiology angles

Diabetes

28. **Answer B. Close contact cast**

This patient has a diabetic foot ulcer. His inflammatory markers are normal which suggest it is not actively infected. He has neuropathy, therefore debridement to remove the necrotic tissue and promote granulation can be done in clinic with an aseptic technique by a qualified practitioner (podiatrist or orthopaedic surgeon). Off-loading the ulcers is essential to allow it to heal. Multiple studies have demonstrated that increased plantar pressures significantly contribute to the development of plantar ulcers in diabetic patients. The most effective method for off-loading is total contact cast.

Alexiadou K, Doupis J. Management of diabetic foot ulcers. *Diabetes Ther.* 2012;**3**:4.

Burns J, Begg L. Optimizing the offloading properties of the total contact cast for plantar foot ulceration. *Diabet Med.* 2011;**28**:179–185.

Veves A, Murray HJ, Young MJ, Boulton AJ. The risk of foot ulceration in diabetic patients with high foot pressure: a prospective study. *Diabetologia* 1992;**35**:660–663.

29. Answer A. **Stage 1 Fragmentation**

The patient has a Charcot foot, the clue being that they are diabetic as this is the most common cause of Charcot arthropathy in developed countries. It can be challenging to diagnose, as its earliest manifestations (e.g. swelling, inflammation and warmth) are similar to those seen with deep venous thrombosis, osteomyelitis, cellulitis and rheumatoid arthritis. The Eichenholtz classification is a temporal based system used to assist clinicians in diagnosis, staging and selecting appropriate treatment (Eichenholtz 1966).

Stage 1 presents with radiographic evidence of osteopenia, periarticular debris and fragmentation, and joint subluxation or dislocation. Clinical examination reveals swelling, erythema and/or ligamentous laxity (Rosenbaum & DiPreta 2015).

Stage 2 presents with absorption of periarticular debris, early sclerosis and bony consolidation of some of the larger fragments seen in Stage 1. New bone begins to form in this stage. Clinically there is decreased warmth and swelling of the involved joint are observed.

Stage 3 represents the progression of the joint to a more stable structure. Although deformity still may be evident on radiographs, new bone formation continues and becomes a more prominent feature. Decreased sclerosis, rounding and smoothing of bone fragments, joint space narrowing with arthrosis, and fibrous and/or

Table 10.5 Classification of Charcot's foot

Deformity	Clinical signs	Radiographic signs
Stage 1 Fragmentation	Swelling, erythema, warmth	Osseous fragmentation with joint dislocation
Stage 2 Coalescence	Decreased swelling, erythema, warmth	Coalescence of fragments and absorption of fine bone debris
Stage 3 Reconstruction	Absence of swelling, erythema, warmth, stable joint +/− fixed deformity	Consolidation and remodelling of fracture fragments

osseous ankylosis are seen. On clinical examination, swelling and erythema has dissipated, and the joint will seem stable in the setting of a fixed deformity.

Clinical signs (such as swelling, warmth and erythema) regularly precede the radiographic findings seen with Eichenholtz Stage 1 arthropathy. As such a fourth stage, Charcot foot Stage 0, was added to the conventional Eichenholtz classification (Shibata et al. 1990). The addition of this prodromal stage has important therapeutic implications, because the immobilisation and off-loading of feet with Stage 0 symptoms may prevent progression of skeletal destruction and deformity.

Eichenholtz SN. Charcot Joints. Springfield, IL: Charles C. Thomas; 1966.

Rosenbaum AJ, DiPreta JA. Classifications in brief: Eichenholtz classification of Charcot arthropathy. *Clin Orthop Relat Res.* 2015;**473**:1168–1171.

Shibata T, Tada K, Hashizume C. The results of arthrodesis of the ankle for leprotic neuroarthropathy. *J Bone Joint Surg Am.* 1990;**72**:749–756.

30. Answer E. **It consists of the ratio between the systolic blood pressure of the lower extremity, specifically the ankle, and the upper extremity. Normal value is 0.9–1.4**

The Ankle Brachial Index (ABI) is a non-invasive tool to assess the vascular status of the lower limb. The normal value is 0.9–1.4. A value of less than 0.9 is suggestive of peripheral vascular disease and greater than 1.4 is indicative of vessel stiffening.

Aboyans V et al. *ESC Guidelines on the Diagnosis and Treatment of Peripheral Arterial Diseases, in collaboration with the European Society for Vascular Surgery (ESVS)*; 2017. Document covering atherosclerotic disease of extracranial carotid and vertebral, mesenteric, renal, upper and lower extremity arteries.

McClary KN, Massey P. *Ankle Brachial Index.* Treasure Island (FL): StatPearls Publishing; 2023.

31. **Answer D. Radical debridement**

This patient is presenting with a foot attack, a severe form of diabetic foot infection. Patients require urgent admission, investigations and resuscitation following the local sepsis pathway. Early debridement is essential as this is a life- and limb-threatening condition. Radical debridement should follow the RAG (red-amber-green) model described by Ahluwalia et al. (2019). Tissues should be debrided down to healthy, unaffected tissue (green zone), this is also applicable to bone debridement.

Ahluwalia RS, Reichert ILH. Surgical management of the acute severely infected diabetic foot – the 'infected diabetic foot attack'. An instructional review. *J Clin Orthop Trauma.* 2021;**18**:114–120.

Ahluwalia R et al. Surgical diabetic foot debridement: improving training and practice utilizing the traffic light principle. *Int J Low Extrem Wounds* 2019;**18**:279–286.

32. Answer A. **Conservative management with orthoses**

The management of acquired flat foot deformity is complex. It includes a combination of soft tissue balancing with bony realignment. Conservative management is always the first option regardless of stage.

For stage I, the main line of treatment is conservative management with physiotherapy and orthoses. Physiotherapy is aimed at addressing weakness in specific muscle groups and improving gait kinematics. A UCBL brace is the

orthotic of choice for a flexible flatfoot whilst a rigid (accommodative) bracing is used for more severe deformities in patients unfit for surgery. In those rare cases that surgical management is required this may include tibialis posterior tendon debridement/tendon repair/FDL transfer.

Stage II includes a combination of soft tissue and bony corrections. The choice depends on each individual case but includes medial calcaneal osteotomy, gastrocnemius recession, FDL transfer and spring ligament reconstruction.

Stage III is a fixed deformity therefore arthrodesis of the talonavicular, naviculocuneiform +/− calcaneocuboid is needed.

Stage IV includes deformity at the ankle level; for stage IVA, the deformity is flexible so in addition to the arthrodesis described above, the ankle deformity can be addressed with deltoid ligament reconstruction. For those cases with a fixed ankle deformity (Stage IVB) ankle arthrodesis or ankle replacement is also required.

Ling SK, Lui TH. Posterior tibial tendon dysfunction: an overview. *Open Orthop J.* 2017;**11**:714–723.

Vulcano E, Deland JT, Ellis SJ. Approach and treatment of the adult acquired flatfoot deformity. *Curr Rev Musculoskelet Med.* 2013;**6**:294–303.

Chapter 11

Spine I Structured SBA

Paul Rushton and Niall Eames

SPINE I STRUCTURED SBA QUESTIONS

Basic Science

1. **Regarding normal spinopelvic alignment, which of the following statements is correct?**
   - A. A change in pelvic incidence (PI) associated with degenerative changes underlies sagittal balance problems in adults
   - B. A vertical plumb line from the centre of the C7 vertebral body should pass just anterior to the sacral end plate
   - C. Mathematically: Sacral slope (SS) = Pelvic incidence (PI)+ Pelvic tilt (PT)
   - D. Patients' lumbosacral lordosis is proportional to their pelvic incidence (PI)
   - E. Sagittal balance problems in adults are usually associated with an increased lumbar lordosis, which can necessitate surgery

2. An implant company is encouraging a surgeon to change to a new type of rod for their scoliosis corrections. They propose changing from the 5.5mm diameter titanium alloy (Ti) rods the surgeon currently uses to their new 5.5mm diameter cobalt-chrome (CoCr) rods.
   Which of the following is true?
   - A. Bending rigidity is inversely proportional to second moment area (SMA) of the rod
   - B. Changing from the Ti to the CoCr rod as suggested will roughly double the bending rigidity
   - C. Changing to a 6mm diameter Ti rod would have a greater increase in bending rigidity than changing to the new 5.5mm diameter
   - D. CoCr rod would be more at risk of fractures due to the surface damage intraoperatively following rod contouring
   - E. Young's modulus describes the plastic portion of the material's deformation on a stress–strain graph

3. A surgeon is undertaking a scoliosis correction with an all pedicle screw construct. They are keen to increase the strength of the bone–screw interface.
   The surgeon is best to use a pedicle screw with which of the following?
   - A. Cannulation
   - B. Larger core diameter
   - C. Larger pitch
   - D. Larger thread diameter
   - E. Larger thread depth

4. **In the normal intervertebral disc, the tissue derived from the primitive notochord is made of which collagen type predominantly?**
   - A. I
   - B. II
   - C. V
   - D. IX
   - E. X

5. As part of a lumbar central decompression you are removing compressive soft tissue material from the interlaminar region.
   This tissue is made predominantly of which of the following?
   - A. Elastin
   - B. Proteoglycans
   - C. Sharpey's fibres
   - D. Type I collagen
   - E. Type II collagen

Paediatric Spine

Questions 6–7 Stem:
You see a 12-month-old boy presenting with a scoliosis. He is otherwise well. He has only just started to walk. On examination he has a subtle thoracic scoliosis and grossly normal neurological examination. A plain radiograph demonstrates a single thoracic fully segmented hemivertebra.

6. **What is the most relevant next step in his management?**
   A. CT scan with 3D reformats
   B. Referral to orthotics for brace fitting
   C. Renal ultrasound
   D. Review by neurodevelopmental paediatrician
   E. Whole spine MRI scan

7. **The anticipated progression of his deformity would likely be greater if it was which of the following?**
   A. Incarcerated hemivertebra
   B. Block vertebra
   C. Single semi-segmented hemivertebra
   D. Single unsegmented hemivertebra
   E. Unilateral bar

8. A 9-month-old boy has been referred to you by a paediatrician he saw about his plagiocephaly as the physician noted a scoliosis. He is otherwise well with normal milestones and no apparent pain. Neurological examination is unremarkable. A radiograph demonstrates normal segmentation and a left thoracic scoliosis with Cobb angle of 15°. The rib head is in phase 1 and rib vertebral angle difference (RVAD) 16°.
   The most appropriate management at this stage would be which of the following?
   A. Cast treatment
   B. Insertion of growing rod construct
   C. Instrumented correction and fusion
   D. MRI of whole spine
   E. Observation

9. You assess an 11-year-old boy referred from a dermatologist with a rapidly progressive scoliosis. A whole spine radiograph is shown in Figure 11.1.
   The underlying diagnosis related to a mutation in which gene?
   A. *COL1*
   B. *COL2*
   C. Dystrophin
   D. *FBN1*
   E. *NF1*

10. You are seeing an otherwise well, pre-menarchal 12-year-old girl referred in with a thoracic scoliosis. Examination is unremarkable aside from the left thoracic scoliosis with a small rib hump. She has a normal neurological examination. Whole spine X-rays confirm the scoliosis with apex at T8 with Cobb angle of 20° and normal segmentation.
    The most appropriate next step in management is which of the following?
    A. Application of CTLSO brace
    B. Application of TLSO brace
    C. MRI scan of whole spine
    D. Observation with repeat X-ray in 3–6 months
    E. Posterior instrumented correction and fusion

Figure 11.1 PA whole spine standing radiograph

Questions 11–13 Stem:

You are seeing a 16-year-old female with a scoliosis first diagnosed 4 years previously. She is otherwise well and is now 2 years post-menarchal. Examination demonstrates a thoracic scoliosis, right-sided rib hump on Adam's forward bending and the right shoulder slightly higher than the left. A whole spine MRI scan is normal, aside

from the scoliosis. At presentation, radiographs showed a right thoracic curve measuring 25°. A PA standing whole spine radiograph taken today (Figure 11.2).

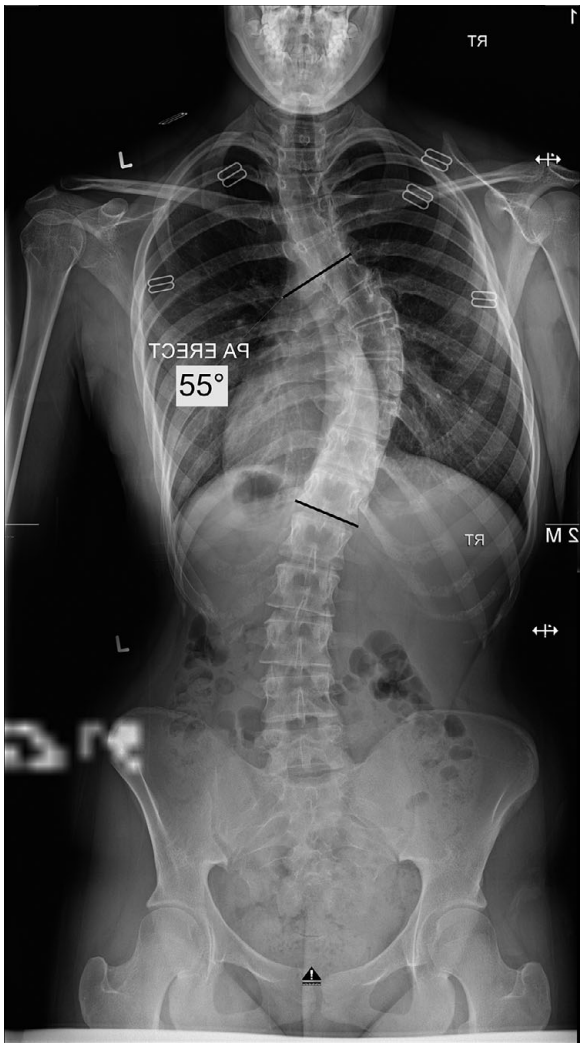


Figure 11.2 PA standing whole spine radiograph

11. **What is likely to happen regarding her potential curve progression?**
    A. Curve resolution may occur if the rib vertebral angle difference (RVAD) is <20°
    B. Given the size of the curve, it is likely to progress rapidly
    C. Her curve is likely to progress slowly during adult life
    D. She has significant spinal growth remaining, over which time her curve may worsen
    E. The curve is not likely to progress now as she is skeletally mature

12. You are counselling the patient and family about the condition. They would like to know the likely outcome if left untreated.
    You explain that without treatment, compared with someone unaffected, she is more likely to experience which of the following?
    A. Have back pain and depression
    B. Have concerns about cosmesis
    C. Have reduced life expectancy
    D. Struggle with activities of daily living such as prolonged sitting
    E. Struggle with childbirth and have an increased need for caesarean section

13. The patient opts for surgical management by way of posterior instrumented correction and fusion. Bending films are obtained, demonstrating the main thoracic curve reduces to 40°. A left-sided proximal thoracic curve measures 15° and lumbar curve 20° on the left bending film.
    Surgery should aim to correct and fuse which of the following?
    A. Lumbar and proximal thoracic curves
    B. Main thoracic and lumbar curves
    C. Main thoracic and proximal thoracic curves
    D. Main thoracic curve
    E. Proximal thoracic, main thoracic and lumbar curves

14. You are seeing a 10-year-old boy referred to you for recurrent falls. He has a complex background first noted on prenatal screening and had cardiac surgery in the first few weeks of life. He sees a paediatric orthopaedic surgeon about his hips, but they do not think the falls are related. He denies any pain, but his mother says he has seemed quite clumsy over the past few months. He has a flattened facial profile and nose. He looks to have a straight spine on examination but will not allow detailed neurological examination today.
    The most indicated action at this point is which of the following?
    A. Cervical spine flexion/extension views
    B. CT of cervical spine
    C. MRI scan of whole neuroaxis

D. Observation, bring back in 4 weeks to allow complete neurological examination
E. Standing whole spine X-rays

15. You are seeing a 15-year-old girl in clinic with a background of quadriplegic spastic cerebral palsy, GMFCS 5, referred from a community paediatrician. Carers report problems with seating and care due to her spinal shape alongside poor nutrition and recurrent chest infections. She is seated poorly with signs of costo-pelvic impingement but with some curve flexibility on elevation. A sitting radiograph is shown in Figure 11.3.

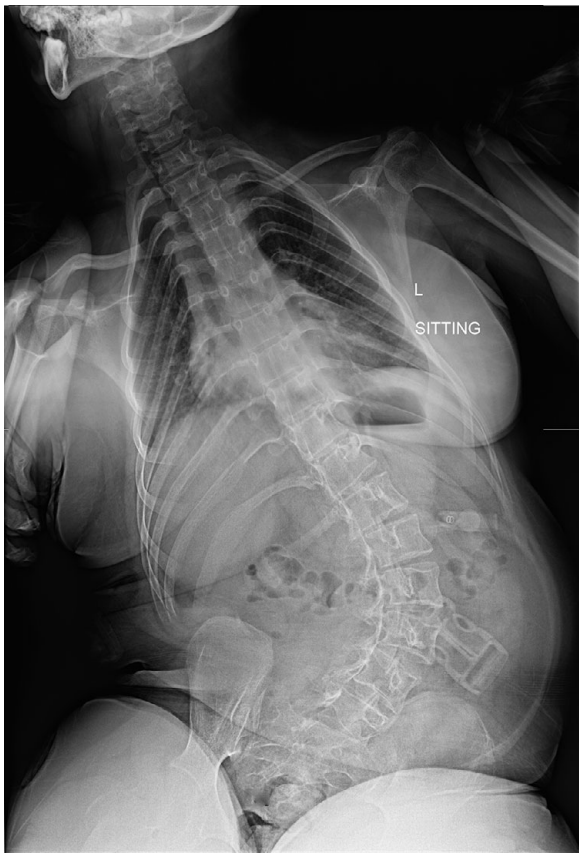


Figure 11.3 AP whole spine sitting radiograph

Which of the following is the most appropriate action to take at this time?

A. Anterior release and posterior correction and instrumented fusion T3–pelvis
B. Moulded brace
C. Observation; further appointment in 12 months
D. Paediatric gastroenterology review
E. Posterior correction and instrumented fusion T3–pelvis

16. A 14-year-old girl presents with low back pain and symptoms affecting her right leg. A standing radiograph is shown in Figure 11.4.

Her symptoms are most likely to include which of the following?

Figure 11.4 Standing lateral lumbar spine radiograph

A. Radicular pain felt onto the dorsomedial aspect of the foot
B. Radicular pain felt over the medial aspect of the leg
C. Radicular pain over the lateral aspect of the foot
D. Weakness in ankle plantar flexion
E. Weakness in tibialis anterior

17. A 14-year-old boy who bowls for his county attends with low back pain for the past 3 months. X-rays demonstrate a grade 2 lytic spondylolisthesis.

A step is most likely to be felt between the spinous processes of which of the following?

A. L1 and L2
B. L2 and L3
C. L3 and L4
D. L4 and L5
E. L5 and S1

18. A 16-year-old dancer returns to clinic suffering with low back pain and severe bilateral radicular leg pain. X-rays demonstrate no change to her known grade 2 lytic spondylolisthesis at the lumbosacral junction. She previously responded well to repeated bilateral nerve root and pars blocks and physiotherapy, but symptoms have returned. Pain limits her daily activities despite suitable oral analgesia. She is requesting a more permanent treatment.

    The most indicated treatment is which of the following?

    A. *In situ* L4–S1 instrumented fusion with L4/5 decompression
    B. *In situ* instrumented fusion of L5/S1 with decompression L5 nerve roots in their foramina
    C. *In situ* uninstrumented L5–S1 fusion
    D. L4–S1 instrumented fusion with resection L5
    E. Reduction of spondylolisthesis with instrumented fusion L5–S1 and decompression L5 nerve roots in their foramina

19. A 15-year-old, previously well boy presents with back pain and a temperature of 37.8°C. He has paraspinal muscle spasm on examination, but neurological examination is normal. His CRP is 83 and WCC 17. MRI scans with axial through the level of interest are shown in Figure 11.5.

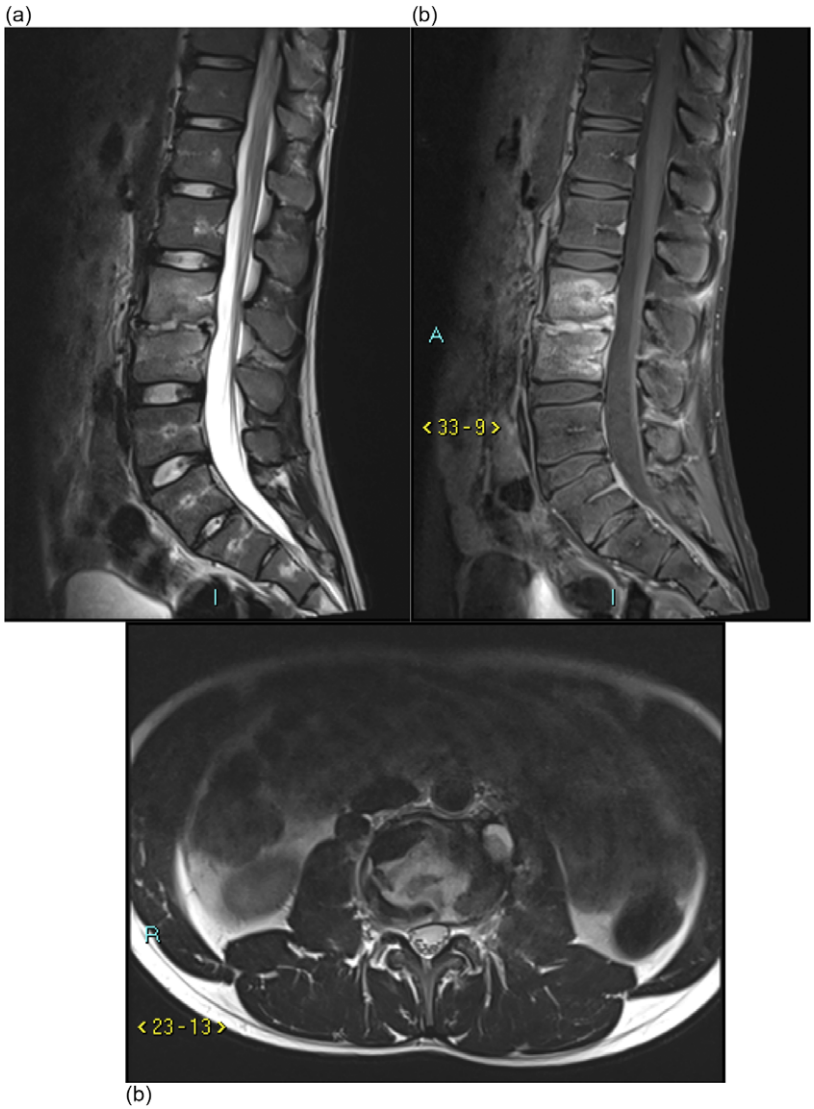


Figure 11.5 (a) Sagittal T2, (b) sagittal T1 with gadolinium enhancement and (c) axial T2 at level of interest MRI images lumbar spine

The most suitable next step in management is which of the following?

A. Administration of IV antibiotics
B. Application of thoraco-lumbo-sacral orthosis
C. Biopsy
D. Blood cultures
E. Surgical debridement of the epidural abscess

20. A 9-year-old boy presents with back pain and weight loss. He is ambulant and neurologically intact. Blood WCC is normal. A whole spine MRI shows enhancement of T10 and T11 vertebral bodies with preservation of adjacent disks with a small paraspinal abscess. On standing X-rays there is 15° kyphosis across the affected area with some collapse of the T10 and T11 vertebrae but is otherwise well aligned. A biopsy shows Langhans giant cells with cultures pending.

The most appropriate treatment at this time is which of the following?

A. Costotransversectomy, debridement with allograft anterior reconstruction and pedicle screw posterior instrumentation
B. Decompression via thoracic laminectomy
C. Nine months of antimicrobials
D. Thoracotomy, radical debridement and anterior reconstruction with rib autograft and instrumentation
E. Three months of flucloxacillin and rifampicin, pending cultures

21. A 14-year-old, 20-month post-menarchal girl presents to your spinal clinic with the condition shown in Figure 11.6. She is mildly concerned regarding her current shape and but has minimal pain. Her neurological examination is unremarkable.

The most appropriate intervention at this time is:

A. Anterior release and posterior instrumented correction
B. MRI whole spine
C. Observation clinical and radiographic follow up in 6–12 months
D. Posterior instrumented correction
E. Referral for brace

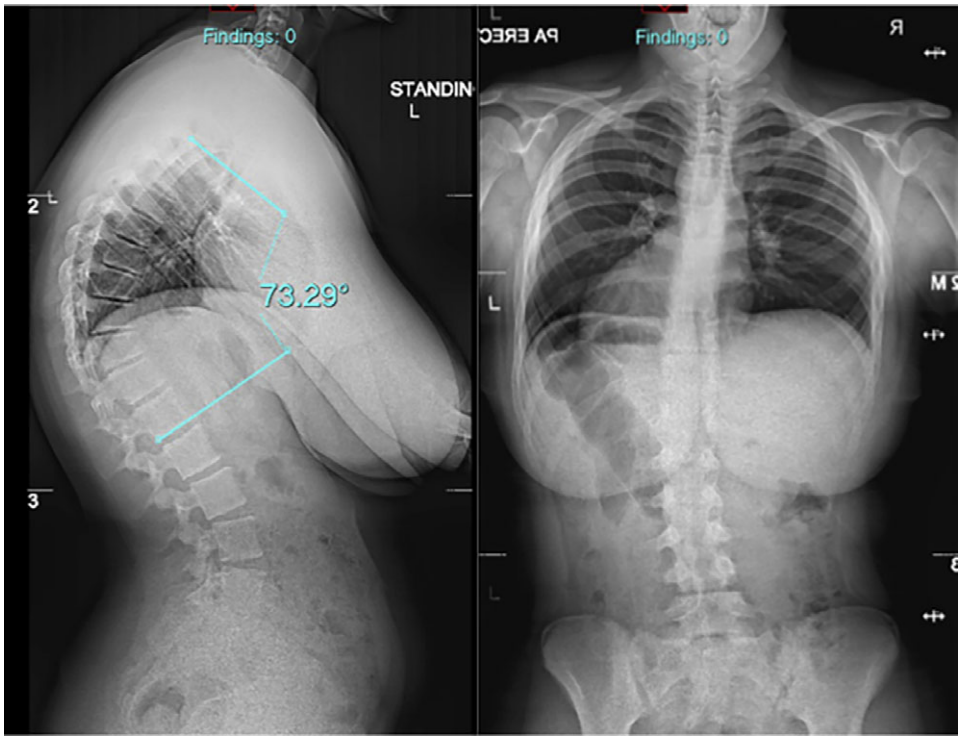


Figure 11.6 Whole spine PA and lateral radiographs

22. You decide to perform an open anterior release on a 16-year-old with large (110°) and stiff but otherwise typical late onset idiopathic scoliosis with apex at the T9 level.
How would you position the patient and over which rib would you make your incision?
A. Left Lateral (Right side up), 7th rib
B. Left Lateral (Right side up), 9th rib
C. Right Lateral (Left side up), 7th rib
D. Right Lateral (Left side up), 9th rib
E. Supine, 9th rib

23. You are reviewing a 5-year-old boy with known spinal abnormality shown in Figure 11.7. He has received no treatment to date but further imaging excludes associated abnormalities. You note progressive deformity over the previous 24 months with kyphosis measuring 60°.
What is the most appropriate action at this point?
A. Anterior release and posterior instrumented fusion
B. Application of hyperextension brace
C. Insertion of conventional growing rods
D. Short segment posterior instrumented fusion/resection of abnormality
E. Shorten follow-up interval with review in 2 months

Degenerative

24. A 60-year-old man has a fall from a standing height and is admitted via ambulance to the ED. He complains of cervicothoracic back pain. He is otherwise well aside from a history of ankylosing spondylitis. On examination, he is in discomfort but neurologically intact. Supine radiographs of the cervical, thoracic and lumbar spine are obtained that do not demonstrate a fracture.
The most appropriate action is which of the following?
A. Mobilise with physiotherapy
B. MRI scan in the morning
C. Obtain swimmer's view
D. Spinal precautions, CT scan
E. Standing (weight bearing) X-rays

25. A 65-year-old male presents with low back pain and pain radiating down the leg to the dorsum of the right foot.
From the list given, what is the most likely diagnosis?
A. L4/5 central canal stenosis
B. L4/5 foraminal disc prolapse
C. L4/5 foraminal stenosis
D. L4/5 lateral recess stenosis
E. L4/5 posterolateral disc prolapse

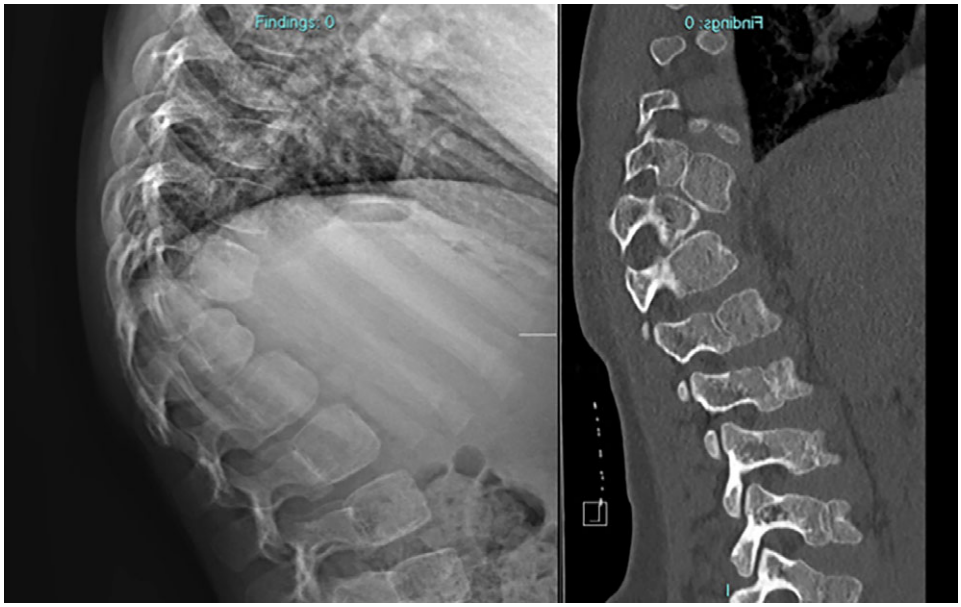


Figure 11.7 Thoracolumbar lateral radiograph (left) and CT sagittal reconstruction of same region (right)

26. A 67-year-old otherwise well male presents with pain down the medial aspect of both shins. MRI confirms that he has bilateral lateral recess stenosis in keeping with his presentation. His standing X-ray is shown in Figure 11.8. He has undergone appropriate conservative treatment involving a 6-week complete relief following bilateral nerve root blocks. His pain has returned, and he is requesting treatment.

Which of the following is the most appropriate treatment?

Figure 11.8 Standing lateral lumbar spine radiograph

A. Continued conservative treatment, which will afford similar outcomes to surgery over the next few years
B. L3/4 decompression
C. L3/4 decompression and instrumented posterolateral fusion
D. L4/5 decompression
E. L4/5 decompression and instrumented posterolateral fusion

27. A 65-year-old retired anatomist presents with radicular leg pain into the dorsum of his right foot. An MRI is undertaken showing lateral recess stenosis that accounts for his symptoms. You go on to describe the pathology.

In his case, the nerve root in question is most likely being compressed by which of the following?

A. Disc osteophyte complex
B. Inferior articular process of L4
C. Ligamentum flavum
D. Pedicle of L5
E. Superior articular process of L5

28. A 67-year-old man presents suffering with left leg pain. He reports diffuse pain over much of the lower leg and foot without clear stenotic symptoms. He has no specific neurological deficit and good distal pulses. An MRI demonstrates multilevel pathology, including bilateral L4 foraminal stenosis, a grade 1 degenerative spondylolisthesis at L4/5 with associated lateral recess stenosis and broad-based left L5/S1 impinging on the traversing nerve root.

To guide targeted surgery, the most appropriate diagnostic injection is which of the following?

A. Bilateral L3/4, L4/5, L5/S1 facet joint medial branch blocks
B. Caudal epidural
C. L5/S1 and L4/5 discography
D. Left L5 nerve root block +/– further injections
E. Lumbar epidural

29. A 48-year-old female presents with back and bilateral leg pain. Her standing radiograph is shown in Figure 11.9. On recent MRI scan, central stenosis, lateral recess stenosis and right sided facet joint cyst are contributing to nerve root compression. There are L4/5 facet joint

Figure 11.9 Standing lateral lumbar spine radiograph

effusions and the joints are aligned in the sagittal plane.

Following confirmatory diagnostic injections, the most appropriate treatment is most likely which of the following?

A. L4/5 instrumented fusion and decompression central canal and L4 foramen
B. L4/5 instrumented fusion and decompression central canal and L4 nerve roots in lateral recesses
C. L4/5 instrumented fusion and decompression central canal and L5 nerve roots in lateral recesses
D. Decompression central canal and L4 nerve roots in lateral recesses
E. Decompression central canal and L5 nerve roots in lateral recesses

30. A 40-year-old man presents with right shoulder and neck pain. On examination, he has weakness on Jobe's/empty can test. Following exclusion of shoulder pathology, MRI imaging of his neck is undertaken, demonstrating nerve root compression concordant with his examination findings.

The nerve in question leaves the spine between the pedicles of which of the following?

A. C2 and C3
B. C3 and C4
C. C4 and C5
D. C5 and C6
E. C6 and C7

31. A 36-year-old labourer presents with numbness over the right little finger. On examination, he has a globally reduced range of motion of his cervical spine, isolated altered sensation over the volar aspect of his right little finger but no wasting or weakness.

Which investigation is the most appropriate?

A. Cervical spine radiograph
B. CT wrist and hand
C. MRI cervical spine
D. MRI wrist
E. Neurophysiological studies

32. A 56-year-old plasterer presents with a 3-month history of neck pain. He feels the pain in the mid cervical region in the midline and it is worse after a long day's work. He is otherwise well. He has a reduced range of cervical motion which causes him pain but has no upper or lower limb symptoms or signs. An MRI had been arranged by his GP and is shown in Figure 11.10.

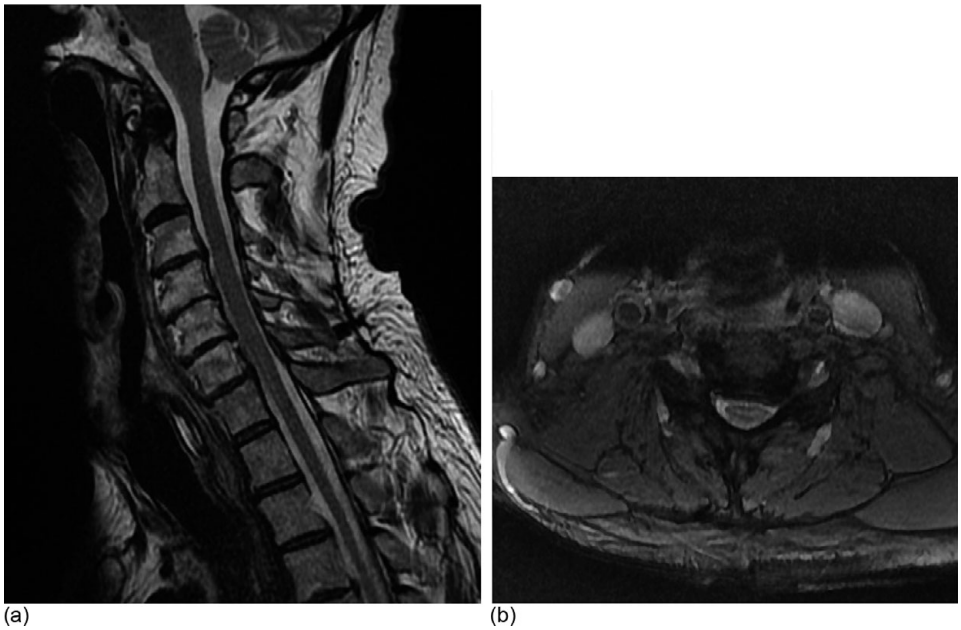


Figure 11.10 (a) Sagittal T2 and (b) axial T2 at C5/6 MRI images of cervical spine

The most appropriate action at this point is which of the following?

A. Bilateral C6 nerve root blocks
B. C4/5 and C5/6 cervical disc replacement
C. C4/5 and C5/6 anterior cervical decompression and fusion
D. Onward referral to local pain service
E. Reassurance, analgesia and mobilisation

33. A 65-year-old otherwise well Caucasian female presents with right brachialgia. On questioning, she has noticed increasing difficulty with her sewing and some unsteadiness on her feet. Examination findings include an inverted supinator reflex.

Which pathology underlying this presentation is most likely?

A. Atlantoaxial instability (AAI)
B. Calcified central thoracic disc prolapse
C. Cervical disc/osteophyte complex
D. Neoplasia
E. Ossification of the posterior longitudinal ligament (OPLL)

34. You are undertaking the approach for an anterior lumbar interbody fusion at L4/5. While mobilising the vessels, you encounter significant haemorrhage.

An injury to which vessel(s) has most likely occurred?

A. Ilio-lumbar vein
B. Left common iliac artery
C. Left common iliac vein
D. Median sacral vessels
E. Right common iliac vein

35. You are seeing a 35-year-old who has had left leg pain to the lateral aspect of his foot for the past 8 weeks. He has no weakness or bladder/bowel symptoms. A recent MRI is shown in Figure 11.11 with axial at the L5/S1 level.

In counselling him about the treatment options at this point, you explain to him which of the following?

A. As the pain has been going on for 8 weeks, he has failed conservative management, and microdiscectomy surgery is the best option
B. Continued conservative treatment will likely lead to reduced back pain at 1 year compared with surgery
C. Continued conservative treatment will likely result in similar resolution of leg pain at 1 year as surgery

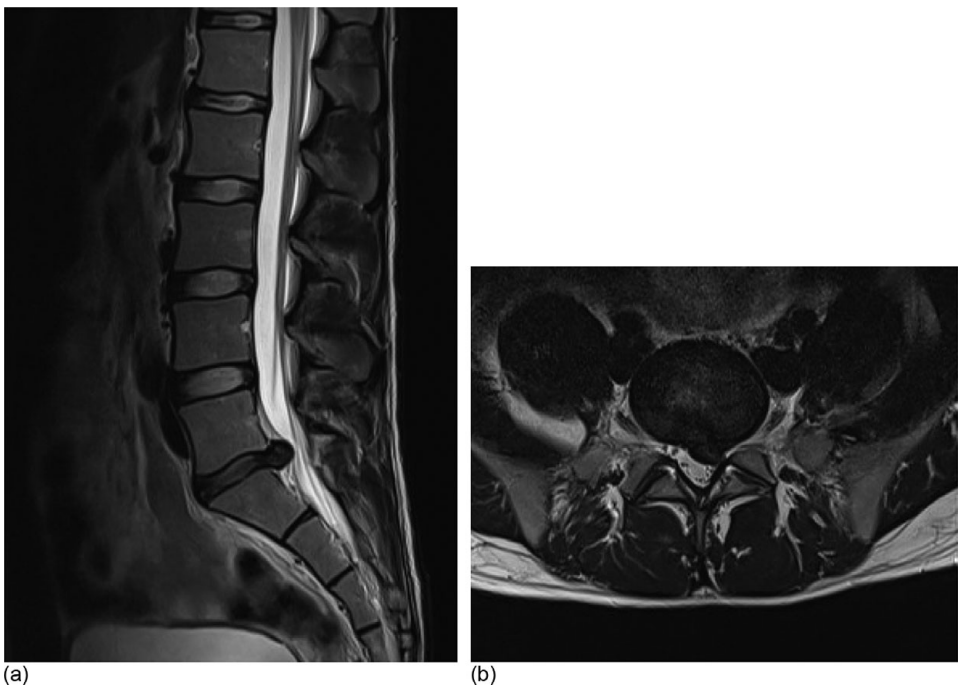


Figure 11.11 (a) Sagittal T2 and (b) axial T2 at L5/S1 level MRI images lumbar spine

D. Recurrence of sciatica in the year following surgery, necessitating revision surgery is about 10%
E. Surgery will reduce the overall disability he suffers over the next year

36. A 70-year-old female with a history of rheumatoid arthritis presents with decreasing hand function and is now struggling to feed herself. Romberg's test is positive on examination, with upgoing plantars and weak upper and lower limbs to power 4/5. Radiographs are undertaken with a posterior atlantodental interval (PADI) of 10mm on flexion view, Ranawat's C1–2 index measures 15mm, the tip of the dens is below the McRae line and there is no subluxation in the lower cervical spine.

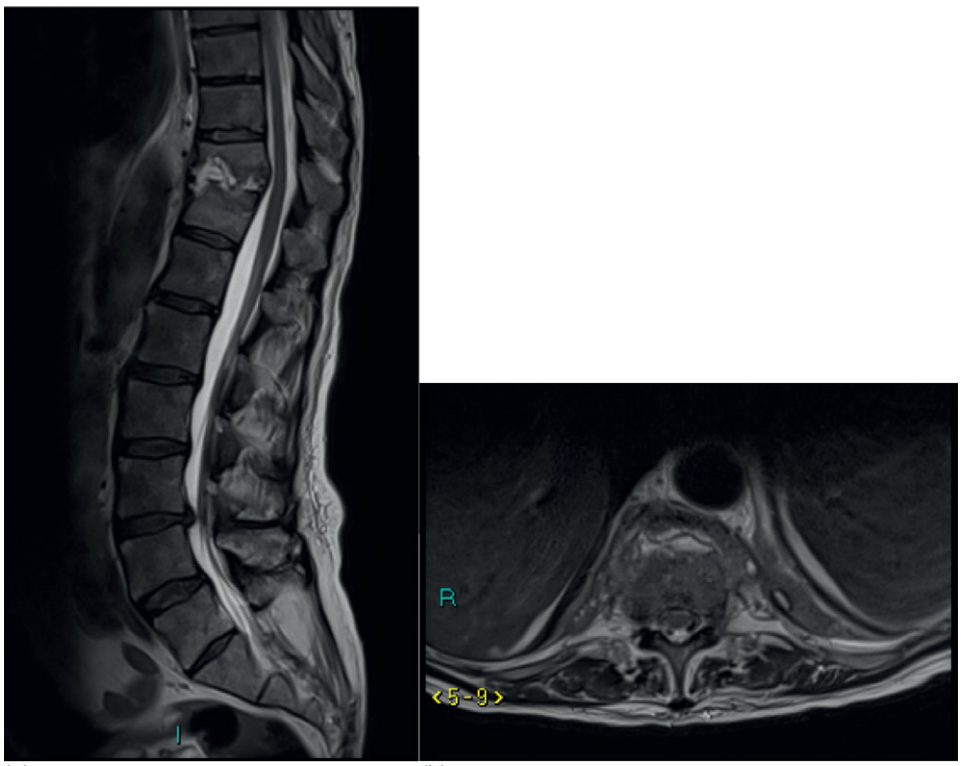
Which treatment is most indicated?

A. C1–C2 fusion
B. Foramen magnum decompression
C. Occiput–C2 fusion
D. Occiput–C5 posterior decompression and fusion
E. Odontoidectomy

37. The plane developed during the approach for an anterior cervical discectomy and fusion is best described as between which of the following?

A. Carotid sheath and pretracheal fascia
B. Carotid sheath and sternocleidomastoid
C. Deep investing layer of cervical fascia and the prevertebral fascia
D. Sternocleidomastoid and platysma
E. Sternocleidomastoid and prevertebral fascia

38. You review a 45-year-old diabetic man on the medical ward. He has been under the care of the medical team for 1 week and has been treated for a presumed pneumonia with oral antibiotics, over which time the blood cultures taken on admission have grown *Staphylococcus aureus*. While on the ward he is complaining of back pain, prompting a whole spine MRI, with the thoracolumbar aspect of this scan shown in Figure 11.12, with axial through the level of



(a) (b)

Figure 11.12 (a) Sagittal T2 and (b) axial T2 at level of interest MRI images thoracolumbar aspect

interest. He has no neurological deficit and is ambulating around the ward with temperature of 37.4°C.

What is the most appropriate action at this time?

A. Anterior decompression with debridement of disc and bone and reconstruction
B. IV antibiotics
C. Percutaneous biopsy and antibiotics based on culture sensitivities
D. Percutaneous posterior stabilisation and IV antibiotics
E. Posterior decompression and discectomy

39. You are asked to see a 26-year-old man with a 3-month history of back pain and weight loss. He has normal neurology and is freely ambulating around the ward. A Mantoux test is positive. An MRI scan shows pathology at the T8 level.

What are the MRI changes most likely to be?

A. Destruction of the intervertebral disc with adjacent bone loss and an enhancing collection anteriorly
B. Enhancement in the vertebral body with preservation of the adjacent discs and elevation of the anterior longitudinal ligament
C. Enhancing lesions to the vertebral body with similar changes at multiple levels; dark on T1, bright on T2
D. Gross T8 bone loss with a 40° focal kyphosis with tenting of the cord and associated myelomalacia
E. Lesion within the right lamina enhancing brightly on T2

40. A 34-year-old female presents to the emergency department with a 5-day history of bilateral sciatica and a 24-hour history of episodes of bladder incontinence. She has a history of LBP for some years.

Which of the following statements correctly describes her evaluation?

A. 24 hours from onset of symptoms to surgery is a critical cut-off for bladder function
B. A poor correlation exists between clinical finding and MRI findings
C. A post void residual (PVR) bladder volume of 125ml is highly significant and establishes a diagnosis of cauda equina syndrome with a 98% positive predictive value
D. An MRI examination is not required if PVR bladder volume is more than 550ml
E. PR examination is a sensitive and specific test of cauda equina function, as the nerves supplying anal function tolerate pressure poorly

41. A 62-year-old man presents with a thoracic disc protrusion. These disc protrusions:

Which statement best describes his presentation?

A. Are less common in Scheuermann's disease
B. Present with sensory symptoms rather than motor symptoms usually
C. The herniation is calcified in 10% of cases
D. When operated on an anterior approach or a costo-transversectomy is considered lower risk for neurological deterioration than laminectomy
E. Will most commonly occur between T3 and T7

42. When consenting a patient for spinal surgery, which statement best describes information patients need to know?

A. After posterior cervical decompression, the risk of a c5 nerve palsy is 5%, with a poor prognosis for recovery
B. Following anterior cervical discectomy and fusion, the incidence of dysphagia is 30%
C. Paralysis is a very rare complication of lumbar surgery and does not need to be mentioned
D. The incidence of dural tears following lumbar discectomy is 7%
E. The overall complication rate for lumbar decompression is around 12%

43. A 45-year-old is referred by the medical team. Having presented 3 days ago with a 48h history of fever, low back pain, mild bilateral leg pain but no urinary symptoms. On admission he had a CRP of 250 and blood cultures were taken with no growth currently. The medical team commenced antibiotics on admission and arranged a whole spine MRI scan, the salient lumbar aspects of which are shown in Figure 11.13. Reviewing him you note he has a temperature of 38.0 and normal power L2-S1 and altered

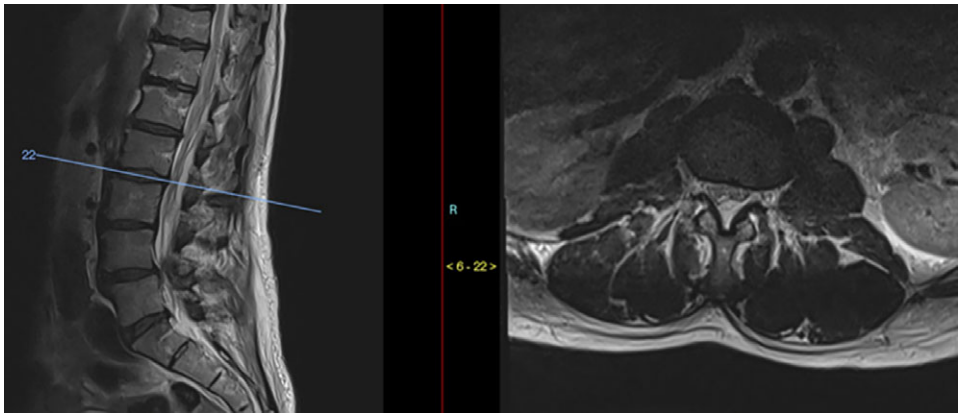


Figure 11.13 Lumbar T2 sagittal with T2 axial through level indicated by blue line

sensation in L4-S1 bilaterally. A post-micturition bladder scan is 25ml. His CRP today is 245.

What is the most appropriate action at this time?

A. Change to broader spectrum antimicrobials.
B. CT chest/abdomen/pelvis
C. Echocardiogram
D. Open spinal decompression/drainage and sampling
E. Spinal decompression/drainage and sampling with instrumented fusion

Trauma

44. **Which of the following spinal cord injuries carries the best prognosis?**
    A. Ipsilateral weakness with contralateral loss of pain and temperature
    B. Loss of motor and all sensory function bilaterally below level of injury aside the bulbocavernosus reflex
    C. Loss of proprioception with preserved power and pinprick sensation bilaterally
    D. Predominantly motor dysfunction disproportionately affecting the upper limbs vs legs
    E. Weakness and numbness in all four limbs with preserved proprioception bilaterally

45. A 28-year-old male is involved in a high-speed RTA, sustaining a cervical spine fracture dislocation, treated with prompt reduction and stabilisation. At 48 hours later he is examined and found to have a present bulbocavernosus reflex. He can flex his elbows against gravity and extend his wrists actively when gravity is eliminated but has no motor function in more caudal levels. He has no peri-anal sensation, but he has normal sensation over the lateral aspect of his arms and forearms.

    What is his ASIA grade and neurological level of injury?

    A. A C5
    B. A C6
    C. B C5
    D. B C6
    E. E C5

46. A 26-year-old is involved in a high-energy car accident in which he drove into a tree, sustaining bilateral femoral shaft fractures and a traumatic brain injury. A CT is undertaken.

    Which of the following is suggestive of an occipitocervical dissociation (OCD)?

    A. Avulsion fractures of occipital condyles
    B. Basion–axial interval (BAI) 10mm
    C. Basion–dens interval (BDI) 5mm
    D. Occipital condyle fracture extending into the base of skull
    E. Powers ratio 0.9

47. A 60-year-old sustained an injury to the right side of C1 while diving into a swimming pool. He is neurologically intact. A CT scan is undertaken and shown in Figure 11.14.

    This suggests which of the following?

    A. Transverse ligament is disrupted and C1–C2 fusion is indicated

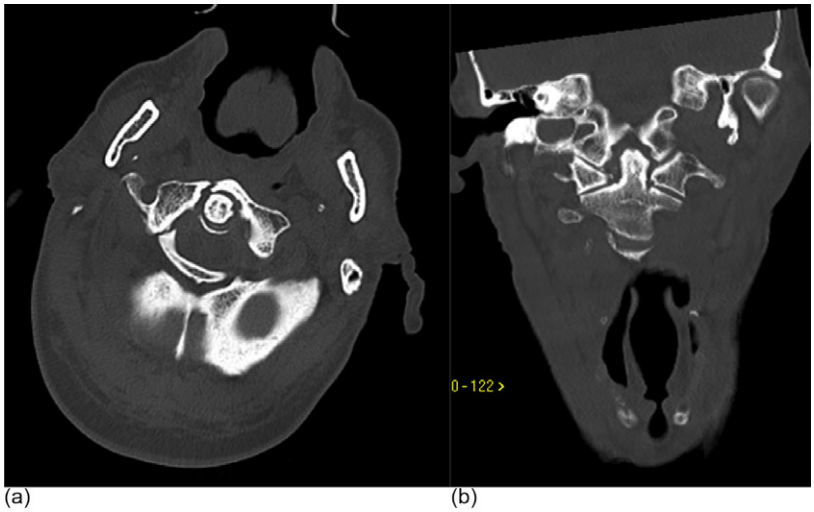


Figure 11.14 (a) Axial CT and (b) coronal reconstruction

B. Transverse ligament is disrupted and C1–C2 fusion is NOT indicated
C. Transverse ligament is disrupted and occiput–C2 fusion is indicated
D. Transverse ligament is NOT disrupted and C1–C2 fusion is indicated
E. Transverse ligament is NOT disrupted and C1–C2 fusion is NOT indicated

48. A 34-year-old amateur rock climber falls 3m from a boulder. He complains of isolated neck pain but is neurologically intact. A CT scan shows a minimally displaced fracture of the odontoid peg extending into the body of the axis bone.

The most suitable treatment at this time is which of the following?

A. Anterior lag screw fixation
B. C1–2 fusion with transarticular screws
C. Posterior Goel-Harms type C1–2 fusion
D. Rigid cervical orthosis
E. Soft collar and mobilisation once pain settles

49. An 83-year-old man falls while cutting the roses in his allotment, sustaining an isolated neck injury. He is otherwise well and neurologically intact. His CT scan is shown in Figure 11.15.

Compared with treatment of this injury with a halo vest, treatment in a semi-rigid collar is more likely to be associated with which of the following?

A. Death
B. Failure to complete treatment
C. Neurological deterioration
D. Non-union
E. Pneumonia

Figure 11.15 (a) Sagittal and (b) coronal CT reconstructions

50. A 65-year-old male is involved in a high-energy motorcycle accident. He is agitated and confused in A&E but appears to have weakness in his hands and lower limbs to a power of 3/5. A CT scan of his head shows frontal cerebral contusions and the sagittal and parasagittal spine CT images are shown in Figure 11.16. He has no other injuries and his anaesthetists say it is safe to go to theatre if needed.

The most appropriate management at this time is which of the following?

A. Administration of methylprednisolone
B. Application of Gardner–Wells tongs and gradual reduction with cervical traction
C. Application of halo jacket
D. MRI scan
E. Transfer to theatre for reduction and stabilisation with C6/7 ACDF +/– posterior instrumentation

51. A 27-year-old male is involved in a high-speed motorcycle accident. On arrival to the ED, he is agitated and trying to remove his mask and lines and has a GCS of 8. He is promptly intubated. He is haemodynamically stable following fluid resuscitation but has obvious lower open fractures. The only injuries on a formally reported trauma pan-CT scan are an intracranial extradural haematoma, AP compression grade 2 pelvic fracture and displaced transverse process fractures of L1–L4. You are consulted regarding spinal stability before transfer for long bone stabilisation and neurosurgical intervention.

The most appropriate action at this time is which of the following?

A. Cervical collar and blocks can be removed, but the patient requires logrolling for the lumbar spine injury

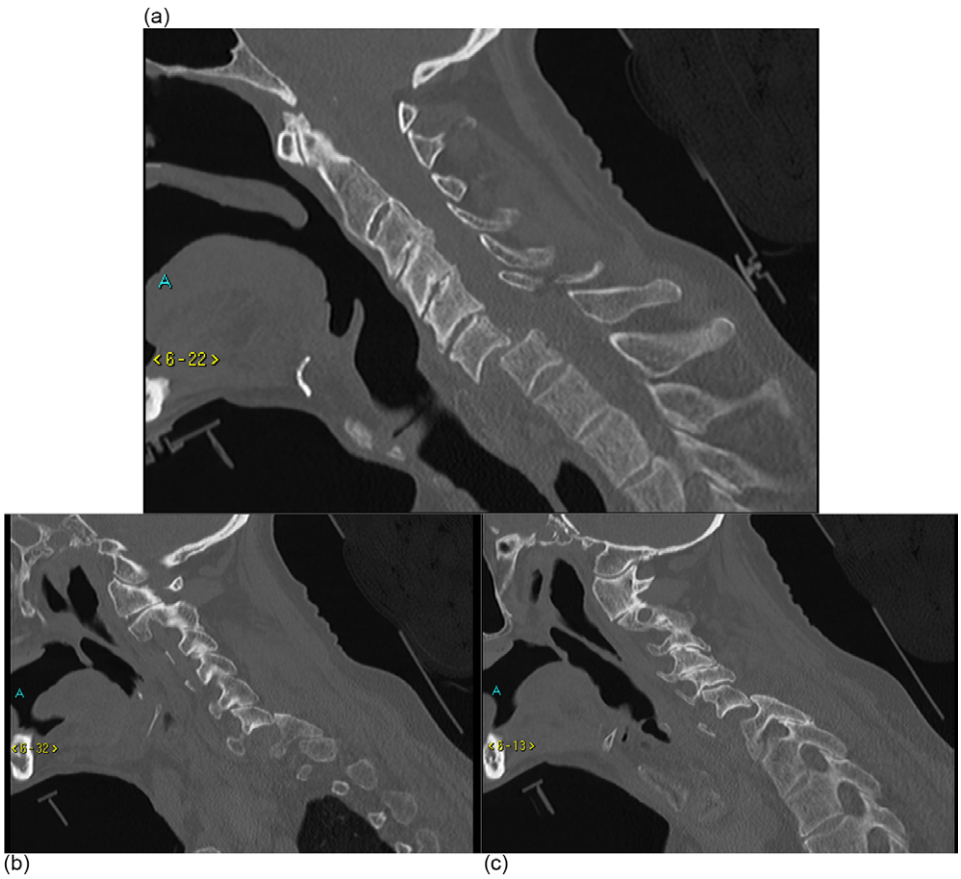


Figure 11.16 (a)–(c) Sagittal and parasagittal CT reconstructions

B. Full cervical protection with collar, sandbags and tape should be maintained until a time when clinical examination can be performed, as he may have an occult unstable injury
C. Full cervical protection with collar, sandbags and tape should be maintained until an MRI scan is undertaken
D. He should be logrolled, and spine clinically examined to assess for swelling or bogginess that may suggest ligamentous disruption
E. The patient can be considered to have a 'stable' spine. All cervical protection can be removed, and the patient positioned carefully in theatre

Questions 52–53 Stem:

A 25-year-old male is involved in a head-on collision in a car going 70mph. On examination, he has swelling and local tenderness over the T12–L1 area but has no neurological deficit. CT scan images are shown in Figure 11.17 with the axial through the level of the injury. When measured formally, the angulation between the superior end plate of T12 and the inferior end plate L2 is 16°.

52. The best description of the nature of this injury is which of the following?

B. Bony flexion distraction injury (Chance)
A. Burst fracture
C. Compression fracture
D. Osseoligamentous flexion distraction injury
E. Translational/rotational injury

53. What is the most appropriate management at this time?

A. Non-operative; standing X-rays, mobilisation +/– TLSO brace
B. Surgery; anterior corpectomy L1 and reconstruction with short segment posterior fixation T12–L2
C. Surgery; long segment posterior fixation T11–L3
D. Surgery; short segment fixation T12–L2/L3
E. Surgery; short segment fixation T12–L2/L3 with fusion

(a) (b)

Figure 11.17 (a) Sagittal CT reconstruction and (b) axial through injured level

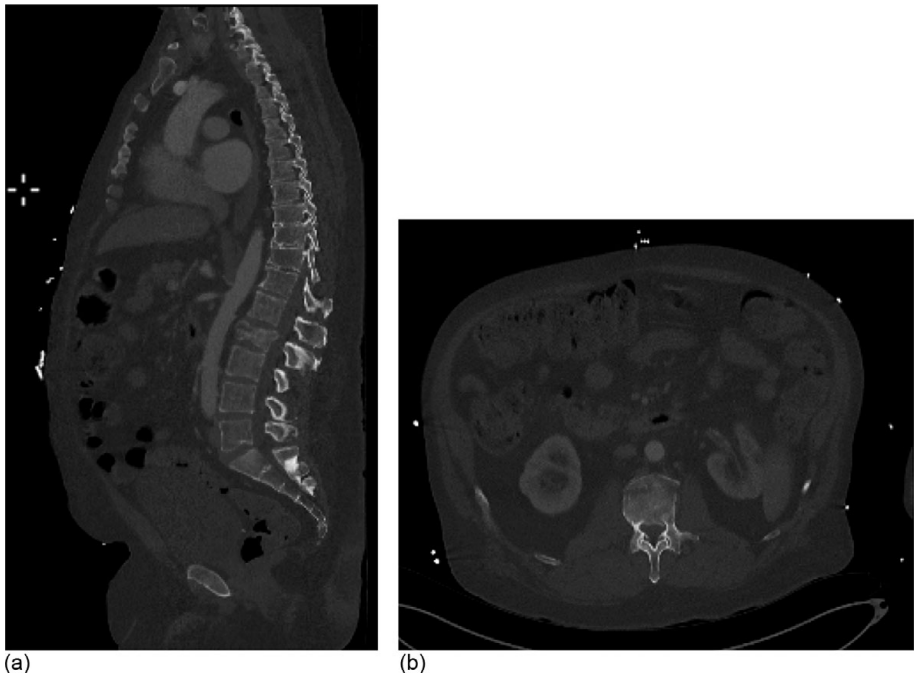


Figure 11.18 (a) Sagittal CT reconstruction thoracolumbar spine and (b) axial cut at area of interest

Questions 54–55 Stem:

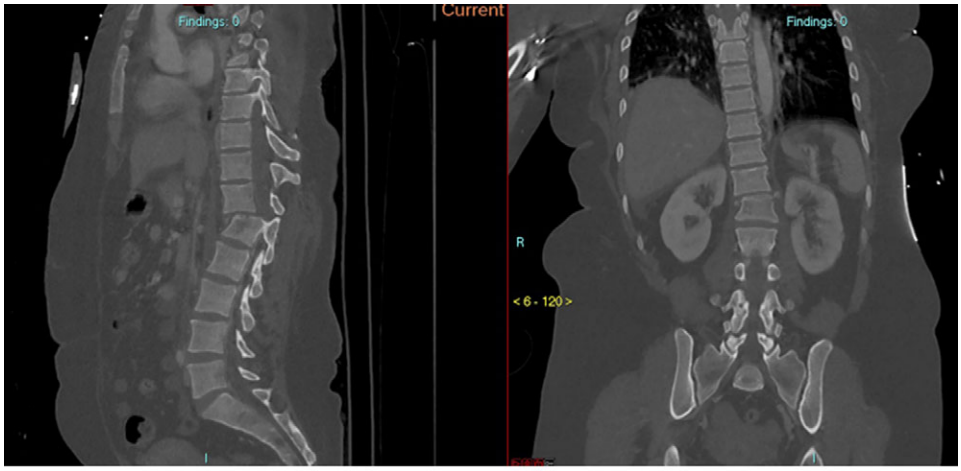
A 58-year-old farmer falls from his tractor. Following a full trauma workup, he is found to have a fracture of L2 with paraesthesia in his right thigh but has no other neurological signs. He has some slight tenderness paraspinally over the lumbar spine but no focal midline tenderness or swelling. CT scans are shown in Figure 11.18.

54. **From the available information, the best description of the nature of this injury is which of the following?**
    - A. Bony flexion distraction injury (Chance)
    - B. Burst fracture
    - C. Compression fracture
    - D. Osseoligamentous flexion distraction injury
    - E. Translational/rotational injury

55. **The most appropriate management at this point is which of the following?**
    - A. Anterior corpectomy and reconstruction +/– posterior instrumentation
    - B. Bed rest
    - C. Mobilisation and standing radiographs when pain allows
    - D. MRI scan
    - E. Short segment posterior stabilisation +/– decompression

56. You are referred a 43-year-old involved in a high-speed RTA. She is maintaining her airway and haemodynamically stable. There are no obvious limb or head injuries. She has MRC 0/5 in L1-S1 myotomes but some sensation peri-anally. A CT scan is undertaken (Figure 11.19). The general surgeons identify a pancreatic injury and duodenal perforation on this imaging. Her last lactate is 1.2 and base excess −1.

    Discussing your thoughts with the general surgeon on call, what would you feel the most appropriate next step is?
    - A. Administration of high-dose methylprednisolone
    - B. Laparotomy for management of general surgical injury
    - C. MRI scan whole spine
    - D. Posterior instrumented fusion with long construct
    - E. Transfer to ITU for further resuscitation



(a) (b)

Figure 11.19 Sagittal and coronal CT reconstructions

57. A 67-year-old man presents to the ED after a minor fall 5 days ago. His back is sore between his shoulder blades. He has a history of ankylosing spondylitis. An X-ray of his spine shows a 'bamboo spine', but no fracture.

Which of the following statements best describes how he should be managed?

A. A CT scan should be performed as it will exclude a fracture and should be performed as an emergency
B. HLA B27 positive patients have a better clinical response to tumour necrosis factor inhibitors and an earlier age at diagnosis compared with HLA B27 negative patients
C. If a fracture is diagnosed and surgery is deemed to be necessary, the patient should be nursed flat with full spinal immobilisation until the surgery which will probably require 3 levels fixation above and 3 levels below the fracture
D. If a fracture is diagnosed, it probably can be treated conservatively
E. If there are no neurological signs at presentation, it is unlikely any will develop as the spine will be osteoporotic

58. A 27-year-old patient with a fracture dislocation of C5/6 is admitted to your ward.

Which of the following best describes the medical management required for this patient?

A. At all times the mean arterial pressure should be kept above 90mmHg and a systolic pressure above 100mmHg
B. Autonomic dysreflexia is a relatively uncommon but life-threatening condition in people who have a spinal cord injury above the level of T6
C. Does not require pain relief for musculoskeletal spasms beneath the spinal cord injury level
D. If described as having an ASIA impairment scale (AIS) of 'C', their function is being described as sensory incomplete
E. Should commence chemical thromboprophylaxis with low molecular weight heparin within 10 days of admission

Tumour

59. A 45-year-old otherwise well female is referred to you following assessment by a gynaecology colleague for pelvic pain, having been found to have a lesion in the midline of the sacrum. Staging identified this to be an isolated lesion. The cells appear vacuolated on biopsy.

What is the best description for the type of cell the lesion derives from?

A. Endoderm
B. Mesoderm
C. Neuroectoderm
D. Notochord
E. Yolk sac

60. A 65-year-old male presents with an 8-week history of back pain. He has no leg weakness or bladder/bowel symptoms. A full neurological examination is normal. An MRI scan of the whole spine is undertaken and shown in Figure 11.20 with axial through the L3 level.

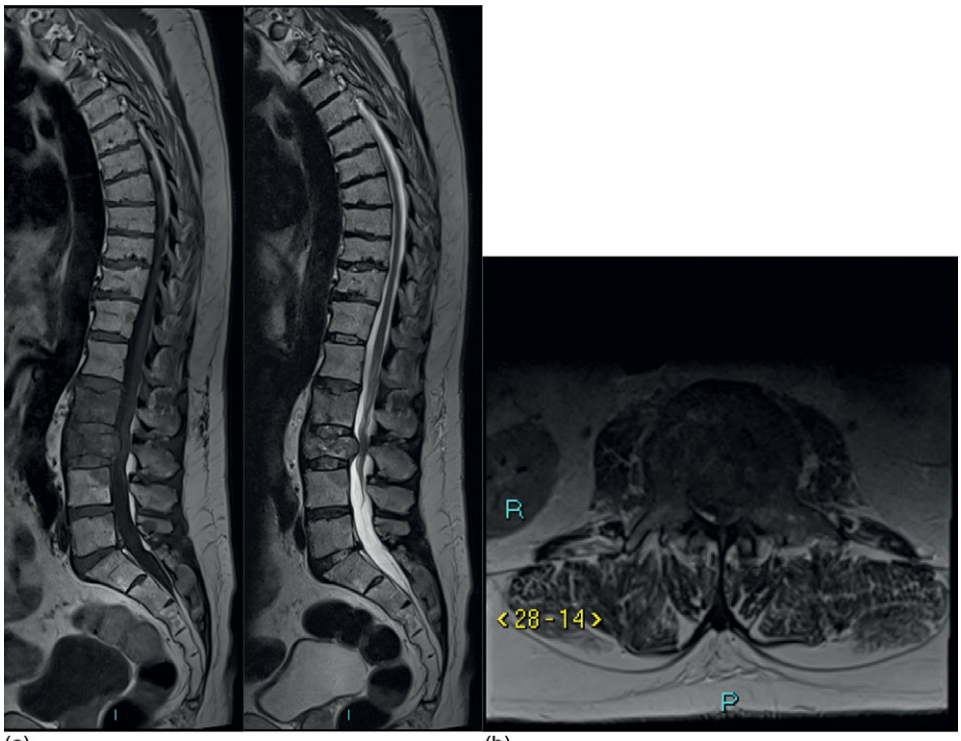
The next most appropriate action is which of the following?

A. Biopsy
B. CT scan chest, abdomen and pelvis
C. Reassurance; the underlying pathology is a benign haemangioma
D. Urgent decompression and stabilisation
E. Vertebroplasty

61. A 70-year-old man presents with progressive weakness in both legs over 48 hours. He is now struggling to walk but has minimal back pain and remains continent. Usually he lives with his wife independently, walking with a stick. On examination, power is 4/5 in lower limb myotomes with a sensory level at T11. MRI images are shown in Figure 11.21 with axial at T11. A staging CT is suggestive of prostate cancer with metastatic spread to the spine, right ilium and liver.

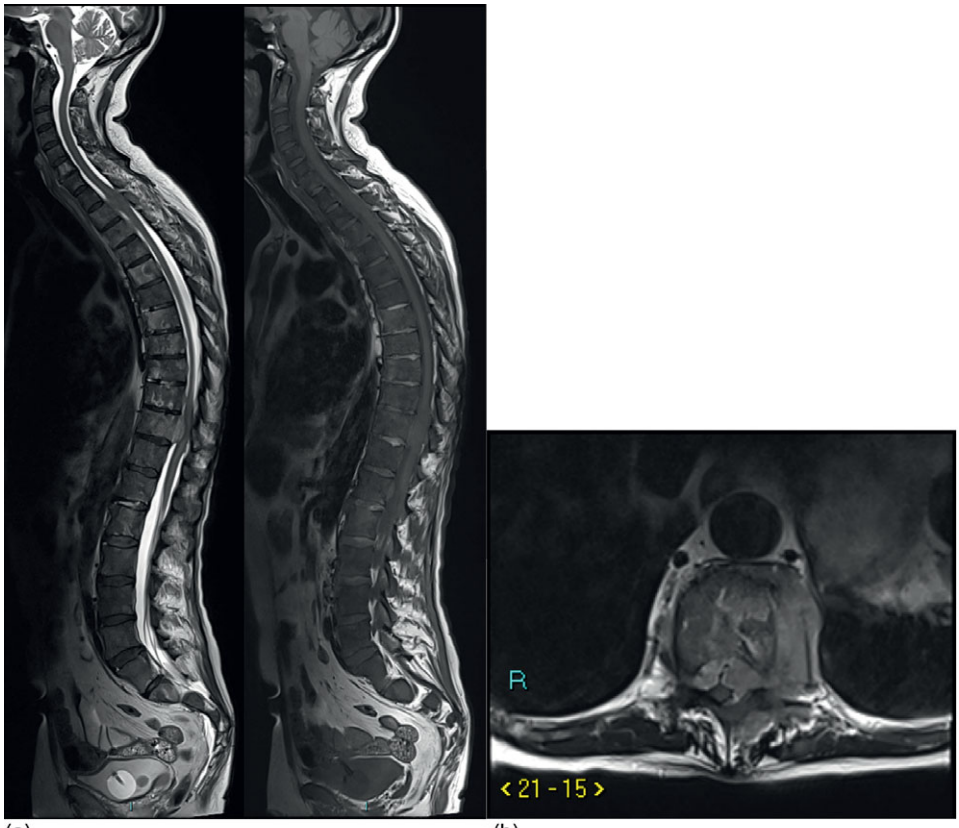
The most appropriate next step management of this man is which of the following?

A. Biopsy
B. Decompressive laminectomy
C. Decompression and stabilisation
D. En bloc excision with reconstruction
E. Palliative radiotherapy, based on his Tokuhashi score



(a) (b)

Figure 11.20 (a) T1 and (b) T2 sagittal whole MRI spine images and (c) T2 axial cut at area of interest



(a) (b)

Figure 11.21 (a) T1 and (b) T2 sagittal whole spine MRI images and (c) T2 axial at T11

62. A 14-year-old boy presents with 3 months of severe low back pain. The pain is worse at night and relieved by ibuprofen. X-rays demonstrate a small lumbar scoliosis.

Which of the following is true regarding the likely underlying diagnosis?

- **A.** It tends to affect the vertebral body
- **B.** Radiofrequency ablation is the treatment of choice
- **C.** Recurrence is common following intralesional curettage
- **D.** The pathological lesion tends to be placed on the concavity of the scoliosis
- **E.** The radiolucent area in the lesion is >2cm

63. A 54-year-old with a history of breast cancer is seen in the spine clinic. Her oncologist arranged a whole spine MRI scan after a few weeks of intermittent low back pain and asks for your opinion. The MRI demonstrates a round lesion in the body of T5 with high signal on T1- and T2-weighted imaging.

The most appropriate action at this point is which of the following?

- **A.** Biopsy
- **B.** En bloc resection and reconstruction
- **C.** Observation
- **D.** Tumour decompression and stabilisation
- **E.** Vertebroplasty

64. A 58-year-old male presents with 9 weeks of severe thoracic back pain, worse at night, causing him to pace up and down the ward to try and gain some relief. He is neurologically intact. An X-ray shows a lytic lesion at T8. MRI of the spine shows normal spinal alignment with preservation of vertebral height at all levels. The lesion in the body of T8 is dark on T1 and bright on T2, with encroachment on the spinal cord. Following blood test results, a bone marrow biopsy is

undertaken showing plasma cells. He has trialled conventional analgesics.

The most appropriate treatment at this time is which of the following?

A. Medical management
B. Percutaneous stabilisation
C. Spinal decompression and stabilisation
D. Vertebrectomy and anterior reconstruction with posterior stabilisation
E. Vertebroplasty

65. A 10-year-old girl presents with a 6-week history of back pain. There is no history of trauma and she is denying systemic symptoms. Plain imaging and an MRI scan are shown in Figure 11.22. A biopsy is undertaken.

The best description of the likely histology is which of the following?

A. Bilobed eosinophils
B. Monoclonal plasma cells
C. Multinucleated giant cells
D. Small round blue cells
E. Spindle cells embedded in osteoid

66. A 35-year-old is started on a monoclonal antibody medication for initial treatment of their sacral giant cell tumour.

The mechanism of action of this medication is best described as which of the following?

A. Binds PTHrP
B. Increases osteoprotegerin
C. Induces tumour apoptosis
D. Inhibits farnesyl pyrophosphate synthase
E. RANKL antagonist

67. You are the on-call spinal surgeon at a regional centre and referred a 60-year-old woman with a background of breast cancer at 22.00 from a local district general hospital (DGH). Over the past 5 days, she has noted progressive difficulty walking and feels both legs are weak, but she remains continent. On examination, she has minimal back pain, power 4/5 in all lower limb myotomes and altered sensation below the umbilicus. The hospital does not have access to an out-of-hours MRI scanner.

The most appropriate treatment at this point is which of the following?

A. Administer oral dexamethasone
B. CT scan whole spine at DGH with soft tissue rendering
C. Suggest contacting the oncologists for preoperative radiotherapy
D. Transfer to regional centre for imaging and surgery that night
E. Transfer to regional spinal surgical centre for overnight MRI scan

68. A 58-year-old male with a history of metastatic prostate cancer diagnosed 4 months ago presents

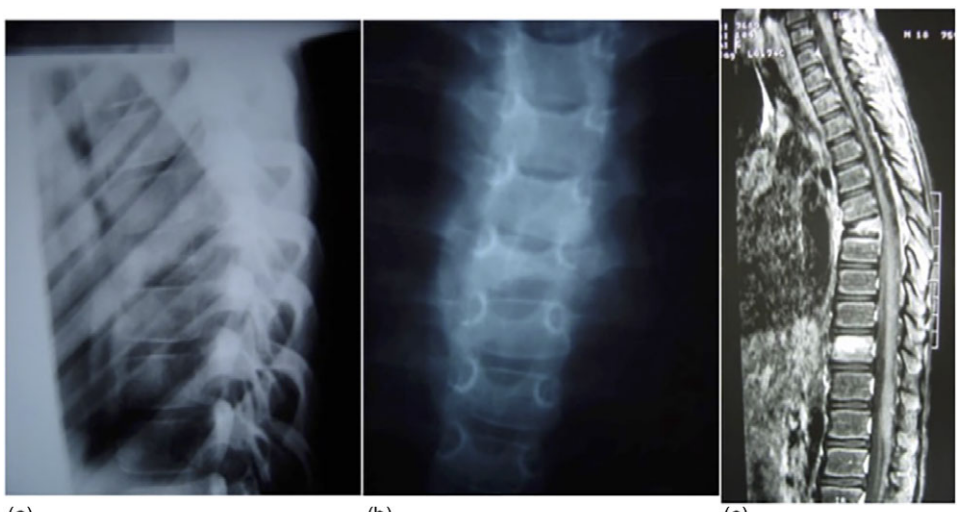


Figure 11.22 Plain imaging (a) lateral, (b) PA views and (c) sagittal T2 MRI image

with severe back pain over the thoracolumbar junction. Pain is worse on attempted mobilisation. He is wearing a TLSO brace, which he finds helpful, but he struggles to get out of bed even with it. He has no neurological deficit. The oncologists plan to start new treatments soon. A CT and MRI scan show mixed lytic/blastic metastatic lesions to the ilium and ribs but also to L1 with tumour infiltrating the body, both pedicles and superior articular processes. There is 20° kyphosis across the thoracolumbar junction associated with loss of vertebral body height of around 25% and there is expansion of the posterior wall indenting the dura.

The appropriate action at this point is which of the following?

A. Posterior decompression and stabilisation
B. Posterior stabilisation
C. Refer to oncologists for consideration for radiotherapy
D. Staged anterior and posterior decompression and stabilisation
E. Vertebroplasty

69. An oncologist asks you to see a 43-year-old male with a history of previous right nephrectomy 4 years ago for renal cell carcinoma. He presents with severe thoracic back pain without neurological deficit. MRI, CT and PET imaging suggest an isolated metastatic lesion within the body of T10. The spine is well aligned and there is no neural compression.

The most appropriate next action at this point is which of the following?

A. Anterior en bloc excision with reconstruction
B. Biopsy
C. Embolisation
D. Posterior intralesional resection decompression and stabilisation
E. Radiotherapy

SPINE I STRUCTURED SBA ANSWERS

Basic Science

1. Answer D. **Patients' lumbosacral lordosis is proportional to their pelvic incidence (PI)**
Spinopelvic alignment is a complex topic, but is now entering the sphere of the FRCS exam. Sagittal vertical axis (SVA) refers to a C7 plumb line, which should pass through the S1 end plate, usually its posterosuperior corner. PI is an angle from the centre of the femoral head axis to the midpoint of the sacral plate and a line perpendicular to the sacral plate. As it relates the bony sacrum to the ilium through the almost immobile sacroiliac joints, it is a fixed anatomical parameter and does not change following skeletal maturity. Mathematically, PI = SS + PT. Usually, a patient's lumbosacral lordosis is approximately equal to their PI. Commonly, a loss of lumbar lordosis is fundamental to clinical sagittal balance problems, and osteotomies may be undertaken to restore a patient's sagittal balance to a value similar to the PI.

Roussouly P, Nnadi C. Sagittal plane deformity: an overview of interpretation and management. *Eur Spine J.* 2010;**19**:1824–1836.

2. Answer B. **Changing from the Ti to the CoCr rod as suggested will roughly double the bending rigidity**
Bending rigidity is equal to the SMA of the structure multiplied by the Young's modulus of the material. SMA of a solid circular rod is proportional to the fourth power of the radius. Young's modulus describes the gradient of the elastic part of the stress–strain curve. Ti has a Young's modulus of approximately 100GPa in comparison to around 200GPa for CoCr; changing from the former to the latter will roughly double the bending rigidity. While small differences in diameter have a relatively large effect on rigidity, a change in radius of only 0.25mm is insufficient to double the bending rigidity, increasing it by a factor of 1.4. Ti is more 'notch sensitive' than CoCr.

3. Answer E. **Larger thread depth**
While pertaining to the spine, this is a simple question about screw pull-out strength. Cannulation tends to increase core diameter, which reduces thread depth. A narrower pitch would increase pull-out strength. The key screw-based factor is increased thread depth, so is the best answer. Increased thread (outer) diameter may increase thread diameter but depends on any change to core diameter.

4. Answer B. **II**
The notochord gives rise to the nucleus pulposus of the intervertebral disc. The predominant collagen is type II. Proteoglycans, water and chondrocyte-like cells are also present.

5. Answer A. **Elastin**
The ligamentum flavum is removed as part of a lumbar decompression. It is attached to the cranial edge of the inferior vertebra and anteriorly midlamina of the superior vertebra. Its dry mass is predominantly elastin.

Paediatric Spine

6. Answer C. **Renal ultrasound**
A whole spine MRI scan in this age group requires a general anaesthetic. Whilst there is a clear association of congenital scoliosis with intraspinal abnormalities (around 30%), in the absence of neurological concerns and good motor development this can be safely deferred until he is older. A CT scan necessitates significant radiation dose. This imaging may be prompted if surgery is being considered but is not necessary at this point. There is nothing to suggest a review by a paediatrician is necessary; his motor milestones are satisfactory. Other mesodermal congenital abnormalities should be actively sought including renal and cardiac systems. A renal ultrasound is indicated. Bracing does not generally affect the natural history of congenital scoliosis so is not indicated.

7. Answer E. **Unilateral bar**
The anticipated progression of a congenital scoliosis is determined by the growth disparity on each aspect of the spine. Congenital scoliosis is classified as failure of formation, e.g. hemivertebra, failure of segmentation, e.g. bar or a mixed abnormality. McMaster and Ohtsuka (1982) described the natural history of these abnormalities, identifying that for each type of deformity the progression was greater in midthoracic abnormalities than upper thoracic-cervical and thoracolumbar worst of all. Pertinent to the question, the pattern

with the greatest progression was a unilateral bar with contralateral hemivertebrae, followed by a unilateral bar, two hemivertebrae, single hemivertebra and block vertebra in that order. Fully segmented hemivertebrae have two additional growth plates than the contralateral side so a greater progression is anticipated than a semi-segmented hemivertebra with a single additional growth plate. Unsegmented hemivertebrae and incarcerated hemivertebrae have non-additional growth plates so are usually benign.

McMaster MJ, Ohtsuka K. The natural history of congenital scoliosis: a study of two hundred and fifty-one patients. *J Bone Joint Surg Am.* 1982;**64**:1128–1147.

8. Answer E. **Observation**
This presentation is of infantile idiopathic scoliosis. He has only a mild curve. The rib phase and RVAD are reassuring that this may resolve. At this point the child needs close clinical and radiographic follow up only, every 4–6 months. At age 9 months, an MRI scan would need to be given under a general anaesthetic. In the absence of clinical findings suggestive of intraspinal abnormality with a small, potentially resolving curve, it is reasonable to hold off an MRI scan at this point. Cast treatment may be necessary if the curve is shown to progress. There is no role for growing rod or fusion surgery at this time.

Mehta MH. The rib-vertebra angle in the early diagnosis between resolving and progressive infantile scoliosis. *J Bone Joint Surg Br.* 1972;**54**:230–243.

9. Answer E. ***NF1***
The radiograph shows a short sharp upper thoracic curve with potential pencilling of ribs on the right, characteristic of a dystrophic curve associated with neurofibromatosis type 1 (NF-1). Vertebral scalloping and enlarged neuroforamina may also be seen in this condition. Scoliosis in NFM1 may also be 'non-dystrophic' and look and behave more like a typical idiopathic curve. This autosomal dominant condition is diagnosed clinically using a defined criterion and relates to a mutation in the neurofibromin 1 gene on chromosome 17. The criteria include cutaneous manifestations such as neurofibromas, axillary freckling and café au lait spots. The remaining answers relate to other genetic conditions associated with scoliosis: Duchenne muscular dystrophy (dystrophin), osteogenesis imperfecta (COL1), Marfan syndrome (FBN1) and spondyloepiphyseal dysplasia (COL2).

10. Answer C. **MRI scan of whole spine**
Despite the normal neurological examination in an otherwise well child, the presence of a left thoracic scoliosis in an adolescent necessitates investigation of the neuroaxis with MRI scan. The rate of neurological abnormality in left-sided curves is high, reported in 20–50% of cases including Chiari malformation, tethered cord, syringomyelia and diastematomyelia.

Wu L, Qiu Y, Wang B, Zhu ZZ, Ma WW. The left thoracic curve pattern: a strong predictor for neural axis abnormalities in patients with 'idiopathic' scoliosis. *Spine (Phila Pa 1976)* 2010;**35**:182–185.

11. Answer C. **Her curve is likely to progress slowly during adult life**
This is a clinical description of adolescent idiopathic scoliosis (AIS), the progression of which is largely governed by growth. The main period of curve progression is during the patient's premenarchal growth spurt, over which time curves may progress rapidly. This patient is skeletally mature, now 2 years post-menarchal and Risser grade 5 on the radiograph. However, given the curve is $>50°$ it may well still progress into adult life, but any progression over the next few years will slow, around 1°/year. RVAD is a useful measure in infantile idiopathic scoliosis, not AIS.

Weinstein SL. Idiopathic scoliosis: natural history. *Spine* 1986;**11**:780–783.

12. Answer B. **Have concerns about cosmesis**
An understanding of the long-term outcome of untreated AIS is fundamental to decision making for patients. The few available studies of long-term follow up of untreated AIS indicate that in general it is a relatively benign condition. Specifically, patients have no greater issue with childbirth, and similar life expectancy, rates of depression and general function to those unaffected. While those with untreated AIS are more likely to report back pain than those unaffected, the severity is generally mild-

moderate, occurring only occasionally, with most patients requiring analgesia only rarely. Patients consistently report increased cosmetic concerns.

13. Answer D. **Main thoracic curve**
Level selection in idiopathic scoliosis correction is controversial, but in the broadest terms fusion should include all structural curves, with the expectation that any compensatory non-structural curves will reduce spontaneously. The Lenke classification is useful in guiding level selection and defines that in the coronal plane a structural curve is one that remains $\geq 25°$ on bending X-rays. By that measure, only the main thoracic curve in this case is structural and needs treatment, a Lenke 1 curve.

Lenke LG et al. Adolescent idiopathic scoliosis: a new classification to determine extent of spinal arthrodesis. *J Bone Joint Surg Am.* 2001;**83**:1169–1181.

14. Answer A. **Cervical spine flexion/extension views**
The description is in keeping with Down's syndrome, the spinal ramifications of which include scoliosis but also atlantoaxial instability. The resultant myelopathy can present in subtle ways, including recurrent falls, altered gait and apparent clumsiness, necessitating a high degree of suspicion. Flexion/extension views of the cervical spine will identify instability, allowing diagnosis in the clinic. Further cross-sectional imaging may be undertaken before treatment following these simple investigations. As myelopathy is typically progressive, simple observation should be avoided.

15. Answer D. **Paediatric gastroenterology review**
Decision making in neuromuscular scoliosis is challenging. Long-term data would suggest curves $>40°$ before age 15 years are likely to continue to progress. Bracing is largely not helpful in neuromuscular scoliosis. Surgery is well demonstrated to improve quality of life for patients and carers, but risks are high, including wound infections, pneumonia and death. While surgery may be indicated in this case, it is important that if surgery is to be undertaken risks are minimised with appropriate medical optimisation. Given her poor nutrition, a PEG should be considered preoperatively; input from a gastroenterologist should be sought. Over this period, detailed discussions can be had with the family and wider care team regarding the potential benefits and risks of surgery in her case. Surgery, if undertaken, would likely entail posterior correction and fusion to the pelvis, given the pelvic obliquity, with an anterior release only if extremely stiff.

Saito N, Ebara S, Ohotsuka K, Kumeta H, Takaoka K. Natural history of scoliosis in spastic cerebral palsy. *Lancet* 1998;**351**:1687–1692.

16. Answer A. **Radicular pain felt onto the dorsomedial aspect of the foot**
The X-ray shows a lytic spondylolisthesis at the lumbosacral junction. This typically results in L5 nerve root compression in the foramen, rather than compression in the lateral recess as seen in degenerative spondylolisthesis. The only answer describing L5 symptoms is B. Answers A and E report L4 symptoms and answers C and D, S1 symptoms.

17. Answer D. **L4 and L5**
Lytic spondylolisthesis is most common at the L5/S1 level. The spinous process, lamina and caudal aspect of the pars remain in place with the body of L5 and more cranial spine moving anteriorly. The step is therefore felt between the L4 spinous process, which has moved anteriorly with the L5 body, and the relatively normally placed L5 spinous process (Figure 11.23).

18. Answer B. ***In situ* instrumented fusion of L5/S1 with decompression L5 nerve roots in their foramina**
The patient is suffering from both back pain and leg pain; hence, surgery must aim to stabilise the spondylolisthesis and decompress the L5 nerve roots, which are compressed in their foramina. Option C is not unreasonable but is less likely to address the leg pain. While a controversial topic in respect to high grade (3–4) spondylolisthesis, reduction is not necessary for a grade 2 spondylolisthesis and would increase the risks of L5 nerve root injury. Option D, Gaines procedure, is an option for spondyloptosis.

19 Answer D. **Blood cultures**
The description is of discitis. In a child with suspected sepsis, empirical treatment is

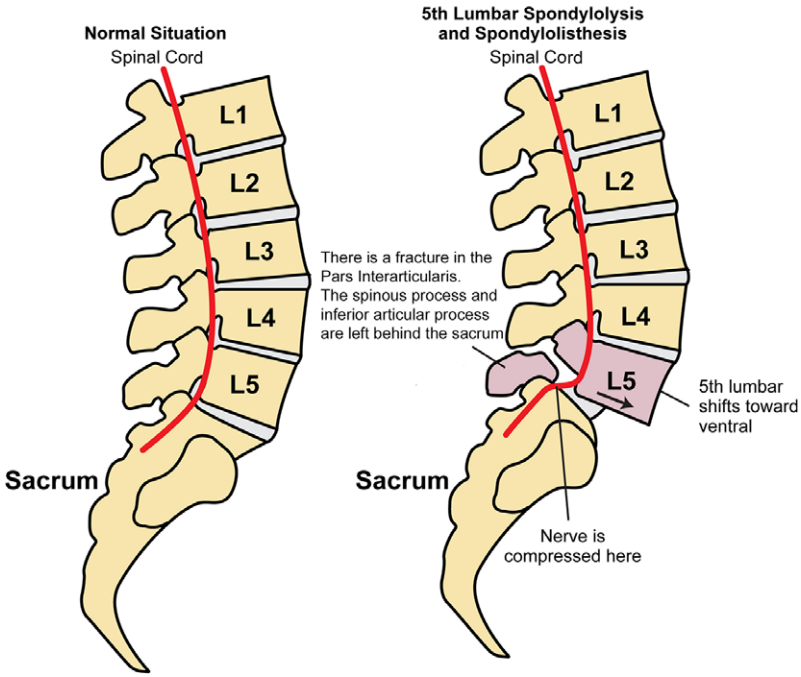


Figure 11.23 There is a fracture in the pars interarticularis. The posterior arch of L5 remains attached to the sacrum with L5 body and more cranial spine displaced anteriorly

necessary, in accordance with Surviving Sepsis Campaign Guidelines. Blood cultures should be taken, ideally before administration of antimicrobials. In an otherwise well child, *Staphylococcus aureus* is the most likely organism. Biopsy can be undertaken if the child fails to respond to empirical antibiotics. There is no significant epidural abscess shown on the scan. Bed rest and the use of orthoses are often helpful in infection, but the application is not a priority at this time.

20. Answer C. **Nine months of antimicrobials**
The history, biopsy and MRI imaging are suggestive of spinal tuberculosis. Medical management is the mainstay of treatment; 2 months of isoniazid, rifampicin, ethambutol and pyrazinamide and a further 7 months of isoniazid and rifampicin. Indications for surgery include progressive neurology, drainage of large collections to aid antimicrobial penetration and current or expected deformity. The patient has no current neurology or significant deformity. There is no mention of 'spine at risk' radiological signs as defined by Rajasekaran (2001): separation of facet joints, retropulsion of vertebrae, translation of vertebral column and the toppling anteriorly of spine cranial to the infection.

Dunn RN, Ben Husien M. Spinal tuberculosis: review of current management. *Bone Joint J.* 2018;**100-B**:425–431.

Rajasekaran S. The natural history of post-tubercular kyphosis in children: radiological signs which predict late increase in deformity. *J Bone Joint Surg Br.* 2001;**83**:954–962.

21. Answer C. **Observation clinical and radiographic follow up in 6–12 months**
The radiographs demonstrate Scheuermann's kyphosis characterised by wedging of 3 consecutive vertebrae >5° and endplate changes. She appears to be skeletally mature: Risser 4 in keeping with her age and menarchal status. A brace can be useful in those that are skeletally immature and helpful for pain and potentially improve spinal shape. Surgery may be indicated if she suffers significant progression, develops significant cosmetic concerns or intractable pain. In most centres surgery would entail posterior instrumented correction with posterior column osteotomies. However, at this time reassurance and observation is all that is required.

22. Answer: A. **Left Lateral (Right side up), 7th rib**
The patient is described as having a typical curve i.e. right thoracic. As the approach is to the convexity of the curve they should be positioned with right side up; left lateral. Given the obliquity of the ribs' visualisation is typically optimal approaching through the rib two levels above the area of interest; in this case T9, thus the 7th rib.

23. Answer D. **Short segment posterior instrumented fusion/resection of abnormality**
This is a case of progressive congenital kyphosis due to a posteriorly sited hemivertebra. Bracing will not alter the natural history of this abnormality. Given the proven progression it is likely to progress further as the child grows which may have neurological sequelae; further observation is not appropriate and surgery is indicated. The principle of treatment is to negate the growth disparity by achieving a posterior fusion. The role for resection of the congenital abnormality can be debated. Growing rods would necessitate treatment of a large section of normal spine, are ill suited to the control of kyphotic deformities and mandate recurrent operations thus are not indicated.

24. Answer D. **Spinal precautions, CT scan**
Fractures in ankylosing spondylitis are commonly poorly seen on plain X-ray. Moreover, ankylosis of the spine leads to long lever arms and a propensity for highly unstable fracture patterns. A high index of suspicion is needed to safely manage these cases with a low threshold for cross-sectional imaging.

25. Answer D. **L4/5 lateral recess stenosis**
The symptoms are of an L5 radiculopathy. From the available options, this could be caused by an L4/5 posterolateral disc prolapse or L4/5 lateral recess stenosis. In a 65-year-old, lateral recess stenosis would be the more common of the two, so is the preferred answer. L4/5 foraminal stenosis or L4/5 foraminal disc prolapse would compress the exiting L4 nerve root. Central canal stenosis rarely causes well-defined radicular symptoms.

26. Answer B. **L3/4 decompression**
The SPORT studies are of value when considering treatment for spinal stenosis. In the RCT, there was significant crossover between surgery and conservative. But when analysed 'as treated' surgery was superior at 4 years in respect to function and pain. The vignette describes L4 radicular pain secondary to lateral recess stenosis, which would be at the L3/4 level. The standing film demonstrates no spondylolisthesis. From the given information, there is no indication for fusion. Note that even in the presence of a degenerative spondylolisthesis, the indication for fusion is debatable.

Weinstein JN et al. Surgical versus nonoperative treatment for lumbar spinal stenosis four-year results of the Spine Patient Outcomes Research Trial. *Spine* 2010;**35**:1329–1338.

27. Answer E. **Superior articular process of L5**
All the options given can contribute to lateral recess stenosis. But E is the preferred answer, as the traversing nerve is typically compressed most significantly between the hypertrophic superior articular process and the vertebral body/disc in the entrance zone of the lateral recess. This contrasts with central canal stenosis where the inferior articular process and ligamentum flavum contribute most significantly.

28. Answer D. **Left L5 nerve root block +/– further injections**
This is a common clinical presentation with diffuse symptoms and widespread MRI findings. Epidural injections can be of diagnostic benefit in central stenosis, to ensure a spinal cause of claudication, but this presentation is of radicular leg pain. Medial branch blocks and discography assess the relative influence of the facet joint and disc on a patient's back pain. The most appropriate diagnostic injection would be a nerve root block with potentially further nerve root blocks depending on clinical response.

29. Answer C. **L4/5 instrumented fusion and decompression central canal and L5 nerve roots in lateral recesses**
The patient is presenting with degenerative spondylolisthesis at L4/5. This is characteristically associated with L5 nerve root compression in the nerves' lateral recesses and central canal stenosis; hence, decompression will need to address these areas. The indications for fusion in

degenerative spondylolisthesis are debatable. Patient's age and likely bone quality influence decision making. Facet joint effusions and cyst and sagittally oriented facets are often considered relative indications for fusion to limit cyst recurrence and iatrogenic instability.

30. Answer C. **C4 and C5**
Jobe's test is predominantly of the supraspinatus, supplied by C5. The C5 nerve leaves between the pedicles of C4 and C5 where it can be commonly compressed by a pathology such as a posterolateral C4/5 disc prolapse.

31. Answer E. **Neurophysiological studies**
The differential is of a C8 nerve compression or a peripheral nerve lesion. The absence of brachialgia, dermatomal and myotomal neurological findings suggests a peripheral nerve lesion. The examination findings suggest ulna nerve compression in Guyon's canal. Being purely sensory, this is likely to be distal to the deep motor branch (zone 3). The commonest causes in this area are ulna artery thrombosis and aneurysm. Nerve conduction studies are the most appropriate investigation at this time. If these do show ulna nerve compression, further imaging could be arranged.

32. Answer E. **Reassurance, analgesia and mobilisation**
The MRI shows multilevel degenerative changes, the axial image demonstrates disc osteophyte complexes compressing the exiting C6 nerve roots. This man presents with axial pain, potentially discogenic in origin. He has no radicular symptoms or signs nor myelopathic features; hence, there is no indication for nerve root blocks or surgery. The patient should be reassured at this point that there is no sinister cause for his pain, and symptomatic management is required. If initial management between the patient and GP is unsuccessful, onward pain referral may be necessary, but a trial of simple measures is most appropriate at this point.

33. Answer C. **Cervical disc/osteophyte complex**
The presentation is one of cervical radiculomyelopathy. All the available options can result in myelopathy. From the answers offered, disc-osteophyte complex is the most likely. OPLL is a common cause in the Asian population, particularly males. AAI is seen predominately in inflammatory arthritis. The patient is described as otherwise well, and an initial presentation of inflammatory arthritis with AAI is very rare. Thoracic disc prolapse can result in lower limb upper motor neuron signs but would not explain her brachialgia or reduced hand function.

34. Answer A. **Ilio-lumbar vein**
The retroperitoneal approach to the lower lumbar spine requires vessel mobilisation to access the disc spaces. All the answers given could lead to significant bleeding. When accessing the L5/S1 disc, the median sacral vessels must be mobilised and/or ligated. To access the L4/5 disc, the iliac vessels are mobilised to the right; the ascending ilio-lumbar vein may need ligation to allow this.

35. Answer C. **Continued conservative treatment will likely result in similar resolution of leg pain at 1 year as surgery**
The MRI shows a left-sided posterolateral disc prolapse at L5/S1 with resultant S1 nerve root compression. While surgery is commonly undertaken if radicular leg pain secondary to disc prolapse fails to settle after 6–12 weeks, it is vital to understand the natural history of this pathology. In an important RCT, Peul et al. (2007) randomised patients who had severe sciatica for 6–12 weeks to microdiscectomy or conservative treatment. While there was some crossover from conservative to surgery over the course of follow up, the results are of significance. Surgery led to a more rapid reduction in leg pain. At 1 year, the leg pain, back pain and Roland Disability Questionnaire scores were similar. Measures of the total disability during the year were also similar between the groups. Post-operative recurrence of sciatica leading to revision surgery within 1 year was 3%.

Peul WC et al.; Leiden – The Hague Spine Intervention Prognostic Study Group. Surgery versus prolonged conservative treatment for sciatica. *N Engl J Med.* 2007;**356**:2245–2256.

36. Answer A. **C1–C2 fusion**
The history is one of myelopathy; given the history of rheumatoid arthritis, cervical instability is

the most likely underlying diagnosis. Given the reduced PADI (abnormal: <14mm), atlantoaxial instability is present. The tip of the dens is below the McRae line, and the Ranawat's index (abnormal <13mm female, <15mm male) suggests basilar invagination is not present. There is no suggestion of subaxial instability. Given this, the treatment of choice is C1–2 fusion.

37. Answer A. **Carotid sheath and pretracheal fascia**
The anterior approach to the cervical spine involved cutting or splitting the platysma muscle to identify and split the deep investing layer of cervical fascia and develop a plane between the carotid sheath and pretracheal fascia. The prevertebral fascia is incised and longus colli retracted to expose the spine.

38. Answer B. **IV antibiotics**
This man has discitis. He has grown a characteristic organism from his blood cultures, so antibiotics can be tailored according to these sensitivities. A biopsy may be of use if he fails to improve on appropriate IV antibiotics. Stabilisation is useful in resistant infections or the presence of instability. There is nothing to suggest decompression is necessary.

39. Answer B. **Enhancement in the vertebral body with preservation of the adjacent discs and elevation of the anterior longitudinal ligament**
The history is suggestive of spinal infection or malignancy. The Mantoux test confirms tuberculosis exposure. Characteristically, in contrast to pyogenic infection described in A, TB infection starts in the vertebral body, with preservation of the adjacent discs, C. While significant bone loss and deformity can occur, as described in D he is likely to have neurological findings in the presence of myelomalacia. B is suggestive of spinal metastases. E suggests osteoid osteoma/osteoblastoma.

40. Answer B. **A poor correlation exists between clinical finding and MRI findings**
Clinical finding and MRI appearances correlate poorly. MRI is still the gold standard means of making a diagnosis. A post void residual volume of less than 200 ml has a negative predictive value of 97% for CES. A PVR volume of 550ml is a strongly predictive measure of CES, but the diagnosis requires confirmation rapidly with an emergency MRI scan, and assuming the diagnosis is confirmed emergent surgery – this is a time-dependent condition (Venkatesan et al. 2019). PR is a poor test of nerve function – it is neither sensitive nor specific. However, PR examination needs to be documented during a patient's assessment along with other neurological tests. It is correct however that the cauda equina nerves do respond poorly to pressure as shown by animal models and have a poorly developed myelin sheath. Historically, 24h was thought to be an important time for neurological recovery, but the more we learn we see that CES is a time-dependent condition. The timing varies for different patients. Each patient needs to be treated with rapid assessment, diagnosis and surgery. 24 hours may or may not be critical for an individual patient.

Venkatesan M, Nasto L, Tsegaye M, Grevitt M. Bladder scans and postvoid residual volume measurement improve diagnostic accuracy of cauda equina syndrome. *Spine* 2019;**44**:1303–1308.

41. Answer D. **When operated on an anterior approach or a costo-transversectomy is considered lower risk for neurological deterioration than laminectomy**
Upper thoracic disc protrusion is seen uncommonly, most occurring in the lower thoracic spine and seen more commonly in Scheuermann's disease. The anterior spinal tracts are usually affected as the compression is anterior resulting in motor and proprioceptive problems. Calcification occurs in up to 40% of cases which is seen well on CT scan, making this a useful pre-operative workup. They are solid pieces of disc: hard to remove. Access to the disc can be performed through an anterior transthoracic or various postero-lateral approaches often involving costo-transversectomy. Laminectomy is associated with high neurological complication rates given cord retraction is likely required to access the disc.

42. Answer E. **The overall complication rate for lumbar decompression is around 12%**
Every patient must be fully consented regarding the potential for complications following all

surgeries. Paralysis is a devastating complication that can occur following any spinal surgery. Dysphagia after ACDF is common, as high as 80% in the days following surgery. Usually it improves quickly and resolves, but patients need to be warned of this (Okaro et al. 2021). The incidence of dural tear following lumbar discectomy is approximately 1% (Weinstein et al. 2006). Most are managed at the time of surgery with either repair, glue or patch. Bed rest for 24–48 hours may be required with the majority resolving with no long-term problems. The risk of C5 palsy is 5% following posterior cervical surgery, but the prognosis is good with most patients recovering their shoulder function with time. It is thought to be due to the anatomical course of the nerve (Liu et al. 2021). The overall complication rate following lumbar decompression is 12% which also rises with age and comorbidities (Li et al. 2008).

Li G et al. Effects of age and comorbidities on complication rates and adverse outcomes after lumbar laminectomy in elderly patients. *Spine (Phila Pa 1976)* 2008;**33**:1250–1255.

Liu B et al. Analysis of risk factors for C5 nerve root paralysis after posterior cervical decompression. *BMC Musculoskelet Disord.* 2021;**22**:614.

Nasser R et al. Complications in spine surgery. *J Neurosurg Spine* 2010;**13**:144–157.

Okaro I et al. Risk factors for postoperative dysphagia and dysphonia following anterior cervical spine surgery: a comprehensive study utilizing the hospital for special surgery dysphagia and dysphonia inventory (HSS-DDI). *Spine J.* 2021;**21**:1080–1088.

Weinstein JN et al. Surgical vs nonoperative treatment for lumbar disk herniation: the Spine Patient Outcomes Research Trial (SPORT) observational cohort. *J Am Med Assoc.* 2006;**296**:2451–2459.

43. Answer: D **Open spinal decompression/drainage and sampling**
The history is in keeping with spinal infection. The MRI shows a large epidural collection. At this time he remains pyrexial with little change in inflammatory markers despite antibiotics. The organism is yet to be defined. It is logical to drain the epidural abscess to achieve source control and aid identification of an organism. There is no sign of instability to suggest instrumentation is necessary. An ECHO is warranted to assess for a source of the infection such as endocarditis, but treatment of infection is the main priority currently. Working closely with microbiology/infectious diseases is crucial in such cases, whose decision making regarding antimicrobials would be aided by a sample of the infection. Cross-sectional imaging may be useful if his infection fails to settle despite abscess drainage and appropriate antibiotics over the coming days.

Trauma

44. Answer A. **Ipsilateral weakness with contralateral loss of pain and temperature**
D described a central cord; E, anterior; C, posterior; and E, Brown-Séquard syndrome. B describes complete cord injury. Brown-Séquard carries the best prognosis.

45. Answer A. **A C5**
His bulbocavernosus reflex is present, indicating the patient is no longer in spinal shock and his neurological injury can be classified. He has no sacral sparing, indicating a complete cord injury (ASIA A). The most caudal level with motor power $\geq$3 and intact sensation is C5, indicating the neurological level of injury.

American Spinal Injury Association. *International Standards for Neurological Classification of Spinal Cord Injury*; 2019.

46. Answer A. **Avulsion fractures of occipital condyles**
Occipital condyle fractures extending into the base of the skull tend to be stable in comparison to avulsion fractures, which are more suggestive of OCD. The Powers ratio, measured on the lateral radiograph, suggests an anterior OCD when the distance between the basion and posterior arch of C1 is greater than the distance from the opisthion to the anterior arch of C1, i.e. ratio >1.0. Harris's rule of 12 states a BDI and BAI <12mm to be within the normal range.

47. Answer E. **Transverse ligament is NOT disrupted and C1–C2 fusion is NOT indicated**
The CT shows fractures of the anterior and posterior arch of C1 on the right side. The left arch is

incompletely seen on this axial cut; in any case, the question details that the injury is right sided. The coronal image demonstrates no significant displacement and no overhang of the lateral masses of C1 on C2. In other cases, a combined overhang of >6.9mm (8mm on plain film allowing for magnification) suggests the transverse ligament is disrupted and the fracture is unstable, necessitating surgery by way of C1–2 arthrodesis or at least rigid external orthosis, e.g. halo. The injury in this case, with seemingly intact transverse ligament, is considered stable and can be managed in a collar.

48. Answer D. **Rigid cervical orthosis**
This describes a type III fracture via the Anderson and D'Alonzo classification, which has a high rate of union and in the absence of significant displacement can be managed non-operatively. Alignment can be maintained while union occurs with a cervical collar or halo jacket. Anterior screw fixation is an option for type II fractures. C1–C2 fusion is an option acutely in grossly displaced type II fractures or in the setting of fracture non-union. Goel-Harms type fixation involves stabilisation with rods and screws gaining purchase with C1 lateral mass screws and C2 pedicle screws.

49. Answer D. **Non-union**
Application of a halo vest in the elderly is associated with significant morbidity and mortality, around 50% and 40%, respectively. However, several studies suggest a higher union rate with halo vest vs semi-rigid collar. It can be argued that a stable fibrous union is a satisfactory outcome in a frail elderly patient, with the chance of late neurological deterioration with myelopathy reportedly very small.

50. Answer D. **MRI scan**
This CT shows anterolisthesis of over 50% of C6 on C7 due to bifacetal dislocations, seen on the parasagittal images. The patient has an incomplete cord injury and concomitant head injury. This is a controversial topic, in particular the need for an MRI scan before reduction, to identify a disc injury that may cause cord injury on reduction. Cervical traction, without MRI scan, is suitable management for a patient with a neurological injury who is alert and able to comply with serial examinations, to allow removal of traction if a neurological deterioration occurs. In a patient who cannot comply with serial examinations, e.g. intoxicated, intubated or head injury or the patient is neurologically intact, an MRI is indicated, prior to reduction. The use of steroids in cord injury is another controversial topic, with the NASCIS trials open to interpretation. Most centres in the UK, in keeping with the UK NICE guidelines, do not use steroids in acute cord injury. The patient requires reduction and stabilisation, not a halo jacket.

51. Answer E. **The patient can be considered to have a 'stable' spine. All cervical protection can be removed, and the patient positioned carefully in theatre**
Maintenance of spinal precautions can lead to morbidity and practical issues in ITU. MRI scans are also impractical. A fine-cut CT scan reported by a senior radiologist is sufficient to clear the spine, allowing removal of spinal protective devices. Naturally, any trauma patient should be carefully positioned intraoperatively. Isolated lumbar spine transverse process fractures are of no structural consequence. Log-rolling is to be avoided, if at all possible, in the setting of an unstable pelvic fracture.

British Orthopaedic Association Standard for Trauma (BOAST). *BOAST 2 Spinal Clearance in the Trauma Patient*; 2008.

52. Answer D. **Osseoligamentous flexion distraction injury**
The history, clinical findings and CT are in keeping with an AOSpine B2 injury (osseoligamentous flexion distraction injury). This involves loss of the posterior tension band suggested by the posterior tenderness and swelling, the distraction between spinous processes of T12 and L1 as well as potential avulsion fracture from the spinous process of T12 on CT. While there is an associated body fracture (incomplete burst, AO A3), the distraction element is the key aspect in understanding the fracture pattern. Erect radiographs are important in fracture management, with measurements made on supine imaging less informative.

53. Answer E. **Surgery; short segment fixation T12–L2/L3 with fusion**
This is an unstable pattern and surgery is indicated. Posterior ligamentous healing is unpredictable, so fusion is indicated across the disrupted soft tissues, in this case, T12–L1. There is a minor body fracture of L2 hence instrumentation may need to extend to L3 depending on screw purchase. Long segment fixation or anterior + short segment posterior surgery is more often indicated in type C injuries and those with significant vertebral body fragmentation and displacement.

The Thoracolumbar Injury Classification and Severity Score (TLICS) can be applied, scoring 7 [Morphology = distraction (4), posterior ligamentous complex = disrupted (3), neurologically = intact (0)] indicating surgery.

Vaccaro AR et al. A new classification of thoracolumbar injuries: the importance of injury morphology, the integrity of the posterior ligamentous complex, and neurologic status. *Spine* 2005;**30**:2325–2333.

Vaccaro AR et al.; AOSpine Spinal Cord Injury & Trauma Knowledge Forum. AOSpine thoracolumbar spine injury classification system: fracture description, neurological status, and key modifiers. *Spine* 2013;**38**:2028–2037.

54. Answer B. **Burst fracture**
The vertebral body fracture involves the posterior wall, indicating a burst pattern of the body, which would be A4 by the AOSpine classification. There is no suggestion clinically or radiologically of injury to the posterior tension band, which would indicate a flexion-distraction, AO B type injury. There is no translation or rotation, C type features.

55. Answer C. **Mobilisation and standing radiographs when pain allows**
The description is of a burst fracture in good alignment on supine imaging with a patient showing some nerve root irritation but no other neurological concerns. An MRI could be of use to further image the posterior ligamentous complex but can be difficult to interpret in the trauma setting. A trial of conservative management is appropriate with standing radiographs once patient is able. A failure to mobilise in a few days to get the radiographs or significant kyphosis on standing would necessitate a re-evaluation of diagnosis and treatment with consideration of surgery.

The Thoracolumbar Injury Classification and Severity Score (TLICS) can be applied, scoring 4 [Morphology = burst (2), posterior ligamentous complex = intact (0), neurologically = nerve root (arguably scores 2)], suggesting conservative management.

Jaffray DC, Eisenstein SM, Balain B, Trivedi JM, Newton Ede M. Early mobilisation of thoracolumbar burst fractures without neurology: a natural history observation. *Bone Joint J.* 2016;**98-B**:97–101.

Mehta JS, Reed MR, McVie JL, Sanderson PL. Weight-bearing radiographs in thoracolumbar fractures: do they influence management? *Spine* 2004;**29**:564–567.

56. Answer: D: **Posterior instrumented fusion with long construct**
This patient has a grossly unstable T12/L1 C pattern spinal injury with associated spinal cord injury and visceral injury. She is described as haemodynamically stable and lab results confirm this, thus further resus is not necessary. An MRI scan may be indicated in due course but is not likely to change the spinal surgical plan at this time. Immediate spinal stabilisation will help limit secondary cord injury, allow the general surgical treatment to be carried out in a more stable environment and avoid stress on any surgical repairs that prone positioning for spinal stabilisation would necessitate. Methylprednisolone is not indicated.

57. Answer B. **HLA B27 positive patients have a better clinical response to tumour necrosis factor inhibitors and an earlier age at diagnosis compared with HLA B27 negative patients**
Although there are many similarities among AS patients possessing HLA-B27 and those lacking this gene, the former group has a younger age of onset, a shorter delay in diagnosis and a better clinical response to tumour necrosis factor inhibitors (Akkoç et al. 2017). Any patient with ankylosing spondylitis presenting following an injury – no matter how minor, should be assumed to have a fracture until proven

otherwise. A radiograph is not sensitive in this pathology. The whole spine should be imaged with CT scan and surgeons should have a low threshold for MRI if negative: a negative CT does not exclude a fracture. Fractures in the setting of ankylosis are typically unstable given the long lever arms involved and usually require operative treatment with long segment instrumentation at least 3 levels above and below the fracture. These spines are osteoporotic, but these injuries have a high neurological complication rate both at presentation, whilst awaiting treatment and after surgery (Schwendner et al. 2021). Patients with ankylosing spondylitis typically have significant kyphotic deformity thus nursing flat in the presence of a fracture may effectively perform an extension osteotomy for the patient and result in a neurological deficit. The patient needs to be nursed in the natural position of their spine usually propped up with pillows to mimic the kyphosed 'normal' position of their spine.

Akkoç N, Yarkan H, Kenar G, Khan MA. Ankylosing spondylitis: HLA-B*27-positive versus HLA-B*27-negative disease. *Curr Rheumatol Rep.* 2017;**19**:26.

Schwendner M, Seule M, Meyer B, Krieg SM. Management of spine fractures in ankylosing spondylitis and diffuse idiopathic skeletal hyperostosis: a challenge. *Neurosurgical focus*, 2021;**51**:E2.

58. Answer B. **Autonomic dysreflexia is a relatively uncommon but life-threatening condition in people who have a spinal cord injury above the level of T6**

The national guidelines from the British Association of Spinal Cord Injury Specialists state that at all times the mean arterial pressure should be kept above 80mmHg and a systolic pressure above 90mmHg – in order to allow adequate perfusion of the injured spinal cord. The ASIA scoring system is an invaluable means of classifying and monitoring spinal injuries. The impairment scale ranges from A – complete to E – normal, with ASIA C 'motor incomplete'. The risk of venous thrombosis is very high in patients with SCI and in particular fatal PE. UK guidelines support both physical and chemical prophylaxis upon hospital admission to reduce this risk (Gall et al. 2008). It is very important to recognise autonomic dysreflexia: a potentially life-threatening condition. The most common causes of autonomic dysreflexia are bladder and bowel distension. Symptoms and signs include raised BP, bradycardia, pounding headache, flushing, sweating or blotching above level of injury; pale, cold, goosebumps below level of injury. It requires immediate treatment. Paralysed patients are at risk of developing painful spasms and contractures leading to musculoskeletal pain. These need to be treated with analgesia, physiotherapy and splints.

BOAST. *Boast – The Management of Traumatic Spinal Cord Injury*; 2022. https://www.boa.ac.uk/resources/knowledge-hub/boast-8-pdf.html.

Gall A, Turner-Stokes L, Guideline Development Group. Chronic spinal cord injury: management of patients in acute hospital settings. *Clinical Medicine (London, England)* 2008;**8**:70–74.

National Institute for Health and Care Excellence (NICE). *Recommendations: Spinal injury: Assessment and initial management: Guidance*; 2016. https://www.nice.org.uk/guidance/ng41/chapter/Recommendations#communication-with-tertiary-services.

Tumour

59. Answer D. **Notochord**

The history and histology description are characteristic of a chordoma. The vacuolated cells on biopsy are typically described as physaliferous. This develops from primitive notochordal tissue, which forms within the mesoderm in the midline of the embryo. Surgery is undertaken when possible with wide margin resection.

60. Answer B. **CT scan chest, abdomen and pelvis**

The MRI scan shows likely metastatic lesions to L2, L3 and L4, with marrow replacement showing dark on T1, with some compression of the cauda equina on the axial image. A haemangioma shows high signal in both the T1- and T2-weighted sequences. While radiologically there is compression of the cauda equina, the patient at this point has no neurological signs or symptoms. Before any sort of treatment can be considered, the lesion must be staged and

graded. A CT scan to look for a primary metastasis and assess for other metastases would be a logical next step, along with blood markers including PSA. Further treatments will depend on the investigations and clinical picture.

61. Answer C. **Decompression and stabilisation**
This is a presentation of metastatic prostate cancer with cord compression. Decision making in these cases is not straightforward. Scoring systems such as Tokuhashi are of some use, but the specifics of these systems are likely beyond the level of the FRCS exam. But most surgeons would agree that in a patient presenting with good background function and life expectancy over 3 months, progressive weakness and who at this point is ambulatory, surgery is indicated. Biopsy is preferable to confirm a diagnosis before treatment but would lead to unacceptable delay in this case, given the progressive neurology. Level 1 evidence by Patchell et al. (2005) has identified that surgical decompression and stabilisation lead to better outcomes than radiotherapy alone. Likewise, decompressive laminectomy alone is rarely indicated, as the cord compression tends to be anterior, as in this case, and posterior decompression may result in instability. En bloc excision is not indicated in widespread metastatic disease.

Patchell RA et al. Direct decompressive surgical resection in the treatment of spinal cord compression caused by metastatic cancer: a randomised trial. *Lancet* 2005;**366**:643–648.

Tokuhashi Y, Matsuzaki H, Oda H, Oshima M, Ryu J. A revised scoring system for preoperative evaluation of metastatic spine tumor prognosis. *Spine (Phila Pa 1976)* 2005;**30**:2186–2191.

62. Answer D. **The pathological lesion tends to be placed on the concavity of the scoliosis**
The description is classically of an osteoid osteoma, which tends to affect the posterior elements of the spine. By definition, the radiolucent nidus is <1cm. The lesion tends to be placed on the concavity of a scoliosis, presumably resulting in spasm to initiate the curve. Radiofrequency ablation is commonly used in treatment of peripheral skeletal osteoid osteomas, but intralesional resection is the treatment of choice in the spine, with low recurrence rates.

63. Answer C. **Observation**
The lesion is characteristic of a haemangioma, which is likely a chance finding given the location of her pain relative to the lesion. This benign lesion typically requires no treatment. On rare occasions, when associated with unremitting pain, vertebroplasty, curettage or resection and reconstruction can be undertaken.

64. Answer A. **Medical management**
This history and investigations suggest multiple myeloma. In general, this condition is treated medically and rarely requires spinal surgery. At this time medical management of his chemotherapy by a haematologist/oncologist is appropriate. He has no clinical signs of metastatic cord compression; decompression is not indicated. As he is ambulating freely with normal alignment, no loss of height or posterior structure involvement on scan the spine is likely stable; stabilisation is not indicated. Vertebroplasty or kyphoplasty can be indicated for pain relief and is commonly effective in cases of myeloma with refractory pain despite adequate treatment of myeloma and analgesia. Radiotherapy could also be indicated.

65. Answer A. **Bilobed eosinophils**
Langerhans cells histiocytosis is a proliferation of dendritic cells within the vertebral body. This may lead to collapse and a characteristic vertebra plana. On biopsy, bilobed 'coffee bean' eosinophils in eosinophilic cytoplasm are characteristic. On electron microscopy, tennis racquet-shaped 'Birbeck granules' are seen.

D is in keeping with osteosarcoma. Small round blue cells are seen in several tumours, including Ewing's sarcoma. B is characteristic of myeloma. Giant cells may be seen in LCH but are more in keeping with a giant cell tumour.

66. Answer E. **RANKL antagonist**
Denosumab is a RANKL antagonist increasingly used in the management of GCTs, bone metastases and osteoporosis. RANKL is produced by osteoblasts in response to tumour-produced PTHrP. RANKL binds RANKL receptors on the osteoclast, increasing bone resorption. Osteoprotegerin is the physiological antagonist to RANKL. Inhibition of farnesyl pyrophosphate synthase is a mechanism of action of aminobisphosphonates.

67. Answer A. **Administer oral dexamethasone**
This is clearly a case of metastatic spinal cord compression. Given the symptoms have been progressing slowly over 5 days, MRI imaging could safely be undertaken at the DGH first thing in the morning as there is no role for emergent, out-of-hours, surgery in this case. Dexamethasone should be given and may improve or stabilise the neurological picture to allow suitable workup to be completed, including a CT of chest, abdomen and pelvis. From the available information, surgery is likely indicated and offers the patient a better outcome than radiotherapy (see Question 39).

68. Answer B. **Posterior stabilisation**
This patient presents with metastatic spinal disease manifesting in instability pain based upon the history and imaging description provided. He has no clinical cord/cauda equina compression to suggest decompression is necessary at this point. Vertebroplasty or radiotherapy will not address the mechanical instability of the spine. Stabilisation is indicated.

The Spinal Instability Neoplasic Score can be applied in theses settings (SINS). This case scores 14 [region = junctional (3), mechanical pain].

Fisher CG et al. A novel classification system for spinal instability in neoplastic disease: an evidence-based approach and expert consensus from the Spine Oncology Study Group. *Spine (Phila Pa 1976)* 2010;**35**:E1221–9.

69. Answer B. **Biopsy**
The history and imaging are suggestive of an isolated renal cell metastasis, but biopsy must be undertaken to confirm the clinical picture. Embolisation would result in tumour necrosis and compromise the yield from a biopsy. But embolisation would be advisable before surgery, which would most likely be en bloc resection and reconstruction in the setting of a truly isolated renal cell metastasis.

Chapter 12

Spine II Structured SBA

Prasad Karpe

SPINE II STRUCTURED SBA QUESTIONS

1. A 40-year-old patient with a background of ankylosing spondylitis with spinal deformities has arrived at the ED after an RTA at 70 mph. He is conscious and speaking, with a blood pressure of 90/60 mm Hg and HR of 120.
   Which of the following is likely to negatively affect the outcome of this patient?
   A. Assess airway and breathing and start high-flow oxygen
   B. FAST scan
   C. Pass 2 large IV bore lines and assess for sites of bleeding
   D. Trauma CT scan
   E. Triple immobilisation of the cervical spine with rigid collar

2. **Which of the following statements is true regarding pelvic incidence?**
   A. It changes with posture like other parameters of pelvic morphology
   B. It is pelvic tilt minus the sacral slope
   C. It is the angle formed between a line drawn from the centre of the S1 end plate to the centre of the femoral head and a second line drawn perpendicular to the S1 end plate, intersecting it at the centre
   D. Lower pelvic incidence necessitates more lumbar lordosis to maintain sagittal balance
   E. There is no correlation between pelvic incidence and the Meyerding grade of spondylolisthesis

3. A 13-year-old girl is seen in the paediatric clinic with scoliosis. It was noticed by her mother 18 months ago that it is gradually getting worse.
   Which of the following is not an indication of MRI scan of the full spine?
   A. Asymmetric abdominal reflexes on examination
   B. Axillary and inguinal freckling on examination
   C. Left-sided curve on X-rays
   D. Rib prominence on forward bending
   E. Right-sided short angular curve on X-rays

4. An 8-year-old boy has come to the orthopaedics clinic with back pain and scoliosis. The boy's mum mentions that the pain is more prevalent at night and has responded to anti-inflammatory agents.
   Which of the following is the only TRUE statement about this condition?
   A. Fine cuts of CT and MRI scan help best in determining treatment plan
   B. It is larger than 2cm in diameter
   C. It is most often present with neurological deficit
   D. Radiofrequency is the first line of treatment in all lesions
   E. The lesion is typically present on the convex side of the scoliosis

5. A 40-year-old man has arrived in the ED with penetrating injury to his upper abdomen. His BP is 100, HR 110 and RR 20. He has 15/15 GCS and normal neurology in all four limbs.
   His CT shows minimal tear to his descending aorta with no bony injuries. He undergoes laparotomy with repair of the descending aorta. His surgery lasts for 4 hours under general anaesthesia, with his blood pressure always above 110mmHg. Post-operatively he wakes up with weakness of the muscles in his foot, reduced sensations in both lower limbs but intact proprioception. His power, sensations and proprioception are normal in both upper limbs. His

blood pressure now is 120mmHg, HR 90, SaO_2 100% on 2 litres of oxygen, RR 18.

Which of the following is the MOST likely cause of the patient's weakness?

A. Central cord syndrome
B. Damage to feeding vessel from the left side between T8 and L1
C. Neurogenic shock
D. Posterior cord syndrome
E. Spinal shock

6. A 60-year-old man with a background of hypertension has been referred by his GP with symptoms of low back pain, neurogenic claudication and gait disturbances. On examination, he has brisk reflexes in all four limbs and 4/5 power in all four limbs. He denies any symptoms of bowel or bladder dysfunction. His lumbar spine is tender in the region of the facets, and lumbar extension is painful. Both pedal pulsations are well felt. His GP has already performed an MRI of the lumbar spine that shows severe canal stenosis at L3/4 and L4/5.

The NEXT most appropriate step in the management of this patient is which of the following?

A. Facet joint injections lumbar spine
B. Laminectomy L3–L5
C. Laminectomy, medial facetectomy and instrumented fusion
D. MRI of cervical and thoracic spine
E. Transforaminal interbody fusion L3/4 and L4/5

7. **Which of the following is a true statement regarding the Smith–Robinson (anterior cervical spine) approach?**

A. Dissection of the longus colli muscle risks damage to the parasympathetic chain
B. Hyoid bone roughly lines up with C5
C. The location of the maxilla decides the ease of access to the C2/3 disc
D. The superficial fascia, pretracheal fascia and prevertebral fascia are encountered from superficial to deep
E. Utilises the plane between the carotid sheath laterally and the trachea with internal jugular medially

8. A 68-year-old female sustains an osteoporotic fracture. After failure of conservative treatment, she undergoes vertebroplasty.

Which of the following statements is correct regarding this procedure?

A. Chemical destruction of the nerve endings due to chemical composition of the cement has been proposed
B. Vertebroplasty has more advantages than kyphoplasty
C. Vertebroplasty is indicated in patients with ongoing pain after recent unhealed fracture, pain confirmed at the level of fracture by examination and MRI showing low signal on T2
D. It works by destruction of the nerve endings due to extreme low temperature reached by the polymerisation of the injected cement
E. It works by stabilisation of the fractured bone by forming a chemical bond

9. An 8-year-old boy presents with fever and low back pain. He is very tender in the L2/3 region. Hip and knee examinations are normal. His inflammatory markers are raised.

Which of the following is a true statement about this condition?

A. Disc space narrowing is the earliest radiographic sign
B. Batson plexus is the most common pathway of mode of spread to spine
C. Most common organism is *Staphylococcus aureus*
D. CT imaging is the investigation of choice
E. Vertebral end plates get infected first

10. **Which of the following is not an imaging finding for spinal infection in adults?**

A. Loss of disc height and abnormal disc signal
B. Loss of end plate definition on both sides of the disc
C. Paraspinal soft tissue or loculated fluid collection
D. Posterior elements are most commonly affected
E. Vertebral collapse

11. **The root value of the ankle reflex is which of the following?**

A. L3/L4
B. L4/L5
C. L5/S1
D. S1/S2
E. S2/S3

12. An 11-year-old girl comes to the spinal clinic with recent onset of noticing deformity. She has no neurology in her legs and no generalised syndromic features. AP radiograph of her spine is as depicted in Figure 12.1.

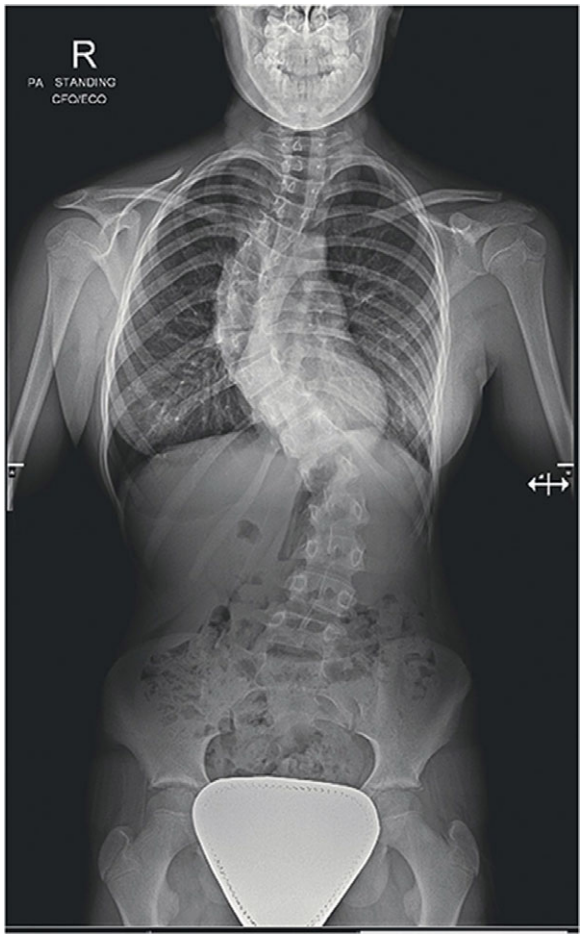


Figure 12.1 AP radiograph spine

Which of the following is an ideal indication of a brace?

A. Curves greater than 40°
B. Overweight adolescent patients with curve progression
C. Patients unable to cope emotionally with treatment
D. Thoracic lordosis
E. Skeletally immature patients

13. A 4-year-old boy is brought unconscious to the ED with a history of a motor vehicle accident.

Which of the following is true about paediatric spinal trauma?

A. Injury to the spinal cord can only happen with visible changes on X-rays and CT scan
B. CT scan is the investigation to diagnose injury to the cord and ligament injuries
C. Upper cervical trauma is more common in children younger than 8 years of age
D. The child should be immobilised on a standard spinal board
E. There can be a normal anterior translation between C5 and C6

14. A 30-year-old male ankylosing spondylitis patient with kyphosis needs a sagittal correction spinal procedure.

Which of the following statements correctly describes pedicle subtraction osteotomy?

A. Correction happens at the level of the vertebral body and not the disc
B. It opens up the anterior column, closes the middle column somewhat and closes the posterior column
C. It is classically performed at T11/T12 vertebrae
D. It provides more correction than Smith-Petersen osteotomy and vertebral column resection
E. PSO is associated with fewer complications

15. **All of the following are true about radiology in ankylosing spondylitis EXCEPT which answer?**

A. 50% of ankylosing spondylitis patients with fractures can have normal-looking X-rays
B. The earliest sign on pelvic X-rays is erosion on the iliac side of sacroiliac joint
C. Marginal syndesmophytes are present in the vertebrae
D. MRI is the modality for early detection of ankylosing spondylitis
E. Sacroiliac joint involvement is often asymmetric

16. A 40-year-old man visits a clinic, complaining of chronic back pain. There are no red flags on history or abnormalities on examination.

Which of the following is the most appropriate method of treatment?

A. Acupuncture
B. Caudal epidural injection
C. Combined physical and psychological programmes

D. Lumbar corset or belt
E. Opioid analgesics

17. **Which of the following statements about spine anatomy is true?**
A. The cell bodies of the sympathetic nervous system are found in the lateral horn grey matter of spinal cord segments T7–T9
B. The preganglionic sympathetic preganglionic cell bodies lie in sacral segments S2, S3, S4
C. The C8 nerve exits the foramen superior to the pedicle of C7
D. The inferior limit of the spinal cord in adults is L1 or L2
E. The inferior limit of the dural sac and subarachnoid space is the L2 vertebra

18. A 30-year-old man has been brought to the ED after a motor vehicle accident. He appears drowsy and a trauma CT shows a small contusion in the brain with 50% subluxation of the C6/7 vertebrae. He has triple immobilisation in place. He is also seen by neurosurgeons who say he is able to undergo any cervical procedures.
The most appropriate next step in management of this patient is which of the following?
A. Anterior cervical fusion
B. Cervical orthosis for 6 weeks
C. Immediate closed reduction of the subluxation
D. MRI scan
E. Posterior cervical fusion

19. **A patient with T4 spinal cord injury and paraplegia is not likely to have which of the following complications?**
A. Autonomic dysreflexia
B. Major depressive episode
C. Orthostatic hypertension
D. Urosepsis
E. Venous thromboembolism

20. **Which of the following pelvic parameters does not change on posture?**
A. Lumbar lordosis
B. Pelvic incidence
C. Pelvic tilt
D. Sacral slope
E. Sagittal vertical axis

21. Ankylosing spondylitis (AS) and DISH (Diffuse Idiopathic Skeletal Hyperostosis) can mimic each other.
Which of the following is a correct statement when differentiating the two?
A. AS have normal discs while with DISH the discs could be ossified
B. The facet joints are normal in AS whilst fused in DISH
C. Unilateral sacroiliac joints are involved in DISH whilst bilateral in AS
D. There is ossification of ligaments and entheses in DISH while erosive enthesopathy in AS
E. Marginal syndesmophytes in DISH and flowing periosteal reaction/non-marginal in AS

22. A 13-year-old boy with a background of cerebral palsy presents with the deformity as depicted in sitting spinal radiographs (Figure 12.2).

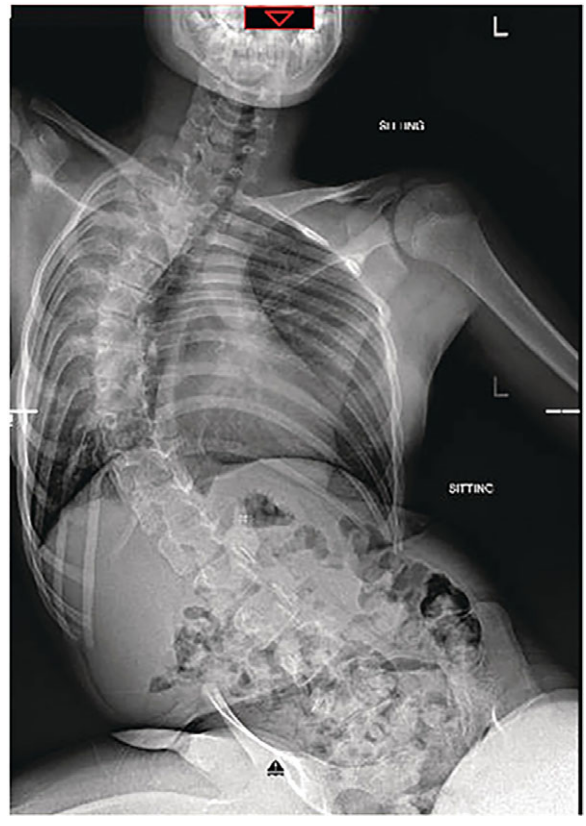


Figure 12.2 Sitting radiographs spine

Which of the following statements is true regarding this type of scoliosis?

A. It usually presents later than most cases of idiopathic scoliosis
B. It responds well to orthotic treatment
C. Surgical treatment is rarely needed
D. It tends to exhibit longer curves as compared with idiopathic scoliosis
E. It is less likely to progress in severity

23. A 15-year-old boy presents with Duchenne muscular dystrophy. He has a scoliotic curve measuring 35° with apex at T11 and pelvic obliquity.

Which of the following is the most appropriate next step in management?

A. Bracing
B. Combined anterior and posterior fusion
C. Long segment fusion
D. Observation
E. Short segment posterior fusion

24. **Which of the following is not a criterion for recommending surgery for thoracolumbar burst fractures?**

A. CT evidence of canal compromise with no neurology
B. Disruption of posterior column
C. Greater than 50% loss of vertebral body height
D. Inability to immobilise patient in brace due to associated injuries
E. Kyphosis greater than 25–30° at the level of fracture

25. A 41-year-old woman in a static car is hit from the rear by HGV. She is brought in with stable vitals and trauma CT shows T8 fracture, multiple rib fractures and sternal fractures. She has a chest tube inserted for left haemothorax and has no neurological deficit. Plan for surgical stabilisation is made.

Which of the following is a factor for considering conservative treatment?

A. Canal compromise more than 50%
B. Disc in fracture
C. DISH/ankylosis spondylitis spine
D. Little or no comminution
E. Neurological compromise

26. **Which of the following is not a component of Thoracolumbar Injury Classification and Severity (TLICS) score for thoracolumbar fractures?**

A. Canal compromise on axial CT scan
B. Injury morphology
C. MRI signal change in region of interspinous ligaments
D. Neurology
E. Widening of interspinous distance

27. A 36-year-old man is involved in a motor vehicle accident. He is a seat belt-restrained car passenger. He sustains a flexion distraction type of injury of the thoracolumbar spine.

Which of the following is true about this injury?

A. It will always need surgical stabilisation
B. Injury pattern is always through posterior ligamentous complex, facet capsules and intervertebral discs
C. It will involve the middle and posterior column of the spine
D. There is a low incidence of intra-abdominal injuries
E. Progressive kyphosis is a known complication in unrecognised injuries

28. **Which of the following is not a cause of myelopathy?**

A. Bilateral cervical facet dislocation
B. Prolapsed cervical disc
C. Multiple sclerosis
D. Myasthenia gravis
E. Vitamin B_{12} deficiency

29. A 70-year-old man with a background of poorly controlled diabetes and prostate cancer with skeletal metastases presents with gait disturbances. There are no abnormalities in upper limb examination, but he has brisk lower limb reflexes and upgoing plantar reflex.

Which of the following is most likely to explain his findings and will need to be investigated further?

A. Brain metastases
B. Cervical spondylotic myelopathy
C. Lumbar spine metastases
D. Peripheral neuropathy
E. Thoracic spine metastases

30. **Which of the following levels is most likely to be injured following trauma in adults?**

A. Lower cervical spine
B. Lumbosacral spine
C. Thoracic spine
D. Thoracolumbar spine
E. Upper cervical spine

31. **Return of the bulbocavernous reflex after spinal trauma could mean which of the following?**
A. Complete spinal cord lesion
B. Incomplete spinal cord lesion
C. Neurogenic shock
D. Reversal of spinal shock
E. Sacral nerve root injury

32. A 40-year-old man is brought to the ED with a history of a heavy object falling on his head while performing construction work. He was wearing a helmet and had no signs or symptoms of head injury. He complains of neck pain and is in a collar. He has no neurology. CT scan confirms anterior and posterior arch fracture. Open mouth view X-ray shows a combined lateral displacement of 5mm.
Which of the following is true regarding this injury?
A. There is a high risk of associated spinal injury at another level
B. It is associated with a high risk of neurological injury
C. It is an unstable injury
D. Patient needs surgery in the form of C1/2 or occipitocervical fusion
E. Transverse and alar ligaments are ruptured in this case

33. **Which of the following is true regarding a hangman's fracture?**
A. May be due to unilateral fracture of pars interarticularis
B. Is traumatic posterior spondylolisthesis of C2
C. Always unstable injury
D. High incidence of neurological injury
E. Caused by hyperextension with secondary flexion

34. A 30-year-old rugby player gets involved in a tackle. He complains of unilateral pain along C5 and C6 dermatomes along with transient weakness of deltoid and biceps, with normal cervical range of motion.
Which of the following fits this pattern of injury?
A. Brachial plexus axonotmesis
B. Cervical disc herniation
C. Cervical fracture
D. Scapula fracture
E. Stinger

35. **Which of the following mechanisms is the least likely injury pattern responsible for stinger or burner?**
A. Axial compression of the cervical spine
B. Direct blow to a point just above the clavicle
C. Hyperextension, compression and rotation towards the involved arm
D. Lateral neck flexion with shoulder depression
E. Trauma to Erb's point

36. **Regarding intervertebral disc, which of the following statements is true?**
A. Annulus fibrosus is the outer structure that contains predominantly type I collagen that is vertically oriented
B. Dorsal root ganglion innervates the annulus fibrosus through the sinuvertebral nerve
C. Nucleus pulposus contains a high collagen to proteoglycan ratio
D. Nucleus pulposus contains predominantly type I collagen
E. Nutrition occurs through diffusion via annulus that is porous

37. **Which of the following is an age-related change in the intervertebral disc?**
A. Increase in disc height
B. Increase in proteoglycan
C. Increase in water content
D. Reduction in collagen
E. Reduction in nutritional transport across the end plates

38. A 50-year-old diabetic patient undergoes posterior spinal fusion for a spinal pathology. She has bone graft taken from the right anterior iliac crest. Post-operatively, she is put in a TLSO and mobilised. She complains of right anterior thigh pain and paraesthesia immediately after surgery.

CT scan confirms no screw malposition and pelvis X-rays are normal.

Which of the following is the least likely differential diagnosis?

A. Diabetes
B. Epidural haematoma at L4 level
C. Graft site morbidity
D. Position during surgery
E. TLSO

39. A 70-year-old woman complains of upper cervical neck pain after being involved in a RTA at 30mph. She has no neurological injury on examination. After ATLS assessment, it is evident that her neck sustained her only injury. CT scan shows a fracture of the odontoid at the waist.

Which of the following is true regarding the injury pattern in this patient?

A. Anterior odontoid screw fixation is treatment of choice for pseudoarthrosis
B. There is a good chance of union considering the fracture pattern
C. There is a high risk of non-union as she is a female
D. There is a high risk of non-union due to her age
E. There is a high risk of non-union if there is delay in starting treatment

40. A 14-year-old boy is brought to a spinal clinic by his mother after she noticed abnormal curvature in his back. He has no history of fever, weight loss or any significant family history. He denies any trauma. He has no back pain. He has no neurological deficit on examination. He has no scoliosis but does have a significant lower thoracic kyphosis that does not correct with extension of spine. Lateral X-ray of his spine is depicted in Figure 12.3.

The most likely diagnosis is which of the following?

A. Congenital kyphosis
B. Normal thoracic kyphosis
C. Infection
D. Scheuermann's kyphosis
E. Traumatic fractures of the thoracic spine

Figure 12.3 Lateral radiograph of spine

41. A 40-year-old soldier is brought in with gunshot wound to his back. CT and MRI scan reveal the bullet lodged in the right half of the spinal cord at the level of T10 in the region of the spinothalamic tract.

Which of the following examination findings is he likely to have?

A. Loss of fine touch, pressure and vibration on the left side, T10 downwards
B. Loss of pain, temperature and crude touch on the left side, T10 downwards
C. Loss of pain, temperature and crude touch on the left side, T12 downwards
D. Loss of pain, temperature and crude touch on the right side, T10 downwards
E. Loss of pain, temperature and crude touch on the right side, T12 downwards

42. A 30-year-old fit and well man is brought in after being involved in a fight. He has a stab wound in his back. He complains of loss of fine touch in his left upper limb.

Which of the following is he likely to have damaged?

A. Anterior spinothalamic
B. Corticospinal tract
C. Fasciculus cuneatus
D. Fasciculus gracilis
E. Lateral spinothalamic

43. A 30-year-old man presents with history of back pain. Imaging reveals a tumour lesion in the posterior spinal elements of T10.
Which of the following is the least likely diagnosis?
A. Aneurysmal bone cyst
B. Chordoma
C. Osteoblastoma
D. Osteochondroma
E. Osteoid osteoma

44. **The most common mode of spread of infection to the spinal column is which of the following?**
A. Along cerebrospinal pathways
B. Arterial
C. Batson plexus
D. Direct
E. Lymphatic

45. A 14-year-old girl is having posterior correction for scoliosis. Halfway through the procedure after screws are inserted and correction is done, there is loss of MEP (Motor Evoked potential) in both lower extremities with retained SSEP (Somatosensory evoked potential).
The next step in the management of this patients is
A. Check leads for loose connection
B. Inform the entire team about loss of signals
C. Intraoperative imaging of the implants, preferable O arm
D. Raise BP and oxygenation
E. Undo the correction

46. **A patient with degenerative listhesis at L4–L5 is likely to have which of the following presentations?**
A. Loss of sensation along the lateral border of the foot
B. Weakness of ankle dorsiflexion
C. Weakness of ankle plantar flexion
D. Weakness of great toe extension
E. Weakness of hip flexion

47. **Which of the following is a classical finding in lumbar canal stenosis?**
A. Pain on walking uphill.
B. Pain on spinal extension
C. Positive straight leg raise
D. Weak pedal pulsation
E. Weakness in great toe extension

48. A 42-year-old woman has come to the ED at 20.00h with a 3-week history of back pain and a 2-day onset of bilateral radiculopathy. She denies any bowel or bladder disturbances. She has bilateral SLR of 30° and no neurological deficit on examination. MRI images are depicted in Figure 12.4. Pain is under control after receiving morphine.

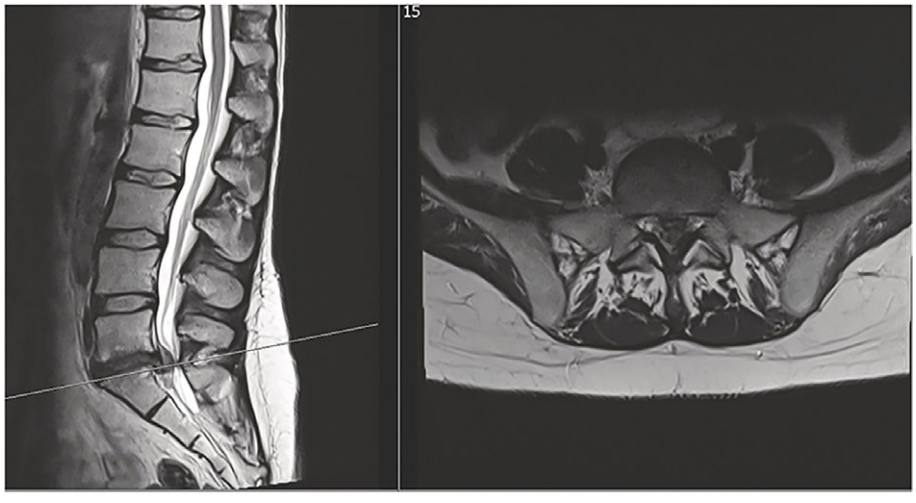


Figure 12.4 (a) Sagittal T2 and (b) axial T2 at level of interest MRI scan spine

Which of the following is the next best management option?

A. Admit, neurological observations, consider surgery following day within 24 hours of MRI
B. Bilateral nerve root injection
C. Discharge if pain under control
D. Emergency surgery
E. Epidural injection

49. A 50-year-old man presents with generalised back pain and gait disturbances. He is a type 2 diabetic on insulin. On examination he has brisk reflexes in the lower limbs but normal reflexes in the upper limbs. He also has right ptosis, miosis and enophthalmos.

Which of the following pathologies can explain the patient's findings?

A. Cervical spondylotic myelopathy C4/5
B. Lumbar canal stenosis
C. Lumbar disc prolapse
D. Peripheral neuropathy
E. Thoracic disc disease T1–T2

50. **Which of the following is the predominant blood supply of the spinal cord?**

A. Anterior spinal artery
B. Artery of Adamkiewicz
C. Intercostal arteries
D. Posterior spinal artery
E. Segmental arteries

51. **Which of the following is arranged in correct order when approaching the spinal cord from superficial to deep?**

A. Dura mater–subarachnoid space–arachnoid membrane–pia mater–epidural space
B. Epidural space–pia mater–dura mater–subarachnoid space–arachnoid membrane
C. Epidural space–dura mater–arachnoid membrane–subarachnoid space–pia mater
D. Epidural space–dura mater–subarachnoid space–arachnoid membrane–pia mater
E. Epidural space–dura meter–pia meter–subarachnoid space–arachnoid membrane

52. **Which of the following can be an indication for cervical disc replacement?**

A. Cervical spondylotic myelopathy
B. Infection
C. Instability
D. Osteoporosis
E. Significant facet arthritis

53. A 60-year-old fit and healthy man presents with a history of gait disturbances and neck pain. MRI sagittal T2 is as depicted in Figure 12.5.

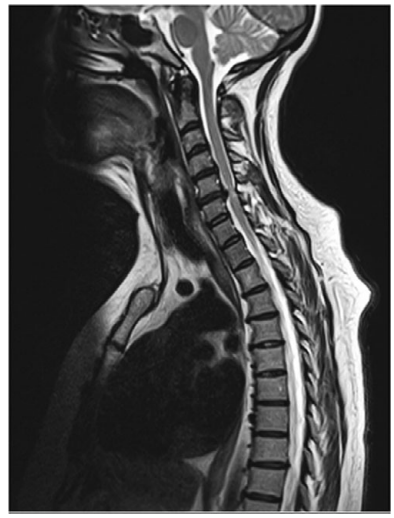


Figure 12.5 MRI sagittal T2 view

The next best management of this patient is which of the following?

A. Acupuncture
B. Cervical epidural
C. Facet joint injections
D. Physiotherapy and analgesia
E. Surgery

54. A teenage girl with thoracic scoliosis of Cobb angle 50° is seen in the clinic. Beaded on history, examination and investigations, it is suggestive of adolescent idiopathic scoliosis. Family would like to know the long-term sequelae of untreated AIS.

Which of the following is a known outcome of the natural history of AIS?

A. Absence of backpain
B. Increased lumbar lordosis
C. Psychological concerns
D. Static curve progression
E. Unchanged sagittal alignment

55. **Which of the following is not a known complication of halo application?**

A. Abducens nerve palsy

B. C5 nerve palsy
C. Loosening
D. Nerve palsy
E. Supratrochlear nerve palsy

56. A 55-year-old man needs revision anterior cervical spine surgery at C4–C5 for adjacent level nerve root compression. He previously had fusion at C5–C6 eight years ago. He has no neck pain but complains mainly of arm pain. X-rays show good fusion at C5–C6 and MRI confirms a soft disc at right C4–C5.

Which of the following does he need prior to the procedure?

A. CT scan cervical spine
B. Gadolinium MRI cervical spine
C. Laryngoscopy
D. Nerve conduction studies
E. Open mouth cervical spine views

57. A 60-year-old rheumatoid patient needs elective hand surgery under general anaesthesia. She also complains of chronic neck pain.

Which of the following is the next important step in the preoperative check-up?

A. AP cervical spine X-ray
B. ESR levels
C. Flexion extension cervical spine X-rays
D. Open mouth view cervical spine
E. Stopping methotrexate

58. An 8-year-old boy presents with short neck, low hairline and reduced neck range of motion.

Which of the following statements is true about this condition?

A. It is not associated with Sprengel shoulder
B. It is less prone for degenerative changes in the cervical spine
C. Long fusions of the cervical spine can allow participation in contact sports
D. Multiple systemic anomalies are common
E. It occurs due to failure of normal segmentation in the first 6 months of life

59. A 68-year-old man presents with neurogenic claudication and low back pain. Examination reveals normal pedal pulses and normal functioning. MRI reveals an L4–L5 degenerative listhesis and severe stenosis with tropism of the facets. He is now receiving pain management and had tried 4 months of conservative treatment. His past medical includes well-controlled hypertension.

What is the next best step to be offered in management of this patient?

A. Acupuncture
B. Isolated laminectomy
C. Laminectomy with instrumented fusion
D. Laminectomy with non-instrumented fusion
E. Lumbar epidural injection

60. Which of the following regarding spinal metastases is correct?

A. Most spinal metastases occur in posterior elements.
B. Spinal cord compression is a component of SINS (Spinal Instability Neoplasticism Score)
C. Thoracic spine is the most common site followed by lumbar and cervical
D. Thyroid is the most common primary followed by prostate.
E. Vertebroplasty can be done even in presence of a posterior spinal wall defect.

SPINE II STRUCTURED SBA ANSWERS

1. Answer E. **Triple immobilisation of the cervical spine with rigid collar**
Patients with ankylosing spondylitis have a kyphotic ankylosed spine. They are prone to having cervical spine fractures due to underlying osteoporosis and large lever arms. Inadvertent rigid collar can force the flexed cervical spine into extension, leading to neurological deterioration and even mortality.

Pre-injury deformity should be ascertained, especially in a conscious patient. Patients should be immobilised in the same position as their pre-injury deformity status.

Clarke A, James S, Ahuja S. Ankylosing spondylitis: inadvertent application of a rigid collar after cervical fracture, leading to neurological complications and death. *Acta Orthop Belg*. 2010;**76**:413–415.

2. Answer C. **It is the angle formed between a line drawn from the centre of the S1 end plate to the centre of the femoral head and a second line drawn perpendicular to the S1 end plate, intersecting it at the centre**
Pelvic incidence is the angle formed between a line drawn from the centre of the S1 end plate to the centre of the femoral head and a second line drawn perpendicular to the S1 end plate, intersecting it at the centre

Pelvic incidence never changes with pelvic morphology as with other pelvic parameters.

Pelvic incidence is pelvic tilt plus sacral slope. Higher pelvic incidence necessitates more lumbar lordosis to maintain sagittal balance, and there is a direct correlation between pelvic incidence and the Meyerding grade of spondylolisthesis.

Hanson DS, Bridwell KH, Rhee JM, Lenke LG. Correlation of pelvic incidence with low-and high-grade isthmic spondylolisthesis. *Spine* 2002;**27**:2026–2029.

3. Answer D. **Rib prominence on forward bending**
Atypical curve pattern like left-sided curve, short angular curve, apical kyphosis and excessive kyphosis are some indications for MRI. Other indications for MRI are any syndromic features (neurofibromatosis – axillary freckling), neurological signs or symptoms.

Isolated rib prominence is present in AIS, and on its own is not an indication for MRI scan.

4. Answer A. **Fine cuts of CT and MRI scan help best in determining treatment plan**
This is a double question. Understanding the diagnosis in the stem is the first step. The age, pain and scoliosis point to osteoid osteoma or osteoblastoma. However, osteoblastomas do not behave differently at night and respond poorly to NSAIDs. So, this boy most likely has scoliosis secondary to osteoid osteoma, which is less than 1.5cm, on the apex of concave side of scoliosis and, unlike osteoblastoma, rarely has any neurological deficit.

Fine cuts of the CT will not only show the sclerosis with surrounding radiolucent nidus, along with MRI they also help to see the proximity to neural structures. Any lesion less than 2mm from a neural structure should not be treated with radiofrequency to avoid risk of neural injury. NSAIDs/observation and not radiofrequency is the initial treatment for osteoid osteoma with a very minimal curve.

5. Answer B. **Damage to feeding vessel from the left side between T8 and L1**
Based on the findings of normal proprioception, this patient has anterior cord syndrome. Patients with spinal shock will have no proprioception. Central cord patients will have more weakness in the upper limbs. As proprioception is normal, posterior cord syndrome is ruled out. Damage to the artery of Adamkiewicz is a known complication of aortic repairs. This can lead to vascular insult of the spinal cord.

6. Answer D. **MRI of cervical and thoracic spine**
Although this patient has lumbar canal stenosis that may need surgery, he also has symptoms and signs of cervical myelopathy with upper motor neuron signs. Tandem stenosis has been reported to have overall incidence of 7.6% in one series (Hsieh et al. 1998). Cervical surgery is then recommended first if there are upper motor neuron signs or predominantly signs in upper extremities.

Hsieh CH, Huang TJ, Hsu RW. Tandem spinal stenosis: clinical diagnosis and surgical treatment. *Changgeng Yi Xue Za Zhi* 1998;**21**:429–435.

7. Answer D. **The superficial fascia, pretracheal fascia and prevertebral fascia are encountered from superficial to deep**
Damage to the sympathetic and not the parasympathetic chain can occur with dissections to the longus colli, leading to Horner's syndrome. The sympathetic chain runs over the longus colli muscle, and hence the retractors need to be placed cautiously beneath the elevated longus colli muscle.

Hyoid bone roughly lines up with C3 and not C5.

The location of the mandible and not maxilla decides the ease of access to the C2/3 disc.

The plane is between the carotid sheath laterally and the trachea with oesophagus medially (internal jugular lies in carotid sheath).

8. Answer A. **Chemical destruction of the nerve endings due to chemical composition of the cement has been proposed**
As per NICE guidance, percutaneous vertebroplasty and percutaneous balloon kyphoplasty without stenting, are recommended as options for treating osteoporotic vertebral compression fractures only in people who have severe ongoing pain after a recent, unhealed vertebral fracture despite optimal pain management *and* in whom the pain has been confirmed to be at the level of the fracture by physical examination and imaging. Chemical destruction, physical destruction and mechanical stabilisation are all proposed mechanisms by which vertebroplasty reduces pain.

It works by mechanical stabilisation of the fractured bone.

It works by thermal destruction of the nerve endings due to the high temperature reached by the polymerisation of the injected cement.

It is indicated in patients with ongoing pain after recent unhealed fracture; pain is confirmed at the level of fracture by examination and MRI showing high signal on T2.

It has fewer advantages as compared with kyphoplasty. Kyphoplasty has the added advantage of correcting kyphosis and providing pain relief for a longer duration.

9. Answer C. **Most common organism is *Staphylococcus aureus*** Loss of lordosis may be the earliest and only X-ray finding for discitis in children. This is followed by disc space narrowing and end plate erosion (10–21 days). The haematogenous route is the most common pathway of spread to spine.

MRI imaging is the investigation of choice. Vertebral end plates get affected first.

Unlike adults, in children the disc is vascular, with the blood vessels extending from the cartilaginous end plate to the nucleus pulposus. So, primary infection of the disc occurs first in children followed by spread of infection to vertebral body. In adults, however, the end plates get infected first, followed by spread to adjacent disc space.

10. Answer D. **Posterior elements are most commonly affected**
Posterior elements are most commonly affected in spinal metastases. Vertebral end plates are most commonly affected in spinal infection in adults. In malignancy, disc space is always preserved. Vertebral body collapse does occur due to bone destruction that can lead to canal compromise and neurological deficit.

In degenerative spine, end plates are preserved and there is minimal or no enhancement with gadolinium. Gadolinium enhances infections and malignancy.

11. Answer D. **S1/S2**
Ankle reflex is a deep tendon reflex that checks if S1 and S2 nerve roots are intact.

The major S2 myotomes are the hamstrings and calf muscles. The S2 dermatome consists of a strip of skin along the back of thigh and calf. S1 dermatome is the lateral aspect of the foot and it supplies gluteal, hamstring, calf and a few muscles in the foot.

12. Answer E. **Skeletally immature patients**
Immature patients are ideal candidates for a brace, as the brace can prevent deformity progression. A brace serves no purpose when the growth is complete. Thoracic lordosis is a contraindication, as it can lead to potential cardiopulmonary restriction.

Curves greater than 40° usually need surgery.

13. Answer C. **Upper cervical trauma is more common in children younger than 8 years of age**

In children older than 8 years, the subaxial region is the most common site of cervical trauma.

The spinal column in children is more elastic than the spinal cord. Hence, SCIWORA (spinal cord injuries without radiographic abnormalities) can be seen in children.

MRI scan is the investigation to diagnose injury to the cord and ligament injuries.

As children have a large cranium in relation to the thorax, immobilisation on a standard spinal board will place the cervical spine in flexion. Use of a paediatric spinal board with a recess for the occiput or double mattress below the thorax is recommended in paediatric cervical spine injuries.

Pseudosubluxation, that is, normal anterior translation, can occur between C2/3 and less commonly between C3/4.

14. Answer A. **Correction happens at the level of the vertebral body and not the disc**
Smith-Petersen osteotomy, pedicle subtraction osteotomy and vertebral column resection can correct sagittal plane deformities.

SPO can correct mild to moderate deformities and it opens up the anterior column, closes the middle column somewhat and closes the posterior column. Correction happens at the disc level.

PSO corrects severe sagittal imbalance. It hinges on the anterior column and closes the middle and posterior column. Correction happens at the vertebral level. VCR provides more correction than PSO.

Correction is usually performed at L12 levels, as the lever at this level allows more correction of the deformity than the thoracic level. The spinal cord ends at this level, minimising the risk of cord damage. The greater disc height and mobility at the lumbar level than the thoracic level allow more correction if performing an SPO, as the correction happens at the disc level.

PSO is a technically demanding procedure and is associated with high number of complications (up to 61% in one series).

Hyun SJ, Rhim SC. Clinical outcomes and complications after pedicle subtraction osteotomy for fixed sagittal imbalance patients: a long-term follow-up data. *J Korean Neurosurg Soc*. 2010; **47**:95.

15. Answer E. **Sacroiliac joint involvement is often asymmetric**
Sacroiliac joint is symmetric in AS.

If there is asymmetric involvement, consider other diagnoses such as psoriatic arthritis or infections. A normal SIJ precludes an imaging diagnosis of AS.

16. Answer C. **Combined physical and psychological programmes**
Though this question is vague with not much on history and examination, it is based on the recommendations for chronic back pain as per NICE.

Caudal epidural is indicated only for sciatica. Opioids, belts/corsets or acupuncture are not recommended for management of chronic back pain.

https://pathways.nice.org.uk/pathways/low-back-pain-and-sciatica/managing-low-back-pain-and-sciatica.

17. Answer D. **The inferior limit of the spinal cord in adults is L1 or L2**
The preganglionic cell bodies of the sympathetic nervous system are located in the intermediolateral nuclei of the thoracolumbar (T1–L2) portion of the spinal cord.

The postganglionic cell bodies of the sympathetic nervous system are found in either the prevertebral ganglia or the paravertebral ganglia. The preganglionic parasympathetic preganglionic cell bodies lie in sacral segments S2, S3, S4, while the postganglionic are located in the terminal ganglia near the organ innervated or the wall of the organ.

The spinal nerves exit the cervical spine above their corresponding vertebral body level. For example, the C5 nerve root exits above C4 through the C4–5 neural foramen. C8 exits in between C7 and T1 since there is no C8 vertebral body level. So, C8 exits inferior to pedicle of C7.

This orientation is reversed in the thoracic and lumbar spine. In the thoracic and lumbar spine, spinal nerve roots exit below their corresponding vertebral body level. For example, the L5 nerve root exits below L5 through the L5/S1 foramen. The inferior limit of the dural sac is S2, not L2. That is the reason lumbar puncture is usually done at the L3/L4 level.

18. Answer D. **MRI scan**
This patient has bilateral facet subluxation. For any patient with mental changes, an MRI scan of the neck is the first step to look for disc herniation that can compress the spinal cord. Closed reduction can further compress the cord, which will be difficult to monitor in patients with mental changes. Closed reduction can be performed only in patients who are awake, followed by MRI and open reduction.

Cervical orthosis is indicated in patients with facet fractures with no subluxation.

Posterior cervical fusion is indicated in patients in the absence of significant disc herniation.

Anterior fusion can be performed after obtaining MRI to look at disc, cord and ligament status.

19. Answer C. **Orthostatic hypertension**
Up to 11% of patients with spinal cord injuries suffer from major depressive episodes associated with suicidal ideation.

Autonomic dysreflexia is a life-threatening condition that can cause death. The most common causes of autonomic dysreflexia are bladder and bowel distension. It can present with raised BP, bradycardia, pounding headache, flushing, sweating or blotching above the level of the injury and pale, cold goose bumps below the level of the injury.

Urosepsis is a common cause of death. Strict asepsis is to be maintained while inserting catheter, and bladder should not be allowed to become overly distended.

As patients have reduced mobility, DVT and PE are dreaded complications.

Orthostatic hypotension, not hypertension, results due to lack of sympathetic tone.

Bombardier CH, Richards JS, Krause JS, Tulsky D, Tate DG. Symptoms of major depression in people with spinal cord injury: implications for screening. *Arch Phys Med Rehabil.* 2004;**85**:1749–1756.

20. Answer B. **Pelvic incidence**
Pelvic incidence correlates with the severity of the disease and does not change with posture. The rest of all parameters given change with posture. Pelvic incidence is the sum of pelvic tilt and sacral slope.

21. Answer D. **There is ossification of ligaments and entheses in DISH while erosive enthesopathy in AS**
DISH, also known as Forestier disease, is defined by presence of non-marginal syndesmophytes at three successive levels (involving 4 contiguous vertebrae).

In AS discs are ossified while DISH the discs are normal.

The facet joints are normal in DISH while fused in AS

Unilateral/Bilateral sacroiliac joints are involved in AS while normal SI joints in DISH.

There is ossification of ligaments and entheses in AS while erosive enthesopathy in DISH.

Marginal syndesmophytes in AS and flowing periosteal reaction/non-marginal in DISH.

Besides, in DISH these no osteopenia but normal or increased bone density. In AS due to inflammatory process and disuse, there is osteopenia/osteoporosis.

22. Answer D. **It tends to exhibit longer curves as compared with idiopathic scoliosis**
Neuromuscular scoliosis presents earlier than most cases of idiopathic scoliosis. Since it presents early, it tends to progress rapidly. It rarely responds well to orthotic treatment, and surgery is frequently needed, depending on fitness for surgical intervention.

The curves tend to be longer, involving more vertebrae, and long segment fusion is usually needed.

23. Answer C. **Long segment fusion**
95% of patients with Duchenne muscular dystrophy develop scoliosis. As these curves progress rapidly with further reduction in pulmonary function, surgical stabilisation is recommended once curves reach 20°. Long segment fusion is the treatment of choice from T2 to iliac fixation, especially with pelvic obliquity.

Combined fusion is indicated in severe deformities and skeletally immature patients to prevent crankshaft phenomenon usually in idiopathic scoliosis. Combined fusion is high-risk surgery in Duchenne muscular dystrophy.

24. Answer A. **CT evidence of canal compromise with no neurology**
With patients with burst fractures and intact neurology, the fact the patient remains neurologically intact means that degree of canal compromise is sufficient not to damage the cord.

Shen WJ, Shen YS. Nonsurgical treatment of three-column thoracolumbar junction burst fractures without neurologic deficit. *Spine* 1999;**24**:412–415.

25. Answer D. **Little or no comminution**
All other factors result in a poor outcome following conservative treatment. Also, consideration of surgery is done if there is sternal fracture (regarded as the 4th column for thoracic spine), T1–T10 fractures, high ISS or injury severity score and multiple rib fracture such as flail chest that could lead to a delay in the patient sitting up.

The above factors are for A0, A1, A2, A3, A4 and B2 fractures.

A0, B1, B3 and C fractures are treated with surgical intervention.

26. Answer A. **Canal compromise on axial CT scan**
TLICS has the following criteria

Injury morphology

- Compression (1 point).
- Burst (+1 point).
- Rotation/translation (+3 point).
- Distraction (+4 point).

Neurological status

- Intact (+0 point).
- Nerve root (+2 point).
- Incomplete spinal cord or conus medullaris injury (+3 point).
- Complete spinal cord or conus medullaris injury (+2 point).
- Cauda equina syndrome (+3 point).

Posterior ligamentous complex integrity

- Intact (+0 point) – no interspinous ligament widening seen with flexion views. MRI shows no oedema in interspinous ligament region.
- Suspected/indeterminate (+2 point) – MRI shows some signal in region of interspinous ligaments
- Disrupted (+3 point) – widening of interspinous distance seen.

A score less than 4 is usually indicative of non-surgical management, while a score above 4 is indicative of surgical management. A score of 4 suggests either surgical or non-surgical management.

MRI signal change in the region of interspinous ligaments or widening of interspinous distance is indicative of disruption of the posterior ligamentous injury. Canal compromise bears no relevance in TLICS classification.

27. Answer E. **Progressive kyphosis is a known complication in unrecognised injuries**
Chance fractures involve all three columns of the spine with the axis of rotation anterior to the vertebral body. Chance fractures could be purely bony or ligamentous. Bony Chance fractures are rare. Injury pattern need not always be through disc; the fracture can run through the bone.

There is a high incidence of intra-abdominal injuries, especially the bowel.

Although most injuries need surgical stabilisation and decompression, bony Chance with no neurology can be treated with TLSO brace in extension.

Unrecognised injury to the PLL leads to progressive kyphosis and pain.

28. Answer D. **Myasthenia gravis**
Myelopathy is any neurological deficit related to the spinal cord. It is an upper motor neuron type lesion with brisk reflexes and hypertonia in muscles. Myelopathy can be surgical, wherein there is compressive lesion-like cervical disc prolapse or bilateral facet dislocation.

Multiple sclerosis is a demyelinating disorder that can affect any part of the nervous system including the spinal cord.

Subacute combined degeneration of the spinal cord is a result of B_{12} deficiency that affects lateral and posterior columns of the spinal cord.

Multiple sclerosis and B_{12} deficiency are examples of non-compressive myelopathy or medical myelopathy.

Myasthenia gravis does not affect the spinal cord but does affect the neuromuscular junction.

It is an autoimmune disease that results in producing antibodies that destroy acetylcholine receptors, thereby preventing nerve impulses from triggering muscle contraction.

29. Answer E. **Thoracic spine metastases**
The spinal cord ends at L1, and any compression above this will present with upper motor neuron findings in the lower limbs. As the upper limb examination is normal, it is unlikely that there is a compressive lesion either in the brain or cervical spine.

Although this patient is likely to have peripheral neuropathy because of his age and diabetes, this would present as sluggish if not absent reflexes.

Hence, the most likely explanation is a lesion in the thoracic spine. Bear in mind that this patient will still require a full workup including whole spine MRI, as he could still have lesions in the brain or lumbar or cervical spine that are not yet compressive. Such lesions may change the management of this patient.

30. Answer D. **Thoracolumbar spine**
The thoracolumbar spine is a transition between the fixed thoracic spine and mobile lumbar spine. This is where the force is concentrated and is most likely to be injured after trauma. 50% of all thoracic and lumbar fractures occur between T11 and L2 (thoracolumbar region).

The thoracic spine is inherently stable due to the sternum and rib cage that significantly limit motion. The orientation of the facets in coronal alignment helps resist flexion and extension forces. However, if fractures do occur here, there is a higher likelihood of neurological injury due to smallest canal-to-cord ratio.

Upper cervical spine injuries constitute a large proportion of cervical trauma in patients older than 60 years. Out of these, the C1/2 complex accounts for the majority of these injuries. However, this incidence is still low compared with the incidence of thoracolumbar fractures.

31. Answer D. **Reversal of spinal shock**
The bulbocavernosus reflex is mediated by the S2–S4 nerves. It consists of contraction of the bulbocavernosus muscle in response to squeezing the glans penis or clitoris and is mediated through the pudendal nerve.

It serves to indicate presence or absence of a spinal shock. Its absence means spinal shock and return means end of spinal shock.

The bulbocavernosus reflex is also absent in conus medullaris lesions and lesions of sacral nerves S2–S4.

Neurogenic shock is loss of sympathetic outflow in high thoracic, cervical or brain lesions.

After return of the bulbocavernosus reflex, if there is some motor or sensory function below the level of injury, it means incomplete spinal cord injury. Likewise, no motor or sensory function means a complete spinal cord injury.

32. Answer A. **There is a high risk of associated spinal injury at another level**
A Jefferson fracture is a bilateral anterior and posterior arch fracture. It is caused by axial compression but can also be caused by hyperextension or lateral compression.

Risk of neurological injury is low, as the canal is wide and there is adequate space for the cord. However, there can be neurological injury if there is gross displacement or other associated fractures.

There is a 50% chance of patients having other spinal injuries.

Stability of a Jefferson fracture depends on the integrity of the transverse ligament. If this is ruptured, then a combined displacement of more than 7mm is seen on open mouth view and this injury is unstable. In this case, the injury is stable, as combined displacement is 5mm. This can be treated with a hard collar or halo immobilisation.

The unstable Jefferson fracture needs surgery in the form of C1/2 fusion or occipitocervical fusion.

33. Answer E. **Caused by hyperextension with secondary flexion**
Hangman's fracture is traumatic anterior spondylolisthesis of C2 due to bilateral fracture of pars interarticularis. It is usually associated with a low incidence of neurological injury due to space available for cord at that level.

The mechanism is hyperextension with secondary flexion. Contrary to the name, most hangman's fractures are not seen in judicial hangings where the forces are of the large traction type.

If the displacement is less than 3mm between C2 and C3, they are stable. Otherwise, fractures with more than 3mm of displacement, significant angulation or with C2/3 facet dislocation need stabilisation and/or surgical reduction.

34. Answer E. **Stinger**
Stinger is a peripheral nerve injury that is associated with pain that follows a dermatomal distribution. Only 5–10% have a neurological deficit that may last hours to weeks, but most often pain, and neurological injury resolves spontaneously in 10–15 minutes.

As this patient has normal ROM of cervical spine, fracture and disc prolapse are ruled out.

Isolated scapula fracture alone cannot explain this injury pattern.

Brachial plexus axonotmesis will have long-lasting weakness and not transient weakness.

35. Answer A. **Axial compression of the cervical spine**
Stinger or burner is a peripheral nerve injury that is associated with unilateral paraesthesia. It may be accompanied by motor weakness that is usually transient.

Nerve root contusion leading to stinger can happen with hyperextension, compression and rotation towards the involved arm.

Direct trauma to the brachial plexus just above the clavicle or Erb's point also can lead to stingers. Erb's point is a site at the upper trunk of the brachial plexus located 2–3cm above the clavicle.

Lateral neck flexion with shoulder depression leads to brachial plexus stretch, leading to stingers.

Axial compression of the cervical spine leads to upper cervical fractures such as Jefferson fracture or subaxial cervical spine injuries such as comminuted body or facet fractures.

36. Answer B. **Dorsal root ganglion innervates the annulus fibrosus through the sinuvertebral nerve**
Annulus fibrosus is the outer structure that contains predominantly type I collagen that is obliquely oriented. The high tensile strength resists distraction but remains flexible to allow some motion.

Nucleus pulposus contains a low collagen-to-proteoglycan ratio. The proteoglycans interact with water to resist compression. It contains predominantly type II collagen.

Nutrition occurs through diffusion via end plates that are porous and not annulus. In children, it is vital to remember that the disc is vascular.

Outer layers of annulus are innervated by the sinuvertebral nerve. The posterior part of the disc receives direct branches in its posterolateral aspect from the ramus communicans or the ventral ramus. Branches of the grey ramus communicans also supply the lateral aspect of the disc. Anterior discal nerves arise solely from the sympathetic plexus surrounding the anterior longitudinal ligament.

Edgar MA. The nerve supply of the lumbar intervertebral disc. *J Bone Joint Surg Br.* 2007;**89**:1135–1139.

37. Answer E. **Reduction in nutritional transport across the end plates**
Water content, disc height and proteoglycans decrease with age. The total amount of collagen remains the same.

The main nutritional pathway of the disc is through the adjacent vertebral end plate. This source of nutrition is at great risk in the ageing disc, as the permeability of the end plate diminishes with advancing age.

Grob D. The aging spine. *Eur Spine J.* 2003;**12**:S84–S85.

38. Answer B. **Epidural haematoma at L4 level**
Meralgia paresthetica is compression of the lateral femoral cutaneous nerve. This is a purely sensory nerve consisting of the posterior nerve roots L2 and L3.

Compression can occur at the level of nerve roots L2 and L3 (disc prolapse), in the abdominal cavity (space occupying lesions, traction in a retroperitoneal approach) or as it exits the pelvis at the level of ASIS (corsets).

Tight TLSO or faulty prone positioning can compress the nerve at the ASIS. Traction of the nerve or haematoma during graft harvest from the ASIS can also cause symptoms.

Diabetic peripheral neuropathy is a systemic condition and can affect all nerves, including LFCN.

Isolated epidural haematoma at L4 cannot explain symptoms at L2–3 but will lead to signs and symptoms of nerves at the lower lumbar and or sacral nerve root levels.

39. Answer E. **There is a high risk of non-union if there is delay in starting treatment**

Koivikko et al. (2004) looked at the risk factors for non-union in type II odontoid fractures treated with halo immobilisation. They found non-union correlated with a fracture gap (>1mm), posterior displacement (>5mm), delayed start of treatment (>4 days) and posterior redisplacement (>2mm). Anterior dislocation, gender and age were unrelated to non-union.

Type II odontoid fractures are at increased risk of non-union due to poor blood supply at the junction between the dens and odontoid body.

Posterior C1/C2 fusion is indicated for pseudoarthrosis of the odontoid. Anterior screw osteosynthesis is not indicated for pseudoarthrosis.

Koivikko MP et al. Factors associated with nonunion in conservatively treated type-II fractures of the odontoid process. *J Bone Joint Surg. Br.* 2004;**86**:1146–1151.

40. Answer D. **Scheuermann's kyphosis**
Since there is no history of trauma, fever or back pain, traumatic fractures or infection are unlikely.

Postural kyphosis will correct on hyperextension.

Congenital kyphosis deformity will be noticed much earlier, as it has been present since birth and rapidly progresses during growth.

Normal thoracic kyphosis range is between 20–40°.

Scheuermann's kyphosis is most commonly diagnosed from ages 12–14 years of age. It is rigid thoracic kyphosis more than 45° and caused by anterior wedging of >5° at three consecutive vertebrae. Patients rarely complain of pain, but there are cosmetic concerns.

41. Answer C. **Loss of pain, temperature and crude touch on the left side, T12 downwards**
The spinothalamic tract is an ascending sensory pathway:

- Anterior tract carries information about crude touch (can't localise).
- Lateral tract carries information about pain and temperature.

The second order axon in this tract ascends upwards one or two levels and crosses to the opposite side, eventually synapsing in the thalamus.

In the scenario, with damage to the spinothalamic tract on the right at T10, the likely finding is loss of pain, temperature and crude touch on the opposite side, two levels below which is left T12. It should also be noted that this patient will also have complete loss of pain, temperature and crude touch at the right T10, as the tracts are entering at this level too, to cross two levels higher. But this loss will be only at right T10 and not below it.

Loss of fine touch, pressure and vibration is seen in damage to the posterior column (fasciculus gracilis and fasciculus cuneatus).

Summary of structures on right T10 of the cord

1. Corticospinal tract – Spastic paralysis below right T10 (upper motor neuron), these are tracts travelling from below.
2. Corticospinal tract – Flaccid paralysis only at the right T10 level (lower motor lesion) and not above or below that myotome level. Tracts entering or starting at right T10.
3. Spinothalamic from left decussation (Left T12) – Loss of pain and temperature two levels below (T12 on the left side). As spinothalamic tracts enter and decussate one/two levels above.
4. Spinothalamic tract entering/starting at right T10 to decussate above level that will get damaged – Loss of pain and temp only at right T10 segment level and not above or below.
5. Post column – Loss of position and vibration on right below T10.

Corticospinal and post columns decussate in medulla (brain) unlike the spinothalamic tract that decussates at the spinal cord level (fasciculus gracilis and fasciculus cuneatus).

42. Answer C. **Fasciculus cuneatus**

- Lateral spinothalamic – pain and temperature.
- Anterior spinothalamic – crude touch (can't localise).
- Fasciculus gracilis – fine touch, proprioception, pressure and vibration from levels inferior to T6.

- Fasciculus cuneatus – fine touch, proprioception, pressure and vibration from levels superior to T6.
- Corticospinal tract – motor tracts.

43. Answer B. **Chordoma**
Although chordoma is the most common primary bone tumour of the spine, unlike the rest of the options, chordoma usually presents in patients older than 50 years of age and involves vertebral body more than the posterior elements.

Also, 50% of chordomas occur in sacrum and coccyx.

The most common tumour of the spine is metastases and the most common primary tumour is chordoma.

44. Answer B. **Arterial**
Bacteraemia (haematogenous – arterial) from an extra spinal primary source is the most common route of infection to the spinal column. This could be pulmonary, cardiac, urogenital, gut, cutaneous or mucous. Vascularised subchondral bone seeding occurs primarily with secondary involvement of the disc space and adjacent vertebrae. In children, however, the disc space infection is primarily owing to vascular channels across the growth plate.

Batson plexus (venous) is less common than arterial.

Lymphatic is the common mode of spread in tuberculosis infection. The most common mode of spread within the spinal column would be directly after tuberculosis infection.

45. Answer B. **Inform the entire team about loss of signals**
Loss of signals is a known entity in deformity surgery. The aetiology could be one of many factors. It could be surgery (screw misplacement, correction), low blood pressure or oxygenation (poor perfusion of the cord) or simple factors such as disconnected leads. While the most recent action is to be reversed, it is pertinent to inform all team members so that simultaneously corrective actions are undertaken.

46. Answer D. **Weakness of great toe extension**
Degenerative listhesis is more common at L4–L5, as the more sagittally oriented facets predispose to this pathology. Isthmic listhesis, on the other hand, occurs due to repetitive hyperextension forces that are prevalent at L5–S1.

The exiting nerve root is involved in isthmic listhesis, while the traversing nerve root is involved in degenerative listhesis. Therefore, L5–S1 lytic listhesis will involve the L5 root, while the S1 root will be involved in degenerative listhesis at L5–S1. In a case of L4–L5 degenerative listhesis, the L5 nerve root will be involved (weakness of great toe extension). Weakness of ankle dorsiflexion (L4), weakness of ankle plantar flexion (S1), loss of sensation along the lateral border of the foot (S1) and weakness of hip flexion (L2) are unlikely in this clinical scenario.

47. Answer B. **Pain on spinal extension**
Patients with lumbar canal stenosis have relief of symptoms on spine flexion such as leaning over a shopping cart, walking downhill or sleeping in a foetal position. Pulses are normal, and they usually have no neurological deficit on examination.

Patients with vascular claudication have weak pulses and their symptoms worsen on walking uphill.

Positive straight leg raise is pathognomonic of nerve irritation in prolapsed disc and not lumbar canal stenosis.

48. Answer A. **Admit, neurological observations, consider surgery following day within 24 hours of MRI**
Todd and Dickson (2016) provided standards of care for cauda equina. They divided CES into the following:

1. CES-S (cauda equina syndrome suspected) – Bilateral radiculopathy. Management – Admission, operate or wait and watch.
2. CES-I (cauda equina syndrome incomplete) – Patient with urinary difficulties. Management – Emergency surgery.
3. CES-R (cauda equina syndrome retention) – Painless retention of urine with overflow incontinence. Management – Emergency surgery. – Early CES-R (<12 hours), uncertain CES-I/CES-R, residual sacral nerve function present. Management – Next acute list – Prolonged CES-R.
4. CES-C (cauda equina syndrome complete) – Loss of all cauda equina function (absent

perianal sensations, patulous anus and paralysed insensate bladder and bowel). Management – Next acute list – Prolonged CES-R.

Bilateral radiculopathy with large central disc is cauda equina suspected, even with no bowel or bladder symptoms. This patient needs admission and neurological observations. If they deteriorate, then emergency surgery needs to be performed. Otherwise, surgery should occur on the following day, acute list.

Injections carry no role in this scenario.

Even though the pain is under control, this patient needs admission for neurological deterioration as she is at high risk of progression to cauda equina syndrome. Emergency surgery is indicated for patients with incomplete cauda equina (bladder or bowel disturbances) or cauda equina patients with retention.

Todd NV, Dickson RA. Standards of care in cauda equina syndrome. *Br J Neurosurg.* 2016;**30**:518–522.

49. Answer E. **Thoracic disc disease T1–T2**
Normal reflexes in upper limbs and brisk reflexes in lower limbs means the lesion should be in the thoracic spine (upper motor neuron). Peripheral neuropathy, lumbar canal stenosis and lumbar disc prolapse are all lower motor neuron lesions.

Cervical spondylotic myelopathy would have brisk reflexes in the upper limbs.

The compression of the anterior root of T1 containing the myelinated axons of the sympathetic cells of origin can explain the Horner syndrome.

50. Answer A. **Anterior spinal artery**
Anterior spinal artery supplies anterior two-thirds of the spinal cord and is the predominant blood supply. Paired posterior spinal arteries supply the posterior one-third of the spinal cord.

Artery of Adamkiewicz typically originates on the left side between T9 and L2. Damage to it can result in infarction of the lumbosacral segments only.

51. Answer C. **Epidural space–dura mater–arachnoid membrane–subarachnoid space–pia mater**
In this scenario, one can rule out some options. For example, the epidural (above dura) has to be superficial to the dura. So too the subarachnoid (below arachnoid) has to be below the arachnoid membrane. Therefore, even if one does not recollect the exact layers in order, the first four options are clearly wrong.

52. Answer A. **Cervical spondylotic myelopathy**
Cervical spondylotic myelopathy in the absence of significant facet disease is not a contraindication for disc arthroplasty. A cross-sectional study of 199 patients who underwent either arthrodesis or arthroplasty found no worsening of myelopathy in the arthroplasty group.

Buchowski JM, Anderson PA, Sekhon L, Riew KD. Cervical disc arthroplasty compared with arthrodesis for the treatment of myelopathy: surgical technique. *J Bone Joint Surg Am.* 2009;**91**:223–232.

53. Answer E. **Surgery**
Patients with cervical spondylotic myelopathy are generally thought to have a poor prognosis without surgical treatment, with a gradual stepwise progression of symptoms.

So, too, patients with cervical canal stenosis and cord compression secondary to spondylosis, without clinical evidence of myelopathy, and who present with clinical or electrophysiological evidence of cervical radicular dysfunction or central conduction deficits, seem to be at higher risk for developing myelopathy and should be counselled to consider surgical treatment.

Clarke E, Robinson PK. Cervical myelopathy: a complication of cervical spondylosis. *Brain* 1956;**79**:483–510.

Wilson JR et al. Frequency, timing, and predictors of neurological dysfunction in the nonmyelopathic patient with cervical spinal cord compression, canal stenosis, and/or ossification of the posterior longitudinal ligament. *Spine* 2013;**38**:S37–S54.

54. Answer C. **Psychological concerns**
Depression and other psychological concerns are common in untreated scoliosis.

68% of curves progress after maturity (1° per year for curve more than 50°).

Back pain is not uncommon and could be due to age-related degenerative changes, sagittal imbalance.

Sagittal imbalance starts due to thoracic hypokyphosis followed by flattening of lumbar lordosis, pelvic retroversion and finally positive sagittal imbalance.

Lumbar lordosis reduces with age and more so in AIS due to sagittal imbalance.

55. Answer B. **C5 nerve palsy**
C5 nerve palsy is a known complication after surgery for cervical myelopathy (4%).

Loosening is the most common complication of halo application and is treated with retightening.

Abducens nerve palsy happens because of traction injury after halo application. Supratrochlear nerve palsy and supraorbital nerve palsy can happen due to incorrectly placed anterior pins.

56. Answer C. **Laryngoscopy**
Laryngoscopy is needed to check vocal cord function. An asymptomatic damage may be present to the unilateral recurrent laryngeal nerve on the side of the previous approach. If that nerve is damaged, anterior approach on the non-operated side could lead to damage of the recurrent laryngeal nerve on that side, resulting in bilateral recurrent nerve palsy. This can be catastrophic, leading to difficulty in breathing and inability to speak. Checking the vocal cords by laryngoscopy is vital for medico-legal purposes too.

Since fusion is well seen on X-rays and it is a soft disc (not an osteophyte), CT scan is not needed. Gadolinium scans are usually useful to distinguish recurrent disc from epidural scar tissue. However, since the pathologies are at different levels and it has been a long time since primary surgery, this scan is not indicated.

Open mouth views are for C1–C2 pathologies.

Nerve conduction studies have a high false negative rate and may be useful to distinguish radiculopathy from peripheral neuropathy or central causes.

57. Answer C. **Flexion extension cervical spine X-rays**
Atlantoaxial subluxation is the most common instability of the cervical spine in rheumatoid patients. This can be picked up by flexion extension X-rays and will need further imaging/precautions such as fibreoptic intubation within line immobilisation.

Methotrexate should not be stopped before elective surgery.

Grennan DM, Gray J, Loudon J, Fear S. Methotrexate and early postoperative complications in patients with rheumatoid arthritis undergoing elective orthopaedic surgery, *Ann Rheum Dis*. 2001;**60**:214–217.

58. Answer D. **Multiple systemic anomalies are common**
Klippel–Feil syndrome has a classic triad of short neck, low hairline and reduced neck range of motion. It is associated with Sprengel's shoulder and multiple systemic anomalies such as renal aplasia and congenital heart disease.

Patient with long fusions should refrain from contact sports due to increased risk of neurological injury following minor trauma. As the spine is fused at some levels, it predisposes to degeneration at other levels.

This condition happens due to failure of normal segmentation at 3–8 weeks of gestation and not during first 6 months of life.

59. Answer C. **Laminectomy with instrumented fusion**
The patient in the scenario is getting rest pain or critical stenosis and had failed conservative management.

Epidural injection in a tight canal is not indicated and it carries a risk of further canal compromise. Besides, it will not relieve the back pain. In addition, acupuncture has no role in this patient.

Surgery is indicated in this case and is supported by the SPORT study. Compared with patients who are treated non-operatively, patients whose degenerative spondylolisthesis and associated spinal stenosis are treated surgically maintain substantially greater pain relief and improvement in function for 4 years.

Laminectomy alone or with non-instrumented fusion will not address the instability. Resection of the hypertrophic facets during laminectomy can lead to further instability.

Weinstein JN et al. Surgical compared with nonoperative treatment for lumbar degenerative spondylolisthesis: four-year results in the Spine

Patient Outcomes Research Trial (SPORT) randomized and observational cohorts. *J Bone Joint Surg Am.* 2009;**91**:1295–1304.

60. Answer C. **Thoracic spine is the most common site followed by lumbar and cervical**
Vertebral body accounts for 80% of spinal metastases with 20% posterior elements

Breast (30%) followed by lung (14%), prostate (7.5%), renal (5%), GI (5%), thyroid (4%) and lastly haemopoietic.

Spinal cord compression is not a component if SINS.

Vertebroplasty is performed with neurologically intact patients and mechanical instability with NO posterior wall defect.

Chapter 13

Shoulder/Elbow I Structured SBA

Razvan Taranu and Shantanu Shahane

SHOULDER/ELBOW I STRUCTURED SBA QUESTIONS

1. A 36-year-old sportsman attends the clinic complaining of left shoulder weakness and deep-seated pain. Examination reveals wasting below the spine of scapula affecting the infraspinous fossa only.
   Which of the following would be the most useful investigation?
   A. CT
   B. MRI
   C. MRI arthrogram
   D. US
   E. X-ray

2. A 71-year-old woman attends complaining of a 3-month history of right shoulder pain and stiffness. There is no history of trauma. Examination reveals active movements of 30° of flexion, 30° abduction and no active external rotation.
   What is the next most useful step in this patient's management?
   A. Arthroscopic capsular release +/– MUA
   B. Bone scan
   C. MRI scan
   D. US
   E. X-ray

3. An 83-year-old man undergoes a reverse polarity shoulder replacement for rotator cuff arthropathy using a McKenzie approach.
   An injury to the axillary nerve directly related to this approach leads to which deficit?
   A. Absent sensation in regimental badge area
   B. Absent sensation in regimental badge area and inability to forward flex the arm
   C. Inability to abduct the arm
   D. Inability to forward flex the arm
   E. Loss of deltoid function

4. An obese patient undergoes a total shoulder replacement through a deltopectoral approach. The surgeon states that large soft tissue retractors had to be used.
   Given the history, the most likely neurological deficit would be which of the following?
   A. Altered sensation in lateral forearm and weak pronation
   B. Altered sensation in lateral forearm and weak supination
   C. Altered sensation in regimental badge area
   D. Altered sensation in regimental badge area and deltoid palsy
   E. Middle and anterior deltoid palsy

5. A 24-year-old athlete sustains a traumatic dislocation of the left shoulder. Following reduction, he is noted to have absent sensation in the deltoid area.
   Which of the following is most likely to be positive?
   A. Empty can test
   B. External rotation lag sign
   C. Gerber's lift-off test
   D. Hornblower sign
   E. O'Brien's test

6. A 36-year-old woman sustained a fall 3 months ago and was referred by her GP to physiotherapy. She was noted to have her arm in fixed internal rotation with reduced flexion.
   What would be the most useful investigation at this stage?
   A. MRI
   B. MRI arthrogram
   C. X-ray
   D. Diagnostic arthroscopy
   E. US

7. A 32-year-old male undergoes a distal biceps tendon repair.

The most likely neurological deficit with this procedure is which of the following?

A. Altered sensation in the first web space
B. Inability to extend the thumb but wrist extension with radial deviation present
C. Altered sensation in the lateral forearm
D. Altered sensation in the lateral forearm and weak supination
E. Inability to flex the thumb IPJ and index/middle fingers DIPJ

8. A 7-year-old child sustains a lateral mass fracture of the right elbow.

What is the most likely late onset functional deficit?

A. Inability to abduct the thumb
B. Inability to adduct the thumb
C. Loss of forearm supination
D. Loss of thumb IPJ flexion
E. Weakness of wrist extension

9. A 9-year-old girl falls off a trampoline and sustains an injury to her elbow (Figure 13.1).

Figure 13.1 AP radiograph elbow

The most likely structure to be injured will result in which of the following deficits?

A. Altered sensations over the lateral aspect of forearm
B. Inability to flex DIPJ of index finger
C. Inability to extend the wrist
D. Inability to flex DIPJ of ring finger
E. Inability to oppose the thumb to little finger

10. A 30-year-old male presents to clinic with pain and bruising in the anterior aspect of his right elbow. He says that 3 days ago he was in the gym and felt a pop in his distal arm.

If he wishes to proceed with non-operative management, he will likely lose approximately which of the following?

A. 50% of grip strength
B. 40% of supination strength
C. 80% of supination strength
D. 60% of flexion strength
E. 10% of flexion strength

11. A 36-year-old body builder sustains a distal biceps tendon rupture and is offered surgical repair.

The more common complication encountered with a two-incision technique as compared with a 1-incision is which of the following?

A. Lateral antebrachial nerve injury
B. Musculocutaneous nerve injury
C. PIN injury
D. Radial nerve injury
E. Synostosis

12. A 25-year-old rugby player sustains recurrent anteroinferior traumatic dislocations of the shoulder. Plain MRI scan was normal and at arthroscopy, no soft tissue or bony Bankart lesion was found. The patient continued to experience recurrent instability.

Which of the following was the most likely lesion that was missed?

A. GLAD
B. HAGL
C. Kim lesion
D. Long head of biceps tendon rupture
E. SLAP lesion

13. A 49-year-old male sustains a traction injury to his left arm while operating a machine in a chocolate factory. Neurophysiological studies suggest a preganglionic lesion.

This is characterised by which of the following?

A. Sensory action potentials deficit and F waves
B. Sensory action potentials deficits only
C. Sensory action potentials intact and motor action potentials deficit
D. Sensory and motor action potential deficits
E. Sensory action potentials deficit and motor action potentials intact

14. A 72-year-old patient is diagnosed with rotator cuff arthropathy. She is offered a reverse polarity shoulder replacement.
What are the main biomechanical advantages of this prosthesis?
A. COR (centre of rotation) moves superiorly and medially
B. COR is fixed and moves inferiorly and laterally
C. COR is fixed and moves inferiorly and medially
D. COR is mobile and moves inferiorly and medially
E. COR is mobile and moves superiorly and medially

15. A 36-year-old male sustains a penetrating injury in the right infraclavicular area. He is noticed to be unable to extend right wrist and fingers. EMG confirms injury to the posterior trunk.
What other positive neurological findings is he expected to have?
A. Absent sensation in lateral aspect of forearm, weak finger flexion and elbow flexion
B. Absent sensation in ring and little fingers, medial aspect of forearm and weak elbow extension
C. Absent sensation in the first dorsal web space, regimental badge area and weak shoulder flexion
D. Weakness of shoulder internal rotation and elbow flexion
E. Weakness on belly press test

16. An elderly patient undergoes shoulder surgery under regional anaesthesia. Post-operatively, he is noticed to keep his right eye half closed.
What other clinical signs is he most likely to present with?
A. Miosis, anhidrosis, high systolic BP
B. Miosis, anhidrosis, low oxygen saturation
C. Miosis, hyperhidrosis, low oxygen saturation
D. Mydriasis, anhidrosis, low oxygen saturation
E. Mydriasis, hyperhidrosis, low systolic BP

17. A 55-year-old female undergoes cervical spine surgery. A few weeks after surgery, she presents with left scapula winging.
What other positive findings is she likely to have?
A. Inability to retract left shoulder
B. Inability to shrug left shoulder
C. Positive Froment's sign
D. Ptosis, miosis, anhidrosis
E. Ptosis, mydriasis, anhidrosis

18. A patient undergoes an open Latarjet procedure for recurrent shoulder dislocations.
A nerve injury most likely to occur during harvesting and preparation of the coracoid graft is most likely to lead to which of the following?
A. Absent elbow flexion
B. Absent elbow flexion and reduced sensation in lateral forearm
C. Reduced sensation in the regimental badge area and weak shoulder abduction
D. Weak elbow extension and reduced sensation in the first web space
E. Weakness of forearm supination

19. A 6-year-old child presents to ED with an elbow injury (Figure 13.2). On vascular assessment, the radial pulse is absent and CRT >5s.

Figure 13.2 Lateral radiograph elbow

What is the next step in this patient's management?
A. Apply back slab and immediate closed/open reduction in theatre
B. Apply back slab, immediate closed/open reduction in theatre and brachial artery exploration
C. Immediate closed/open reduction, re-check pulse and if hand is still ischaemic discuss with the senior orthopaedic surgeon on call
D. Immediate closed/open reduction, re-check pulse and, if absent, discuss with the vascular surgeon on call even if the hand is well perfused

E. Monitor for compartment syndrome and operate on the next available trauma list with the vascular surgery cover

20. A 5-year-old child sustains a Gartland type III supracondylar fracture and undergoes closed reduction and crossed pinning technique. A few hours post-operatively he is noticed to complain of increasing pain, has absent sensations in the little finger and weak interossei.

What is the next step in this patient's management?

A. Analgesia and continue to monitor neurovascular status, as this is most likely due to neurapraxia and is likely to recover
B. Perform urgent nerve conduction studies to assess the level and severity of injury
C. Return to theatre after you discuss with a surgeon experienced in nerve repair
D. Return to theatre urgently and explore the ulnar nerve
E. Split the bandages, gently reposition the limb and reassess

21. An 80-year-old woman undergoes reverse polarity total shoulder replacement. She is doing very well post-operatively, but 8 weeks after surgery she develops sudden, non-traumatic and painless loss of range of motion.

The most likely complication is which of the following?

A. Axillary nerve injury
B. Deep-seated infection
C. Dislocation
D. Fracture of the acromion
E. Loosening of the glenosphere

22. An 84-year-old man with rheumatoid arthritis undergoes reverse polarity total shoulder replacement with excellent post-operative recovery. At 6-month follow up, he complains of sudden pain in the operated shoulder with loss of range of motion. There is no history of trauma.

What is the most likely diagnosis?

A. Axillary nerve injury
B. Deep-seated infection
C. Dislocation
D. Fracture of the acromion
E. Loosening of the glenosphere

23. A 60-year-old fit and healthy woman presents with severe shoulder pain. X-ray reveals severe bipolar glenohumeral joint osteoarthritis. There is less than 10° of glenoid retroversion, and the rotator cuff, though degenerate, is structurally intact.

What is the most appropriate intervention?

A. Anatomical total shoulder replacement
B. Glenohumeral joint steroid injection
C. Reverse polarity total shoulder replacement
D. Stemmed hemiarthroplasty
E. Surface replacement hemiarthroplasty

24. A 26-year-old sustains pain on the back of the elbow while lifting overhead weights. An X-ray reveals the finding shown in Figure 13.3.

Figure 13.3 Lateral radiograph elbow

What is the most likely diagnosis?

A. Avulsion injury of triceps tendon ('flake sign')
B. Ectopic bone formation
C. Fracture of the distal humerus
D. Fracture olecranon
E. Loose body in the elbow joint

25. Controversy exists regarding fixation surgery for clavicle fracture.

All of the following are absolute indications for internal fixation of midshaft clavicle fracture with displacement except which?

A. Associated fracture neck of scapula
B. Compound fracture
C. Fragment overlap of more than 2cm
D. Neurovascular compromise
E. Threatened skin condition with tenting

26. A 43-year-old lady undergoes a humeral nailing procedure for a transverse midshaft humeral fracture. She undergoes a further surgical procedure 6 months later.

What is this surgical procedure most likely to be?

A. Removal of distal locking screws due to backout
B. Removal of nail due to prominence at the greater tuberosity
C. Removal of proximal locking screws due to backout
D. Rotator cuff repair
E. Surgery for non-union of the humeral fracture

27. Neer classified lateral third clavicle fractures into three types.

What characteristic best represents a Neer type I lateral third clavicle fracture?

A. The coracoclavicular ligaments are disrupted completely
B. The coracoclavicular ligaments are attached to the lateral fracture fragment and there is gross fracture displacement
C. The coracoclavicular ligaments are attached to the lateral fracture fragment and there is minimal fracture displacement
D. The coracoclavicular ligaments are attached to the medial fracture fragment and there is minimal fracture displacement
E. The coracoclavicular ligaments are attached to the medial fracture fragment and there is gross fracture displacement

28. A 12-year-old girl is a keen swimmer. She swims for up to 16 hours a week and is planning a professional career in swimming. She presents to the clinic complaining of non-traumatic shoulder instability.

The most likely clinical and radiological findings are which of the following?

A. Beighton's score of less than 3 and a positive sulcus sign
B. Beighton's score of less than 3 and multidirectional instability
C. Beighton's score of less than 4 and a Bankart lesion
D. Beighton's score of more than 5 and a Bankart lesion
E. Beighton's score of more than 6, multidirectional instability and no Bankart lesion

29. A 20-year-old female presents to A&E having dislocated her elbow due to a fall on her outstretched hand. This is reduced under sedation. There are no associated bony injuries. She is discharged from the fracture clinic 6 weeks later after an uneventful recovery with full range of motion and no pain. She presents to the elbow clinic 6 months later complaining of clicking in the elbow joint.

What is the most likely diagnosis?

A. A missed coronoid fracture
B. Ectopic bone formation
C. Loose body in the elbow
D. Medial collateral ligament insufficiency
E. Posterolateral rotatory instability

30. A 45-year-old patient undergoes excision of right medial clavicle for severe osteoarthritis.

Which structure is at most surgical risk?

A. Right brachiocephalic trunk
B. Right brachiocephalic vein
C. Right internal jugular vein
D. Right subclavian vein
E. Right suprascapular artery

31. A 45-year-old male presents to your clinic with intermittent clicking sensation of his right elbow which he has experienced for approximately 6 months. He states that the elbow locks on a weekly basis and this affects his job. You decide to perform an arthroscopy but following the procedure the patient experiences paraesthesia in the radial digits and weakness on flexing his fingers.

Which is the most probable intraoperative technical error when instrumenting the joint?

A. Elbow extension
B. Elbow flexion to 90°
C. Insufficient joint insufflation with saline
D. Joint insufflation and flexion to 90°
E. Lateral position of patient

32. A 29-year-old cricket player has been complaining of pain during throwing for approximately 5 months. His pain occurs with maximum arm abduction and external rotation.

What would be your proposed treatment?

A. Arthroscopic debridement of rotator cuff +/− posterior labrum
B. Arthroscopic rotator cuff repair
C. Mini-open rotator cuff repair
D. Physiotherapy, cessation from throwing and posterior capsular stretching
E. Posterior capsular release

33. A 51-year-old warehouse worker presents to the Upper Limb clinic with a 12-month history of lateral elbow pain. Examination reveals tenderness on direct palpation of lateral epicondyle and pain in the elbow on active extension against resistance of middle finger with the forearm pronated.

The most likely histopathological finding of this condition will be:

A. Angiofibroblastic hyperplasia
B. Fibroblasts/myofibroblasts with abundant type III collagen
C. Mononuclear stromal cells that resemble interstitial fibroblasts
D. Perineural fibrosis
E. Predominantly type III collagen with myofibroblasts

34. A 75-year-old male is 6 weeks following right total shoulder replacement. He was doing well post-operatively until 1 week ago, when he felt sudden anterior shoulder pain and weakness. After detailed history, he admits not wearing the sling at home and having a fall. The X-ray does not show any evidence of dislocation.

What is the most likely clinical finding?

A. Excessive passive external rotation
B. Loss of internal rotation
C. 'Popeye' muscle
D. Reduced active external rotation
E. Weakness on empty can test

35. A 35-year-old male undergoes surgery for a displaced, comminuted right clavicle fracture. The surgeon decides to use a long plate with the medial end seated close to the sternoclavicular joint.

Which is the structure at most risk when drilling the medial holes?

A. Brachial plexus
B. External jugular vein
C. Lung apex
D. Subclavian artery
E. Subclavian vein

36. A 78-year-old female patient suffers from severe left shoulder pain with restricted mobility. Her past medical history includes rheumatoid arthritis and she smokes 10 cigarettes per day. Non-operative treatment, including two previous steroid injections (the last one given by GP 7 weeks ago) has failed to alleviate her symptoms and she is desperate for a shoulder replacement. She undergoes this operation 3 weeks later and this is complicated by a post-operative haematoma.

The following are considered to be risk factors for post-operative joint infection, except:

A. Inflammatory arthritis
B. Old age
C. Post-operative haematoma
D. Smoking
E. Steroid injection within 3 months of surgery

37. A 59-year-old painter-decorator presents with long-standing right dominant shoulder pain with no history of trauma. Examination reveals tenderness on palpating the acromion and a positive Hawkins test. The X-ray is presented in Figure 13.4.

Figure 13.4 X-ray with os acromiale

The following statement is true about this condition:

A. Excision of the anterior acromion does not carry any risks
B. It is associated with rotator cuff tears in 60–75% of the cases
C. It is best diagnosed on lateral Y-view radiograph

D. Pain is given by impingement and motion at the non-union site
E. The most common location is between pre- and meso-acromion

38. A 34-year-old cricket player has been complaining of dominant shoulder pain for the past 6 months; his symptoms occur during late cocking and early acceleration phases of throwing.
Which of the following features is not related to the condition you are suspecting?
A. Bennett lesion
B. Bursal sided fraying of supraspinatus
C. Cartilage damage at posterior glenoid
D. Posterior labral lesion
E. Superior labral lesion

39. A 28-year-old overhead male athlete presents with poorly localised pain in the postero-lateral aspect of his dominant shoulder with a degree of paraesthesia in the lateral shoulder. Examination reveals weakness of external rotation with the arm in abduction. Symptoms are worse at night, without any red flag signs. MRI shows an inferior paralabral cyst and labral tear.
What is the most likely diagnosis?
A. Internal impingement
B. Long head of biceps tendinopathy
C. Parsonage–Turner syndrome
D. Quadrilateral space syndrome
E. Suprascapular neuropathy

40. A 36-year-old volleyball player presents with a 3-month history of dominant shoulder pain and weakness. Examination reveals weakness on empty can test and external rotation at side. Neurophysiological studies suggest suprascapular nerve neuropathy, the site of lesion being at the suprascapular notch.
When you perform the decompression, you expect to find the following structures (in this order):
A. Artery, ligament (arising from medial base of coracoid), nerve
B. Artery, ligament (arising from medial base of spine of scapula), nerve
C. Ligament (arising from medial base of coracoid), nerve, artery
D. Ligament (arising from medial base of coracoid), suprascapular artery, suprascapular nerve
E. Ligament (arising from medial base of spine of scapula), artery, nerve

41. A 13-year-old boy falls off his bike and sustains an injury to his right shoulder. Examination demonstrates a large swelling corresponding to the lateral clavicle and an asymmetry between the 2 shoulders. No visible wounds can be seen. There is no neurological or vascular deficit. The X-ray demonstrates a displaced lateral clavicle fracture.
Which of the following statements is correct about this injury?
A. It is unstable
B. The conoid ligament is torn
C. The periosteal sleeve is intact
D. The trapezoid ligament is torn
E. Treatment is non-operative

42. A 78-year-old woman presents to your clinic with increasing pain in her right shoulder which was replaced 12 years ago. You decide that this prosthesis needs revising.
Which is the most common cause of shoulder replacement failure?
A. Glenoid component loosening
B. Humeral component loosening
C. Infection
D. Instability
E. Subscapularis repair failure

SHOULDER/ELBOW I STRUCTURED SBA ANSWERS

1. Answer C. **MRI arthrogram**
   All these investigations are useful in diagnosing shoulder pathology, but the most indicated investigation in this scenario is an MRI arthrogram, which will clearly show a spinoglenoid notch cyst +/– SLAP tear. Spinoglenoid cyst is a recognised cause of suprascapular compressive neuropathy, which results in wasting of infraspinatus muscle only as the branch to supraspinatus is given proximal to the spinoglenoid notch. A dye is necessary to 'fill' the cyst, and so a plain MRI scan may not be as useful.

2. Answer E. **X-ray**
   Loss of external rotation is most commonly caused by osteoarthritis, adhesive capsulitis, trauma or tumour. The first and most accessible investigation is an X-ray, which, in the scenario, is able to demonstrate any osteoarthritic changes or lytic lesions in the proximal humerus/neck of glenoid. The X-ray may in itself reveal the necessary diagnosis. If not, further investigations may also be later needed.

3. Answer D. **Inability to forward flex the arm**
   Superolateral approach carries the risk of injury to the terminal branch of axillary nerve supplying the anterior deltoid (anterior deltoid palsy). The associated motor deficit will be inability to forward flex the arm, while arm abduction will still be possible as the innervation to middle deltoid is still preserved. The sensory branch to the regimental badge area is given more posterior, thus sensation will still be intact.

4. Answer B. **Altered sensation in lateral forearm and weak supination**
   Though many structures can be injured during this surgery, the structure most at risk when placing the shoulder retractors under the conjoint tendon is the musculocutaneous nerve, which innervates three muscles (biceps brachii, coracobrachialis and medial part of the brachialis) and provides sensation to the lateral forearm.

   An injury to this nerve results in altered sensation in lateral forearm and weakness of forearm supination and elbow flexion.

5. Answer D. **Hornblower sign**
   Absent sensation in the deltoid area suggests an injury to the axillary nerve, which also supplies the deltoid and teres minor muscles. Out of all the possible answers, Hornblower sign is positive when there is weakness of the teres minor (test is performed by assessing external rotation with arm abducted to 90° and in 90° of external rotation). The other tests assess the following pathology: empty can – supraspinatus tear; Gerber's lift-off – subscapularis tear; external rotation lag sign – infraspinatus tear; and O'Brien's test – SLAP tear.

6. Answer C. **X-ray**
   X-ray is the first investigation when there is functional deficit following a traumatic event. In this case, the first diagnosis to rule out would be posterior dislocation. MRI, MRI arthrogram and US are useful in diagnosing shoulder pathology but should only be requested when fracture or dislocation has been excluded or as additional investigation for correct assessment of soft tissue status (after X-ray).

7. Answer C. **Altered sensation in the lateral forearm**
   The most common neurological deficit encountered with distal biceps tendon repair is injury to lateral antebrachial cutaneous nerve (up to 9.9%), leading to altered sensation in the lateral forearm. The other possible answers suggest injuries to other nerves, but with a lower incidence. These will result in the following deficits: altered sensation in the first web space (superficial radial nerve), inability to extend the thumb with preserved wrist extension and radial deviation (posterior interosseous nerve), inability to flex the thumb IPJ and index/middle fingers DIPJ (anterior interosseous nerve).

   Amin NH et al. Complications of distal biceps tendon repair: a meta-analysis of single-incision versus double-incision surgical technique. *Orthop J Sports Med.* 2016;**4**(10).

8. Answer B. **Inability to adduct the thumb**
   Lateral mass fracture can result in lateral physeal arrest and cubitus valgus with tardy ulnar nerve palsy. Weakness of adductor pollicis (innervated by ulnar nerve) leads to inability to properly

adduct the thumb. Inability to abduct the thumb is due to injury to PIN, weakness of wrist extension – PIN/radial nerve; weakness of forearm supination – musculocutaneous nerve; loss of IPJ thumb flexion – anterior interosseous nerve.

9. Answer B. **Inability to flex DIPJ of index finger**
The anterior interosseous nerve is the most commonly injured nerve in extension-type paediatric supracondylar elbow fractures. This results in the inability to flex the index finger DIPJ and IPJ of thumb (inability to make an 'O' sign with thumb and index finger). The other answers suggest an injury to the following nerves: altered sensation over the lateral aspect of forearm – lateral antebrachial cutaneous nerve (terminal branch of musculocutaneous nerve); inability to extend the wrist – radial nerve; inability to flex DIPJ of little finger – ulnar nerve; inability to oppose thumb to little finger – median nerve.

10. Answer B. **40% of supination strength**
Patients who are counselled for non-operative management of distal biceps tendon rupture should be told that their supination strength will reduce by 40%, flexion strength by 30% and grip strength by 15%.

Morrey BF, Askew LJ, An KN, Dobyns JH. Rupture of the distal tendon of the biceps brachii: a biomechanical study. *J Bone Joint Surg Am.* 1985;**67**:418–421.

11. Answer E. **Synostosis**
The more common complication using a two-incision technique as compared with the 1-incision technique is synostosis. All the other complications are more common with a 1-incision technique.

Amin NH et al. Complications of distal biceps tendon repair: a meta-analysis of single-incision versus double-incision surgical technique. *Orthop J Sports Med.* 2016;**4**(10).

12. Answer B. **HAGL**
HAGL lesions (humeral avulsion of glenohumeral ligaments) are a rare and therefore often missed cause of recurrent instability. This can be diagnosed by MR arthrogram as an investigative modality (when the dye is seen to leak extra articular, close to the neck of the humerus). At arthroscopy, if a patient is experiencing recurrent instability and an obvious cause such as a Bankart lesion is not found, a 70° scope should be used to examine for a HAGL lesion, or the scope moved to the anterior portal to diagnose this pathology.

Rhee YG, Cho NS. Anterior shoulder instability with humeral avulsion of the glenohumeral ligament lesion. *J Shoulder Elbow Surg.* 2007;**16**:188–192.

13. Answer C. **Sensory action potentials intact and motor action potentials deficit**
A preganglionic injury is an avulsion to the dorsal root ganglion with a poor prognosis (little potential for motor function recovery; see Figure 13.5 (a) and (b)). Clinical signs of preganglionic injury are sensory intact, Horner syndrome, medial scapula winging, paralysis of hemidiaphragm (phrenic nerve), inability to retract shoulder (rhomboid-dorsal scapular nerve), weak abduction/external rotation (supraspinatus/infraspinatus – suprascapular nerve), paralysis of latissimus dorsi (thoraco-dorsal nerve). Postganglionic injuries have a better prognosis for recovery (Figure 13.5 (c) and (d)).

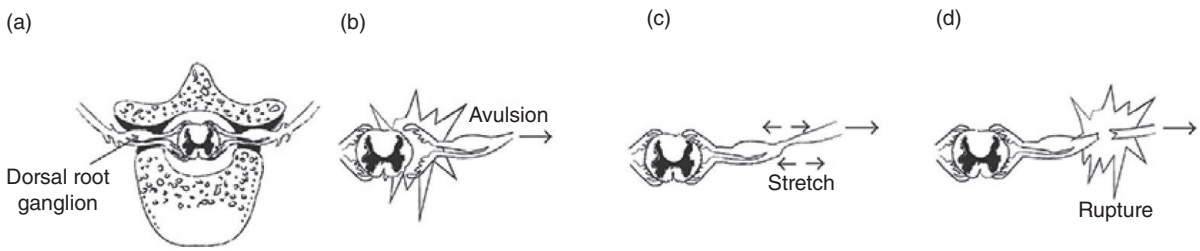


Figure 13.5 (a) Normal anatomy of rootlets and roots. (b) Avulsive preganglionic injury. (c, d) Postganglionic injury

14. Answer C. **COR is fixed and moves inferiorly and medially**
Reverse polarity shoulder prosthesis provides a fixed fulcrum, which prevents superior migration of the humeral head and facilitates deltoid function. COR is also displaced medially and inferiorly to increase deltoid lever arm and length, thus improving its efficiency. This is essential knowledge even if the SBA is rather easy. If you have got this question incorrect, re-evaluate your core knowledge and revision methods.

Although the question is relatively easy it is testing essential knowledge. The question was kept and not discarded as it is those candidates getting this question wrong who are on a sticky wicket.

15. Answer E. **Weakness on belly press test**
The posterior cord gives rise to five nerves: upper subscapular (subscapularis muscle), lower subscapular (subscapularis and teres major), thoracodorsal (latissimus dorsi), axillary (deltoid, teres minor, lateral aspect of proximal arm, glenohumeral joint) and radial (elbow and forearm extensors, supinators, posterior brachial cutaneous, inferolateral brachial cutaneous, superficial radial nerve, posterior antebrachial cutaneous).

Belly press test is performed to assess for weakness of the subscapularis muscle. Weakness is a result of injury to the upper and lower subscapular nerves. All the other answers present a combination of injury to different nerves not limited to the posterior cord:

D. upper/lower subscapular (posterior cord) and musculocutaneous (lateral cord)
C. superficial radial/axillary (posterior cord) and musculocutaneous (lateral cord)
B. ulnar/medial antebrachial cutaneous (medial cord) and radial (posterior cord)
A. musculocutaneous (lateral) and radial (posterior cord)

16. Answer B. **Miosis, anhidrosis, low oxygen saturation**
This patient developed hemidiaphragmatic paresis and Horner syndrome characterised by miosis (small pupil), partial ptosis and anhidrosis (absent sweating). This was due to involvement of sympathetic trunk and phrenic nerve.

Side effects of interscalene block are phrenic nerve block with diaphragmatic hemiparesis (100% incidence, 25% reduction in pulmonary function), Horner syndrome, block of vagus nerve and recurrent laryngeal nerve (voice hoarseness), pneumothorax, permanent neurological injury, vertebral artery injection, severe hypotension and bradycardia (Bezold–Jarisch reflex).

17. Answer A. **Inability to retract left shoulder**
This SBA is testing anatomy of the brachial plexus. The level of injury is at the roots of brachial plexus. The two nerves arising at this level are the dorsal scapular nerve (C5) (rhomboids – shoulder retraction) and long thoracic nerve (serratus anterior (C5, C6, C7) – protracts, upwardly rotates and stabilises the scapula). The sympathetic chain can also be injured, resulting in Horner syndrome (miosis, anhidrosis, ptosis) (answer D), but this is lower (C7, C8, T1). Shoulder shrug is performed by the trapezius (innervated by spinal accessory nerve, which is the XI cranial nerve). Froment's sign is positive in ulnar nerve injury.

18. Answer E. **Weakness of forearm supination**
The nerve at most risk when harvesting and preparing the coracoid graft is the musculocutaneous, which pierces the coracobrachialis approximately 3–8cm distal to the coracoid. The patient will complain of weak forearm supination due to biceps paralysis.

Elbow flexion will be weak but not absent, as other muscles contribute to elbow flexion and are not innervated by musculocutaneous nerve (brachioradialis and lateral part of brachialis – radial nerve). Reduced sensation in regimental badge area and weak shoulder abduction suggest an injury to the axillary nerve. Weak elbow extension and reduced sensation in the first web space are due to radial nerve injury.

19. Answer A. **Apply back slab and immediate closed/open reduction in theatre.**
According to BOAST 11 guidelines revised in October 2020, in the case of a child presenting with an ischaemic limb and elbow supracondylar fracture, the child should be taken to theatre urgently and fracture should be reduced and stabilised. In the majority of cases, vascular impairment resolves with fracture reduction. If there are no clinical signs of ischaemia, brachial artery exploration is not required whether or not the radial pulse is present.

20. Answer D. **Return to theatre urgently and explore the ulnar nerve**
There is a concern of iatrogenic ulnar nerve injury, which can occur with a crossed pinning technique. There is no information regarding intraoperative visualisation of the ulnar nerve, which should be documented when medial wire is used. In this particular situation, the patient should return to theatre and ulnar nerve exploration should be performed.

21. Answer C. **Dislocation**
Fracture of the acromion, loosening of the glenosphere and infection are usually painful. A patient elevating the arm adequately after surgery is unlikely to develop delayed onset axillary nerve palsy. The most common cause of painless loss of range of motion at 8 weeks is dislocation.

22. Answer D. **Fracture of the acromion**
This is due to increased stresses on the acromion, resulting from an increase in deltoid tension, especially in poor rheumatoid bone. Dislocation is usually painless. Infection does not often manifest with sudden loss of range of motion. Delayed axillary nerve injury is uncommon. Loosening of the glenosphere is a possible explanation (though often does not happen so soon after surgery), but fracture of the acromion is more common.

23. Answer A. **Anatomical total shoulder replacement**
Intact cuff and less than 10° of retroversion are good indicators for success of anatomical TSR. Injection is likely to give only short-term relief, and surface replacement or stemmed hemiarthroplasty, though possible, are known to create increased glenoid erosive pain. In this age group, in the presence of intact cuff, reverse TSR is not indicated.

24. Answer A. **Avulsion injury of triceps tendon ('flake sign')**
The image presents the 'flake sign', suggesting an avulsion of the triceps tendon. Loose bodies in elbow are rounded, intra-articular and usually anterior. Fractures of the olecranon have a different configuration.

25. Answer C. **Fragment overlap of more than 2cm**
All are absolute indications for operative fixation except option C, which represents a relative indication. Other relative indications are polytrauma patient, closed head injury, bilateral and displaced fractures, brachial plexus injury.

26. Answer E. **Surgery for non-union of the humeral fracture**
Though any of the complications are possible, distraction non-union is the most common complication after humeral fracture nailing with a reported incidence of 33%.

Hems TE, Bhullar TP. Interlocking nailing of humeral shaft fractures: the Oxford experience 1991 to 1994. *Injury* 1996;**27**:485–489.

27. Answer D. **The coracoclavicular ligaments are attached to the medial fracture fragment and there is minimal fracture displacement**
Neer's classification of lateral third clavicle fractures consists of the following:

Type I – fracture occurs laterally to coracoclavicular ligaments, which are intact.

Type II – A. between CC ligaments (intact trapezoid and torn conoid), B. lateral to CC ligaments (which are torn). Unstable injuries, high non-union rate.

Type III – intra-articular extension into the ACJ (CC ligaments intact). Risk of early osteoarthritis, stable injury.

28. Answer E. **Beighton's score of more than 6, multi-directional instability and no Bankart lesion**
This patient has a hypermobile shoulder and a Polar type II/III instability on the Stanmore triangle (multidirectional, atraumatic, non-structural). They very rarely if ever have a structural pathology such as a Bankart lesion. A Beighton's score of 5 or more is an indication of generalised hypermobility.

The Polar classification of instability are: type I – traumatic, structural, usually unilateral; type II – atraumatic, occasionally secondary structural, not uncommonly bilateral, no muscle patterning; type III – muscle patterning, non-structural.

29. Answer E. **Posterolateral rotatory instability**
Most common traumatic elbow dislocation is posterolateral which can result in injury to LUCL (lateral ulnar collateral ligament). LUCL is the main structure to prevent posterolateral instability (PLI). Chronic PLRI presents with intermittent clicking, often with elbow in extension and when pushing off a chair.

30. Answer B. **Right brachiocephalic vein**
The closest posterior structure to the right sternoclavicular joint is the right brachiocephalic vein.

31. Answer A. **Elbow extension**
Adequate patient positioning and insufflation of joint prior to instrumentation is crucial to avoid intraoperative nerve injury. It has been demonstrated that joint insufflation with normal saline and flexion to 90° leads to a maximum nerve-to-bone distance (12mm for median nerve and 6mm for radial nerve). However, insufflation does not increase the capsule-to-nerve distance. Extension of the elbow negates any advantage obtained through insufflation of the joint.

Miller CD, Jobe CM, Wright MH. Neuroanatomy in elbow arthroscopy. *J Shoulder Elbow Surg.* 1995;**4**:168–174.

32. Answer D. **Physiotherapy, cessation from throwing and posterior capsular stretching**
The patient suffers from internal shoulder impingement which includes a spectrum of injuries: superior and posterior labral lesions, fraying of posterior rotator cuff, hypertrophy and scarring of posterior capsule, cartilage damage at posterior glenoid. All answers are acceptable treatment options, but the first-line management is physiotherapy, cessation from throwing and posterior capsular stretching.

33. Answer: A. **Angiofibroblastic hyperplasia**
Angiofibroblastic hyperplasia occurs in lateral elbow epicondylitis. The other histopathological findings occur in: B – Adhesive capsulitis, C – Dupuytren's disease, D – Giant Cell Tumour, E – Neuroma.

Tendinosis is incompletely understood. Although the term tendinitis is used frequently and often indiscriminately, histopathological studies have shown that specimens of tendon obtained from areas of chronic overuse do not contain large numbers of macrophages, lymphocytes or neutrophils. Rather, tendinosis appears to be a degenerative process that is characterised by the presence of dense populations of fibroblasts, vascular hyperplasia and disorganised collagen. This constellation of findings has been termed angiofibroblastic hyperplasia.

Angiofibroblastic tendinosis refers to the degenerative changes that occur when a tendon has failed to heal properly after an injury or after repetitive microtrauma resulting from overuse. Tendinitis is characterised by the presence of an increased number of lymphocytes or neutrophils. Tendinosis is characterised by the presence of active fibroblasts and vascular hyperplasia.

Bhabra G et al. Lateral elbow tendinopathy: development of a pathophysiology-based treatment algorithm. *Orthop J Sports Med.* 2016;**4**:2325967116670635.

Kraushaar BS, Nirschl RP. Tendinosis of the elbow (tennis elbow): clinical features and findings of histological, immunohistochemical, and electron microscopy studies. *J Bone Joint Surg Am.* 1999;**81**:259–278.

34. Answer: A. **Excessive passive external rotation**
Failure of subscapularis repair is a recognised complication following total shoulder arthroplasty (TSA), especially if the patient is not compliant with the post-operative protocol. Patient will have excessive passive external rotation. Internal rotation of shoulder is reduced, but still possible due to teres major, latissimus dorsi and pectoralis major. Supraspinatus and infraspinatus are expected to be intact 6 weeks following TSA. 'Popeye' muscle may occur prior to surgery (spontaneous rupture in degenerative shoulder or previous surgical intervention) or post-operatively (failed tenodesis). In the latter case, the patient experiences a 'pop' in the anterior aspect of the shoulder.

35. Answer E. **Subclavian vein**
All the above structures are at risk when performing fixation of clavicle fractures. The structure in most danger of being injured when drilling into the medial clavicle is the subclavian

vein, which in some cases is localised immediately behind the posterior cortex.

The brachial plexus, although at risk of injury, is further away from clavicle than the vessels in relation to the medial two-thirds of the bone.

The vein is intimately related to the clavicle, whereas the artery is somewhat protected by the intervening scalenus anterior. An anteroposterior screw trajectory poses the greatest risk of injury to the subclavian vein in this zone, whereas a craniocaudal screw trajectory, as performed in superior plating, appears to be a safe option.

Sinha A, Edwin J, Sreeharsha B, Bhalaik V, Brownson P. A radiological study to define safe zones for drilling during plating of clavicle fractures. *J Bone Joint Surg Br.* 2011;**93**:1247–1252.

36. Answer B. **Old age**
Inflammatory arthritis, young age, smoking, post-operative haematoma and steroid injection within 3 months of surgery are risk factors for prosthetic shoulder joint infection.

Aibinder W et al. Risk factors for complications and revision surgery after anatomic and reverse total shoulder arthroplasty. *J Shoulder Elbow Surg.* 2021;**30**:e689–e701.

Werner BC et al. The timing of elective shoulder surgery after shoulder injection affects postoperative infection risk in Medicare patients. *J Shoulder Elbow Surg.* 2016;**25**:390–397.

37. Answer D. **Pain is given by impingement and motion at the non-union site**
Os acromiale is a failure of fusion at one of the three ossification centres of the acromion: pre-acromion, meso-acromion and meta-acromion. The most common location is between the meso- and meta-acromion. It is associated with rotator cuff tears in up to 50% of the cases, although some studies suggest that this figure is exaggerated. It is best diagnosed on axillary view radiograph with some additional benefit of CT to detect degenerative changes. Pain is given by impingement as the anterior fragment flexes with contraction of deltoid and arm elevation and by motion at the non-union site. Excision of the anterior acromion can lead to weakness of anterior deltoid, depending on the size of the fragment.

You T, Frostick S, Zhang WT, Yin Q. Os acromiale: reviews and current perspectives. *Orthopaedic Surg.* 2019;**11**:738–744.

38. Answer B. **Bursal sided fraying of supraspinatus**
This patient suffers from internal impingement which is a recognised cause of shoulder pain in overhead athletes. This occurs due to repetitive impingement between the undersurface of the rotator cuff and the posterosuperior glenoid, during late cocking and early acceleration phases of throwing. Bennett lesion (also known as thrower's exostosis, ossification near the glenoid attachment of posterior band of inferior glenohumeral ligament), superior and posterior labral lesions, cartilage damage at posterior glenoid are features of internal impingement. Bursal sided fraying of supraspinatus is found in external impingement.

39. Answer D. **Quadrilateral space syndrome**
Quadrilateral space syndrome is a rare cause of postero-lateral shoulder pain in overhead athletes. Symptoms are usually worse at night and are exacerbated by overhead activity or late cocking phase/acceleration phase of throwing. An inferior paralabral cyst can cause compression of the axillary nerve in the quadrangular space. Suprascapular neuropathy is caused by a superior labral cyst with SLAP tear. Long head of biceps tendinopathy and internal impingement are also causes of shoulder pain in athletes, but they are not associated with paraesthesia or weakness of external rotation with arm abducted. Parsonage–Turner syndrome (brachial neuritis) results in patchy muscle paralysis and sensory loss involving the shoulder girdle and upper extremity.

40. Answer A. **Artery, ligament (arising from medial base of coracoid), nerve**
The following structures are present at the level of the suprascapular notch: suprascapular artery, suprascapular transverse ligament (arising from the medial base of coracoid), suprascapular nerve. The surgeon should be aware that the artery is overlying the ligament and can be injured during decompression of the nerve. The nerve is the deepest structure of the three.

41. Answer E. **Treatment is non-operative**
Type IV distal clavicle fractures (paediatric) is a physeal fracture which occurs in skeletally immature patients. Conoid and trapezoid ligaments remain intact, but the clavicle pulls out of the periosteal sleeve. It is a stable injury, with great potential for remodelling and treatment is non-operative.

They are commonly misinterpreted as dislocations of the acromioclavicular joint (ACJ), although they are in fact Salter–Harris type 2 fractures of the lateral clavicular physis. The coracoclavicular ligaments remain intact, unlike following a dislocation of the ACJ, allowing the periosteal sleeve to maintain its relationship with the ACJ. Instead, the metaphysis displaces through the periosteal sleeve, akin to a banana slipping out of its skin; this has been described as a 'pseudo dislocation'.

Dameron and Rockwood (1984) classified these injuries in a similar manner to dislocations of the ACJ, based on the disruption of the periosteal tube and the consequent metaphyseal displacement.

Dameron TB, Rockwood CA. Fractures and dislocations of the shoulder. In Rockwood CA, Wilkins KE, King RE, eds. *Fractures in Children*, 624–653. Philadelphia: JB Lippincott; 1984.

Rashid A, Christofi T, Thomas M. Surgical treatment of physeal injuries of the lateral aspect of the clavicle: a case series. *Bone Joint J.* 2013;**95-B**:664–667.

42. Answer A. **Glenoid component loosening**
All answers listed above can cause failure of shoulder prosthesis, glenoid component loosening being the most common one (around 20%). Humeral stem loosening occurs more often in rheumatoid patients.

Somerson JS, Hsu JE, Neradilek MB, Matsen FA 3rd. Analysis of 4063 complications of shoulder arthroplasty reported to the US Food and Drug Administration from 2012 to 2016. *J Shoulder Elbow Surg.* 2018;**27**:1978–1986.

Chapter 14

Shoulder/Elbow II Structured SBA

Jonny Kent and Faizan Jabbar

SHOULDER AND ELBOW II STRUCTURED SBA QUESTIONS

1. A 19-year-old competitive rugby player sustains a fourth time shoulder dislocation. Their Beighton score is 6.
   Which management option is most appropriate?
   A. Arthroscopic capsular plication
   B. Arthroscopic shoulder stabilisation
   C. Open bone block procedure i.e. Laterjet
   D. Physiotherapy alone
   E. Remplissage procedure

2. Whilst working out in the gym, a patient feels a pop in their elbow and notices bruising on the medial forearm.
   A structure is repaired through a single incision approach, which deficit will be seen if the most involved nerve is injured?
   A. Altered/absent sensation in first dorsal web space
   B. Altered/absent sensation volar lateral forearm
   C. Altered/absent sensation volar medial forearm
   D. Weakness/inability to extend fingers
   E. Weakness/inability to flex thumb IPJ

3. During a shoulder arthroscopy the antero-superior labrum was noted to be absent and the MGHL to be cord-like.
   Which answer is most appropriate to account for this finding?
   A. Frozen shoulder
   B. Normal anatomical variant
   C. Recurrent instability
   D. Rotator cuff tear
   E. SLAP lesion

4. A male patient presents with increasing pain several months following shoulder arthroplasty. His CRP and ESR are normal.
   If infected, where is the most frequently causal bacteria commonly found?
   A. GI tract
   B. GU tract
   C. Oral cavity
   D. Sebaceous glands
   E. Skin surface

5. Following a fall, an 82-year-old female patient sustains a three-part proximal humerus fracture.
   Which factor predisposes her to humeral head AVN the most?
   A. Age
   B. Disrupted medial hinge
   C. Fracture configuration
   D. Medial calcar segment >8mm
   E. Sex

6. During shoulder arthroscopy a Buford complex was inadvertently 'repaired' and 're-attached' to the glenoid.
   As a result of this, what sign is the patient likely to exhibit?
   A. Decreased abduction
   B. Decreased forwards flexion
   C. Decreased external rotation
   D. Decreased internal rotation
   E. Instability

7. A 75-year-old patient with antero-superior escape of the humeral head and arthritis undergoes shoulder surgery.
   Following the most appropriate operation, what predominantly happens to the patient's centre of rotation (COR) compared with their anatomic one (glenohumeral joint)?
   A. Distalised
   B. Distalised and lateralised
   C. Lateralised

D. Medialised
E. Remains the same

8. A student presents to clinic 3 months post injury. Their main complaint is elbow clicking when getting out of a chair.
Which structure is most commonly injured?
A. Annular ligament
B. Lateral ulna collateral ligament
C. Medial collateral ligament
D. Radial collateral ligament
E. Radial head

9. A right-handed 12-year-old gymnast presents with insidious loss of elbow extension.
Where is the typical finding located?
A. Left capitellum
B. Left radial head
C. Left trochlea
D. Right capitellum
E. Right trochlea

10. **Following arthroscopic release of a condition characterised by angiofibroblast hyperplasia, which structure is most at risk?**
A. Annular ligament
B. LUCL
C. MCL
D. Posterior interosseous nerve
E. Ulna nerve

11. A runner falls with their arm in a supinated position and sustains a significant valgus posterolateral force to their elbow.
What is the most common complete sequence of events?
A. LCL–AP capsule–MCL
B. LCL–coronoid–radial head/neck
C. LUCL–AP capsule–MCL
D. LUCL–LCL–AP capsule
E. MCL–AP capsule–LUCL

12. A patient sustains a fall. They present with persistent anterior shoulder pain, and although all movements are well maintained, resisted forearm supination elicits pain and the patient occasionally experiences a clicking sensation.
Which structure is likely injured?
A. Anterior labrum
B. MGHL
C. Pectoralis major tendon
D. Subscapularis
E. Supraspinatus

13. A cricketer presents with decreased bowling speeds and pain after throwing.
Which radiographic finding is least likely to be observed?
A. Calcium deposits in MCL
B. Hypertrophy of humerus
C. Loose bodies
D. Osteophyte formation on the posterolateral olecranon
E. Traction spurs on medial aspect of ulnar notch

14. Following a mastectomy with axillary node dissection, a patient presents with asymmetry of their shoulders.
Which clinical presentation is most likely?
A. Lateral scapular winging
B. Medial scapular winging
C. Wasting of trapezius
D. Weak shoulder abduction
E. Weak shoulder external rotation

15. Following 'awake' rotator cuff repair under regional block, a patient with pre-existing asthma has mild difficulty breathing in the recovery ward.
Which finding is most likely?
A. Basal atelectasis
B. Horner syndrome
C. Local anaesthetic toxicity
D. Pulmonary embolism
E. Raised hemidiaphragm

16. On clinical examination of a patient with tingling down the medial aspect of the arm as well as gross wasting of all the intrinsic muscles of the hand it is noticed that there is reduction of the radial pulse when the shoulder is externally rotated and hyperabducted as opposed to when it is by the side.
The structure most likely causing this reduction in pulse is:
A. Cervical rib
B. Costoclavicular ligament
C. Deltoid
D. Pectoralis minor
E. Scalenus anterior

Figure 14.1 Clinical picture demonstrating external rotation shoulder and hyperabduction. Radial pulse is monitored

17. With regards to damage of the ulnar nerve at the elbow.
Which of the following statements is false?
A. Clawing of the little and ring finger
B. Inability to flex DIP joint of fourth and fifth digits
C. Intrinsic muscle strength will always be lost
D. Paraesthesia ulnar 1½ digits
E. Positive Froment's sign

18. A patient presents with weakness of APB, OP and weakness of flexion of the PIPJ of the index finger. FCR and FCU are intact.
The site of compression is most likely:
A. Between the heads of pronator teres
B. Deep to lacertus fibrosus (bicipital aponeurosis)
C. Deep to the fibrous arch of FDP
D. Deep to the ligament of Struthers
E. Deep to the transverse carpal ligament

19. **A patient with AIN palsy due to entrapment at the tendinous edge of the deep head of pronator teres will have all the following except:**
A. Intact sensation at base of thenar eminence
B. Normal pronation strength with the elbows fully flexed
C. Weakness of flexion to the index DIPJ
D. Weakness of flexion of the DIPJ of the middle/long finger
E. Weakness of flexion of the IPJ of the thumb

20. A 48-year-old right hand-dominant builder develops a 4-month history of weakness of flexion of the right thumb IPJ and index DIPJ.
Which of the following would be your likely treatment?
A. Decompression of the nerve between the two heads of pronator teres
B. Reassurance
C. Release of the Gantzer muscle
D. Release of the lacertus fibrosus edge
E. Splinting of the joints in slight flexion

21. When counselling a patient with a brachial plexus injury following an RTA, which of the following would be a clinical finding that does not necessarily indicate a poor prognosis with regards to the brachial plexus injury?
A. Jobe's test positive
B. Medial winging of the scapula
C. Ptosis
D. Raised ipsilateral hemidiaphragm
E. Unsteadiness in standing

22. A 59-year-old man underwent an uneventful anterior cervical discectomy and fusion (ACDF) C5/C7 for cervical disc prolapses with an excellent result. Four weeks post-operatively, he experienced severe pain in the right shoulder and arm, after gardening. The pain increased in the next 2 days and was followed by weakness of the right arm. There was also hypaesthesia in the right thumb. Three months after surgery he was seen with marked atrophy of the right shoulder girdle, mainly the deltoid and biceps muscles. There was severe tenderness over the right shoulder, biceps and elbow. Active and passive range of motion of the right shoulder were limited. The right biceps and brachioradialis reflexes were absent. The right deltoid strength was graded MRC 2/5, right biceps strength 3/5; all other muscles were normal. Plain radiographs and US

scan showed glenohumeral subluxation but an intact rotator cuff. A CT-scan cervical spine showed correct instrumentation. RI cervical spine did not show any significant residual foraminal stenosis.

The most likely diagnosis is

A. HIV infection
B. Lyme disease (neuroborreliosis)
C. Parsonage–Turner syndrome
D. Post-operative C5 palsy
E. Thoracic outlet syndrome

23. A 23-year-old male sustained a dislocation of his left elbow following a football injury. A closed reduction was performed in the ED. At fracture clinic appointment one week later, he was noted to have weakness in his left forearm and hand.

Which of the following muscle actions is most likely to be the last to recover?

A. Palmer abduction
B. Flexion and abduction of the wrist
C. Flexion at the PIP joint index finger
D. Opposition of the thumb
E. Ring and little finger MCP joint flexion and IP joint extension

24. A 21-year-old male sustains a knife laceration to the dorsal surface of his left arm. This was explored in theatre, and a nerve repair was performed. At follow-up review 3 months later, he still complains of weakness and functional deficit of his left wrist and hand. He is concerned about the lack of progress.

Which of the following muscle deficit(s) is most likely to be the last to recover?

A. Weakness of extension and abduction of the thumb at the MCPJ and CMCJ
B. Weakness of index finger extension at the MCPJ and IPJs
C. Weakness of IPJ thumb extension
D. Weakness of thumb abduction at the CMCJ
E. Weakness unscrewing a jar

25. A 22-year-old right-handed professional javelin thrower attends the outpatient clinic with a 1-month history of right elbow pain. Pain is localised to the medial side of the elbow, and his pain is exacerbated by overhead throwing activities. He denies any locking or catching within the elbow. Clinical examination demonstrates focal tenderness over the medial epicondyle. There is significant pain when a valgus stress is applied to the elbow.

The most likely diagnosis is which of the following?

A. Flexor pronator muscle strain
B. Medial epicondylitis
C. Osteochondral lesion at the humeral ulnar joint
D. Ulnar collateral ligament (UCL) tear
E. Ulnar nerve subluxation

26. A 23-year-old bodybuilder and regular gym user attends clinic complaining of several months' history of tingling and numbness of his right little finger. Examination reveals weakness of pinch.

The most likely site of nerve compression would be which of the following?

A. Anconeus epitrochlearis
B. Arcuate ligament
C. Guyon's canal between the pisiform and hook of hamate
D. Medial head of triceps
E. Osbourne fascia

27. A 53-year-old male patient attends follow-up OP clinic after an MRI scan has been ordered for right shoulder pain. The scan reports a full-thickness tear.

Concerning rotator cuff tears, which of the following is true?

A. A large proportion of patients with full-thickness tears eventually require surgery
B. Cut-off size for tears to be symptomatic is 2.5cm
C. Failure of arthroscopic rotator cuff repair is unusual
D. Most full-thickness rotator cuff tears are symptomatic
E. Pain and functional status are associated with tear size, fatty infiltration and muscle atrophy

28. A 71-year-old woman attends the ED with a periprosthetic fracture of her left shoulder. Her shoulder radiograph is shown in Figure 14.2.

The most common cause for this fracture would be which of the following?

Figure 14.2
Anteroposterior (AP) radiograph periprosthetic shoulder fracture

A. A fall onto the outstretched hand
B. Cortical weakening due to a stress riser
C. Low virulence infection
D. Prosthetic loosening
E. Steroid therapy

29. A 53-year-old male right-handed painter and decorator presents to clinic with a 2-year history of right shoulder pain associated with shoulder movement. He is taking regular paracetamol and NSAIDs. On examination, he had bilateral shoulder symmetry with tenderness limited to the anterior border of the acromion. Active abduction and forward flexion were both limited to 50°. External rotation of the shoulder was full but weak compared with the opposite shoulder.

The next most appropriate step in management would be which of the following?

A. Injection of local anaesthetic into the subacromial space
B. MRI scan of the shoulder
C. Outpatient ultrasound scan of the shoulder
D. Shoulder arthrogram
E. X-ray of the shoulder

30. A 60-year-old male patient without any history of recent trauma had been experiencing disabling pain in the right shoulder for 5 months. The pain progressed at night, especially when he rested on his right shoulder. The weakness of the right shoulder was noted when he lifted objects that weighed more than 5kg. There were neither limitations in range of motion nor atrophy of the musculature of his right shoulder. The empty can test yielded positive results, but there was no dropping sign or external rotation lag in his right shoulder.

Given the history and examination findings, the most appropriate operative intervention would be?

A. Arthroscopic cuff repair
B. Mini open rotator cuff repair
C. Reverse total shoulder arthroplasty
D. Superior capsule repair
E. Tendon transfer

31. A 69-year-old, right hand-dominant female presents to the clinic with an 8-month history of worsening right shoulder pain. She continues to work part-time in a post office. She is generally fit and healthy. On examination, she has terminal loss of full shoulder movement with pain. There is good rotator cuff strength. Her radiographs are shown in Figure 14.3.

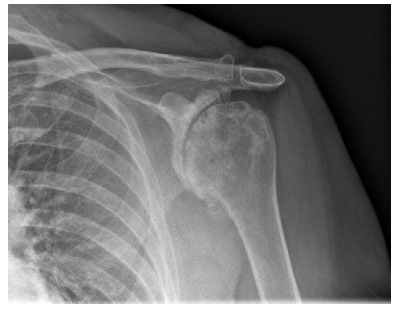


Figure 14.3
Anteroposterior (AP) radiograph shoulder

What is the most suitable treatment option?

A. Resurfacing hemiarthroplasty shoulder
B. Reverse shoulder replacement (RSA)
C. Shoulder hemiarthroplasty
D. Stemless shoulder prosthesis
E. Total shoulder arthroplasty (TSA)

32. Which of the following is true concerning the carrying angle of the elbow?

A. The carrying angle decreases with age
B. The carrying angle increases with elbow flexion
C. The carrying angle is defined as the angle between the long axis of the extended and

supinated forearm as it lies lateral to the long axis of the arm
D. The carrying angle is greater in males than females
E. The normal range for the carrying angle is 5–15°

33. **Concerning the biomechanics of reverse total shoulder arthroplasty, all the following are true except which?**
A. Effective lever arm of deltoid to initiate movement
B. Fixed centre of rotation, distalised and medialised in relation to the glenoid surface
C. Intrinsic stability
D. Medialising the joint centre of rotation increases the torque on the glenoid bone–implant interface and decreases the lengths of the deltoid abductor moment arm
E. Semi-constrained design by large glenosphere and small humeral cup

34. A 78-year-old patient attends for an outpatient follow-up appointment 2 years following reverse total shoulder arthroplasty (RTSA). She complains of loss of active abduction and significantly less shoulder strength than expected. Her radiographs are shown in Figure 14.4.

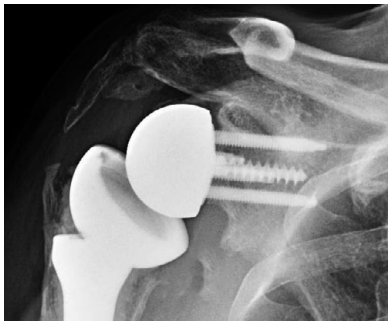


Figure 14.4 Anteroposterior (AP) radiograph right shoulder

Numerous technical strategies have been proposed to reduce the occurrence of this condition including which of the following?
A. Allowing inferior overhang of the glenosphere
B. Concentric glenosphere position
C. Decreased inclination (neck–shaft angle) of the humeral component
D. Implanting of the glenoid component in a position with inferior inclination
E. Increased medial offset

35. A 48-year-old male presents to clinic with a positive Hornblower sign.
The most likely rotator cuff muscles involved in a tear include:
A. Infraspinatus and subscapularis
B. Supraspinatus
C. Supraspinatus and infraspinatus
D. Supraspinatus and subscapularis
E. Supraspinatus, infraspinatus and teres minor

36. A 40-year-old male diabetic patient who 6 weeks ago had shoulder arthroscopy for a labral tear, presents with a 2-week history of severe pain in the same shoulder. Examination found significant wasting of the supra and infraspinatus fossae and an almost full range of passive shoulder movement. His inflammatory markers were within normal limits.
Of the following options, which is the most likely diagnosis?
A. Adhesive capsulitis
B. Cervical discs prolapse
C. Entrapment neuropathy in the supra-glenoid notch
D. Parsonage–Turner syndrome
E. Septic arthritis

37. A 12-year-old boy suffers a Salter-Harris type 3 anterior fracture dislocation of the proximal humerus subsequent to a high energy trauma. He undergoes open reduction and internal stabilisation. After regaining function and achieving union you have concerns, he has focused osteonecrosis of the epiphyseal fragment.
How would you best manage this patient's subsequent care?
A. Capsular release
B. Close outpatient follow up
C. Humeral head surgical debridement and bone grafting
D. Pulsed electrical stimulation
E. Removal of metal work

38. A 68-year-old woman presents with progressive elbow pain over the last 2 years, with a background of previous traumatic elbow injury. Her symptoms now impact her activities of daily living and are severely debilitating. X-rays demonstrate severe end-stage arthritis with multiple

loose bodies, osteophyte formation and complete loss of joint space. You perform a semi-constrained total elbow arthroplasty.

With regard to early presentation, what would be the likely mode of failure?

A. Aseptic loosening
B. Bushing failure
C. Component loosening
D. Infection
E. Instability secondary to component malposition

39. You perform a diagnostic shoulder arthroscopy to assess a patient's rotator cuff with an aim to perform a repair in a high BMI patient. Due to body habitus your posterior portal placement is challenging and you are required to adjust your portal further lateral to establish access.

Which nerve could potentially be at risk in this case?

A. Axillary nerve
B. Musculocutaneous nerve
C. Phrenic nerve
D. Subscapular nerve
E. Suprascapular nerve

40. A 30-year-old male athlete presents with a 1-year history of intermittent posterior shoulder pain and weakness. Clinically he was found to have a degree of unidirectional shoulder instability, weakness in external rotation and inferior scapular muscle hypotrophy. You arrange an outpatient MRI.

Where would you likely find the anatomical location of the underlying pathology?

A. Brachial plexus upper trunk
B. Cervical disc
C. Rotator cuff
D. Spinoglenoid notch and ligament
E. Suprascapular notch and transverse ligament

41. As the upper limb specialist, you see a 35-year-old manual worker who presents with a post-traumatic flail shoulder, however intact distal function. He has found to have complete paralysis and massive rotator cuff pathology. You plan to perform a shoulder arthrodesis.

What position will you fuse his joint to maximise his functional outcome?

A. 10° forward flexion, 10° abduction, 20° internal rotation
B. 10° forward flexion, 20° abduction, 10° external rotation
C. 30° forward flexion, 30° abduction, 20° external rotation
D. 30° forward flexion, 30° abduction, 30° internal rotation
E. 40° forward flexion, 30° abduction, 20° internal rotation

42. An 18-year-old male suffers a traumatic elbow dislocation. Subsequent to this he struggles to perform push-ups at the gym 6 months following his injury. He is referred into your clinic for further assessment.

Which of the following tests will likely demonstrate positive findings?

A. Cozen's test
B. Hyperpronation test
C. Lateral pivot shift-test
D. Provocation testing with passive extension of wrist and elbow
E. Varus stress test with elbow in 30° flexion

43. A young patient undergoes a shoulder arthroscopic Bankart repair subsequent to acute shoulder dislocation.

Which of the following predisposing factors does not increase the risk of recurrent instability?

A. Age under 20
B. Associated greater tuberosity fracture
C. Bilateral shoulder laxity
D. Hill–Sachs lesion on external rotation AP radiograph
E. Involvement in competitive sport

44. A 60-year-old female presents with a progressive history of a painless, swollen elbow, with progressive loss of function and no constitutional symptoms. Radiographs performed demonstrate severe fragmentation, dislocation and severe sclerotic changes throughout the elbow.

From the below options, what is the most common aetiology of the underlying condition?

A. Syringomyelia
B. Hansen's disease
C. Neurosyphilis
D. Diabetes
E. Septic arthritis

SHOULDER AND ELBOW II STRUCTURED SBA ANSWERS

1. Answer C. **Open bone block procedure i.e. Laterjet**
Rationale: The patient's instability severity index score is 6, even without X-rays, which could highlight a Hill–Sachs lesion or glenoid bone loss, increasing it further. Risk factors for recurrent shoulder instability identified by Balg and Boileau (2007) as age (20 years), competitive sportsman, overhead/contact sport, hyperlaxity, Hill–Sachs on A/P X-ray, loss of inferior glenoid contour. A score of $\leq$6 points = an acceptable recurrence risk of 10% with arthroscopic stabilisation. A score of >6 points = an unacceptable recurrence risk of 70% and should be advised to undergo open surgery (i.e. Laterjet procedure).

This patient has recurrent instability (fourth dislocation) and is highly likely to have critical bone loss of the glenoid (Hasegawa et al. 2019).

Although possible, an arthroscopic stabilisation would likely have a higher failure rate. Physiotherapy would not address the patho-anatomical reasons for dislocation although would be useful as pre-hab and necessary as rehab.

Remplissage can be used to fill a Hill–Sachs lesion and can therefore help with off-tack lesions although this is often combined with a Laterjet type procedure if necessary.

Key points:

Description of patient points towards high ISIS (age = 2, competitive = 2, overhead/contact = 1).

Fourth time dislocation – recurrence and therefore glenoid bone loss or the development of Hill–Sachs lesion likely to be present. This would increase ISIS and degree of glenoid bone loss could push towards an open bone block procedure.

High Beighton score suggests hyperlaxity (scores 1 on ISIS).

Balg F, Boileau P. The instability severity index score: a simple pre-operative score to select patients for arthroscopic or open shoulder stabilisation. *J Bone Joint Surg Br.* 2007;**89**:1470–1477.

Hasegawa Y et al. The number of injury events associated with the critical size of bipolar bone defects in rugby players with traumatic anterior shoulder instability. *Am J Sports Med.* 2019;**47**:2803–2808.

2. Answer B. **Altered/absent sensation volar lateral forearm**
Rationale: Distal biceps tendon attaches to the radial tuberosity. A single incision approach utilises a single transverse or 'lazy-s' incision on the proximal volar forearm. The most commonly injured nerve is the lateral cutaneous nerve of the forearm (9.8%) which supplies sensation to the volar surface of the lateral forearm. This can be damaged by excessive retraction or during the skin and subcutaneous fat dissection itself. Other nerves cited as being injured include PIN (2.7%) and median nerve (0.1%).

Amin NH et al. Complications of distal biceps tendon repair: a meta-analysis of single-incision versus double-incision surgical technique. *Orthop J Sports Med.* 2016;**4**(10).

3. Answer B. **Normal anatomical variant**
Rationale: This description is of a Buford complex or sub-labral foramen. The cord-like MGHL originates from near to the bicep anchor and crosses the sub-scapularis tendon to attach onto the humerus. Unlike labral pathology for instability which classically affects the 3–6 o'clock position, the antero-superior labrum is also deficient. While a normal variant, patients with Buford complexes have been shown to have increased ROM and a high incidence of concurrent SLAP lesions. Frozen shoulders are characterised by capsular tightening.

Bents RT et al. The correlation of the Buford complex and SLAP lesions. *J Shoulder Elbow Surg.* 2005;**14**:565–569.

Williams MM. et al. The Buford complex – the 'cord-like' middle glenohumeral ligament and absent anterosuperior labrum complex: a normal anatomic capsulolabral variant. *Arthroscopy* 1994;**10**:241–247.

4. Answer D. **Sebaceous glands**
Rationale: *Cutibacterium acnes* is the most frequently isolated bacteria following shoulder PJI. *C. acnes* resides in sebaceous glands. Males have increased numbers of sebaceous glands thus increasing the chance of seeding during surgery. Diagnosis is difficult as it has low virulence and patients are often systemically well with no local signs and normal or only mildly elevated biochemical markers.

Key points: Male patient, normal inflammatory markers point towards *C. acnes* infection.

Foster AL et al. *Cutibacterium acnes* in shoulder surgery: a scoping review of strategies for prevention, diagnosis, and treatment. *J Shoulder Elbow Surg.* 2021;**30**:1410–1422.

5. Answer B. **Disrupted medial hinge**
Rationale: AVN of the humeral head is a risk associated with proximal humerus fractures. Hertl et al. (2004) assessed fracture morphology to ascertain the relative risks linked to AVN. Strong predictors of ischaemia include a medial metaphyseal calcar length <8mm, a disrupted medial hinge and more complex fracture patterns. Campochiaro (2015) found no correlation with age, sex and fracture type with AVN, citing accuracy of reduction as the most important predictor following fixation.

Campochiaro G. Complex proximal humerus fractures: Hertel's criteria reliability to predict head necrosis. *Musculoskelet Surg.* 2015;**99**:S9–15.

Hertel R et al. Predictors of humeral head ischemia after intracapsular fracture of the proximal humerus. *J Shoulder Elbow Surg.* 2004;**13**:427–433.

6. Answer C. **Decreased external rotation**
Rationale: A Buford complex is a normal anatomical variant seen in shoulders. It is characterised by a cord like MGHL and an absent antero-superior labrum. It is important to distinguish this from pathological findings. If mistaken for a labral tear and repaired, the anterior capsule and MGHL can restrict external rotation. The key here is being aware of what a Buford complex is, and that tightening of the MGHL will restrict external rotation.

Modarresi S et al. Superior labral anteroposterior lesions of the shoulder. Part 1, anatomy and anatomic variants. *Am J Roentgenol.* 2011;**197**:596–603.

7. Answer D. **Medialised**
Rationale: The presence of antero-superior humeral escape and evidence of arthritis points to cuff arthropathy. In this age group the most appropriate operation would be a reverse polarity shoulder arthroplasty. By using a glenosphere and humeral cup, the COR is medialised. This medialisation of the COR decreases shear forces across the glenoid component and creates compressive forces at the bone-implant interface and minimises the ratio of shear to compressive forces at the joint leading to an inherently stable prosthesis.

The humerus is distalised which recruits more parts of deltoid and aligns muscle fibres more vertically whilst increasing the muscles lever arm, gaining a biomechanical advantage.

Rugg CM et al. Reverse total shoulder arthroplasty: biomechanics and indications. *Curr Rev Musculoskelet Med.* 2019;**12**:542–553.

8. Answer B. **Lateral ulna collateral ligament**
Rationale: The symptom described is classically associated with posterolateral rotatory instability. When an axial force is applied with the elbow moving into extension and supinated, the radial head subluxes and can cause mechanical symptoms such as clicking and popping.

The most commonly implicated structure for PLRI is a torn or attenuated LUCL. This can be seen as direct trauma following elbow dislocations/subluxations or due to chronic attrition.

O'Driscoll SW, Morrey BF, Korinek S, An KN. Elbow subluxation and dislocation: a spectrum of instability. *Clin Orthop Relat Res.* 1992;**280**:186–197.

9. Answer D. **Right capitellum**
Rationale: Age (>10 years old) and sport (gymnast) point towards osteochondritis dissecans (OCD). This is strengthened by the insidious loss of extension – an early sign and there not being any specific trauma or mention of systemic signs. With this diagnosis the knowledge aspect is where the OCD is most commonly located. It is most frequently in the dominant capitellum.

Takahara M et al. Long term outcome of osteochondritis dissecans of the humeral capitellum. *Clin Orthop Relat Res*. 1999;**363**:108–115.

10. Answer B. **LUCL**
Rationale: Lateral epicondylitis (tennis elbow) is characterised by angiofibroblastic hyperplasia. It occurs within the ECRB origin. Following failure of non-operative management debridement can be performed. The ECRB arises from the lateral

epicondyle with the LUCL origin being deep and distal to this. As such, during debridement, a clear view of the LUCL is necessary to prevent iatrogenic injury. Unrecognised, this could lead to PLRI.

Kalainov DM, Cohen MS. Posterolateral rotatory instability of the elbow in association with lateral epicondylitis: *a report of three cases. J Bone Joint Surg Am.* 2005;**87**:1120–1125.

11. Answer C. **LUCL–AP capsule–MCL**
Rationale: The patient has sustained an elbow dislocation. This can be ascertained from the position of the arm and the direction of the force applied, in conjunction with the possible answers. With this information it is then applying the knowledge of elbow dislocations and the Horii circle. This describes the patho-anatomy as three stages from PLRI to perched up to a dislocation with increasing instability.

Robinson PM, Griffiths E, Watts AC. Simple elbow dislocation. *Shoulder Elbow* 2017;**9**:195–204.

12. Answer D. **Subscapularis**
Rationale: The patient is most likely to have a partial subscapularis tear and presents with signs and symptoms of an unstable and inflamed long head of biceps (LHB) tendon. The subscapularis is the main medial constraint to the LHB and when torn, allows subluxation. The key points include the anterior pain and positive Yergason's test (resisted forearm supination) pointing towards bicep pathology coupled with the clicking which highlights LHB instability. Clicking can occur for a variety of reasons including labral pathology.

Shi LL et al. Accuracy of long head of the bicep's subluxation as a predictor for subscapularis tears. *Arthroscopy* 2015;**31**:615–619.

13. Answer D. **Osteophyte formation on the posterolateral olecranon**
Rationale: This cricketer has symptoms suggestive of elbow valgus overload. Pain after throwing and a reduction in throwing, bowling or pitching speed and frequency are commonly described. X-rays and CTs often highlight loose bodies (from capitellum), traction spurs on the ulnar, as well as hypertrophy of the humerus (causing further deceased joint space). Osteophyte formation on the posteromedial olecranon is commonly seen due to excessive shear forces on medial aspect of olecranon tip and olecranon fossa.

Wilson FD et al. Valgus extension overload in the pitching elbow. *Am J Sports Med.* 1983;**11**:83–88.

14. Answer B. **Medial scapular winging**
Rationale: Axillary dissection puts peripheral nerves at risk, specifically, long thoracic and thoracodorsal nerves. The long thoracic nerve supplies serratus anterior and results in medial scapular winging (describes the direction in which the scapular migrates), the thoracodorsal nerve supplies the latissimus dorsi and injury would result in weakness and atrophy. Lateral scapular winging occurs with weak levator scapulae, trapezius and rhomboids. Trapezius is supplied by the spinal accessory nerve (CN XI).

Martin RM, Fish DE. Scapular winging: anatomical review, diagnosis, and treatments. *Curr Rev Musculoskelet Med.* 2008;**1**:1–11.

15. Answer E. **Raised hemidiaphragm**
Rationale: A variety of regional blocks can be performed for shoulder surgery, either in conjunction with or instead of a GA. One commonly performed technique is the interscalene block. A phrenic nerve palsy would cause a raised hemidiaphragm on the ipsilateral side and is most likely. This can cause a reduction of 25% of FVC and in patients with pre-existing lung disease can cause symptoms, albeit in this case mild. Although Horner syndrome is recognised following interscalene block, it would not lead to any respiratory symptoms.

Bergmann L et al. Phrenic nerve block caused by interscalene brachial plexus block: breathing effects of different sites of injection. *BMC Anesthesiol* 2015;**16**:45.

Urmey F et al. Hemidiaphragmatic paresis during interscalene brachial plexus block: effects on pulmonary function and chest wall mechanics. *Anesth. Analg.* 1992;**74**;352–357.

16. Answer D. **Pectoralis minor**
Reduction of subcoracoid space by pectoralis minor.

There are four forms of thoracic outlet syndrome.

1. Anterior scalene syndrome.
   Anterior scalene syndrome is a neurovascular entrapment syndrome caused by tight anterior and middle scalenes. Adson's test is used to diagnose this condition.
2. Costoclavicular syndrome.
   Costoclavicular syndrome is a neurovascular entrapment syndrome caused by a decrease of the costoclavicular space between the first rib. Diagnosed by Eden's test.
3. Pectoralis minor syndrome.
   This is a neurovascular entrapment syndrome caused by a tight pectoralis minor. Wright's hyperabduction test stretches and pull this muscle taut, causing it to further compress the brachial plexus and the subclavian/axillary artery and vein.
4. Cervical rib syndrome.
   Usually has a positive Adson's test. The condition is diagnosed with radiographies.

Pectoralis minor syndrome is a neurovascular entrapment syndrome caused by a tight pectoralis minor; the idea is to stretch and pull this muscle taut, causing it to further compress the brachial plexus and the subclavian/axillary artery and vein that run between it and the ribcage. Wright's test involves bringing the patient's upper extremity back into abduction and extension while the examiner palpates the strength of the radial pulse. A positive finding is weakness of the radial pulse.

Costoclavicular syndrome is a neurovascular entrapment syndrome caused by a decrease of the costoclavicular space between the first rib clavicle. Eden's test further decreases this space by bringing the clavicle and first rib closer together, causing further compression of the brachial plexus and the subclavian artery and vein, which run through this space. Eden's test involves asking the client to push out the chest and pull the shoulder girdles back, as if assuming a military position of attention, while the examiner palpates the strength of the radial pulse. Pushing the chest out brings the first rib forward, while pulling the shoulder girdles back brings the clavicle back, thereby decreasing the space between them.

17. Answer C. **Intrinsic muscle strength will always be lost**
Loss of grip strength from denervation of FDP (flexion at ring and little DIPJ) and loss of the FCU (stabilisation of the hand during power grip). The inability to close the ulnar side of the palm in forceful grip results in difficulty grasping objects.

There will still be clawing of the hand, but this may be mild (ulnar paradox).

Remember the Martin–Gruber anastomosis is present in 15–20% patients – i.e. median nerve supplies these muscles normally supplied by the ulnar due to crossover of the nerve. Only motor not sensory. The Martin–Gruber anastomosis is a median to ulnar anastomosis in the forearm. It occurs through a communicating nerve branch between the median nerve and the ulnar nerve in the forearm. An isolated ulnar nerve lesion at the elbow will produce an unusual pattern for intrinsic muscle paralysis. In cases of nerve lesions of the median or ulnar nerve, this anastomosis serves as a conduit or an alternative innervation of parts of the hand and the forearm (it is really a detour). This can be a good explanation for difficult challenges, especially in the differential diagnosis.

Froment's sign is due to a loss of adductor pollicis. A patient grasps a piece of paper between thumb and index finger.

18. Answer E. **Deep to the transverse carpal ligament**
The clinical scenario describes a low median nerve lesion.

The TCL is the middle portion of the flexor retinaculum that runs between the hamate and pisiform medially to scaphoid and trapezium laterally and forms a fibrous sheath which contains carpal tunnel anteriorly within fibro-osseous tunnel.

Posteriorly the tunnel is bordered by carpal bones and transports the median nerve and finger flexor tendons from the forearm to the hand.

Median nerve palsy can be separated into 2 subsections – high and low median nerve palsy. High MNP involves lesions at the elbow and forearm areas. Low median nerve palsy results from lesions at the wrist.

The median nerve runs between the two heads of pronator teres making it a possible site of entrapment.

The ligament of Struthers is a connective tissue band on the medial aspect of the distal humerus. Struthers originally estimated that it was present in 1% of humans. It is a potential site of compression to the ulnar nerve.

The arcade of Struthers is a musculoaponeurotic canal that is formed by the attachments of the internal brachial ligament (a fascial extension of the coracobrachialis tendon), the fascia and superficial muscular fibres of the medial head of the triceps, and the medial intermuscular septum. It may cause entrapment or compression of the ulnar nerve.

The flexor digitorum superficialis (FDS) arch is a potential site of median nerve compression in the forearm. It is not an FDP arch. It can cause pronator syndrome (PS).

PS presents as paraesthesia in the median nerve distribution and aching pain in the proximal forearm with minimal weakness. It can be confused with the more commonly diagnosed carpal tunnel syndrome, as the clinical picture can be very similar.

There are four additional sites of potential compression besides the two heads of the pronator teres muscle. Other areas of potential compression include the lacertus fibrosis (bicipital aponeurosis), the ligament of Struthers (extending from a supracondylar process to the medial epicondyle), by anomalous muscles such as an accessory head of the flexor pollicis longus (Gantzer's muscle) and the flexor digitorum superficialis (FDS) arch.

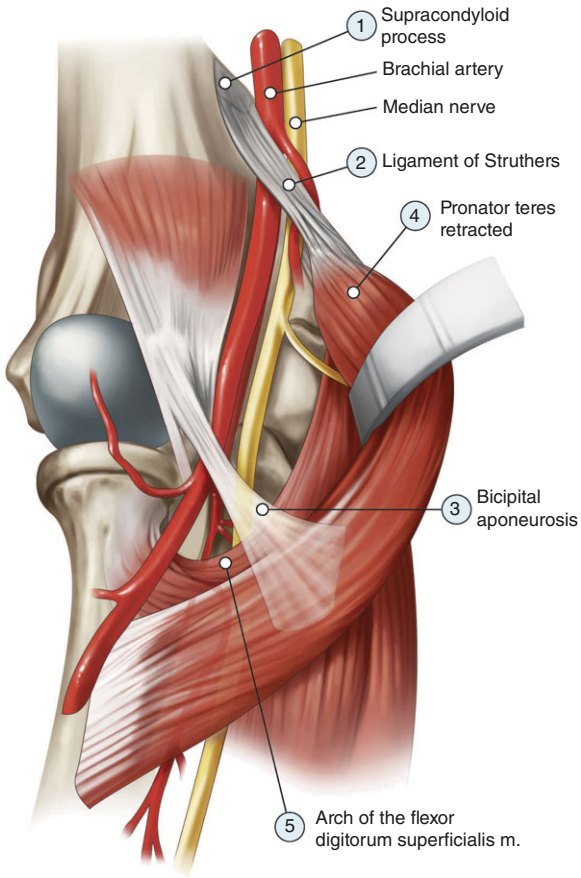


Figure 14.5 Sites of compression of the median nerve. (1) Supracondylar process. (2) Ligament of Struthers. (3) Bicipital aponeurosis. (4) Pronator teres. (5) Fibrous arch FDS

19. Answer B. **Normal pronation strength with the elbows fully flexed**

The anterior interosseous nerve (AIN) innervates 2.5 muscles that are deep muscles of the forearm.

- Flexor pollicis longus
- Pronator quadratus
- The radial (lateral) half of FDP (index and main fingers)

The AIN supplies PQ. PQ is tested with the elbow fully flexed to defunction the PT.

The AIN has no sensory innervation.

Flexion of the IPJ of the thumb is controlled by the flexor pollicis longus (FPL) supplied by the AIN.

Flexion of the DIPJ of the middle finger is controlled by flexor digitorum profundus (FDP) supplied by the AIN.

Flexion of the DIPJ of the index finger is controlled by flexor digitorum profundus (FDP) supplied by the AIN.

20. Answer B. **Reassurance**

Most cases (90%) of AIN palsy are due to neuritis that can take up to 18 months to recover.

The scenario is of an AIN palsy. The patient is unable to perform an 'OK' sign.

The patient would make a triangle sign instead. This 'pinch-test' exposes the weakness of the FPL muscle and the FDP leading to weakness of the flexion of the DIPJ thumb and index finger.

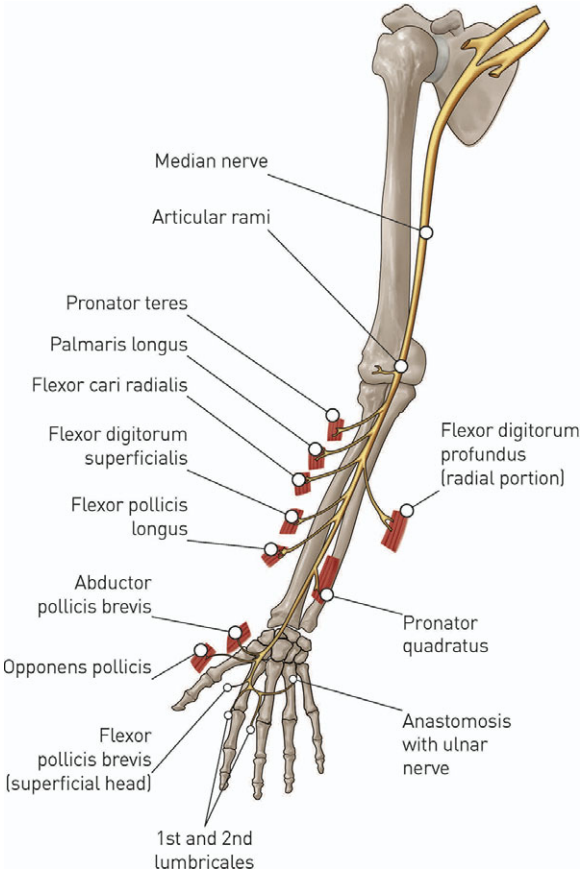


Figure 14.6 Median nerve. Course, supplied branches and anatomy

This results in impairment of the pincer movement and the patient will have difficulty picking up a small item, such as a coin, from a flat surface.

The AIN innervates three muscles in the forearm: flexor pollicis longus (FPL), pronator quadratus (PQ) and the radial half of flexor digitorum profundus (FDP). In the hand, the median nerve innervates five muscles: The two lateral lumbricals, opponens pollicis, abductor pollicis brevis and flexor pollicis brevis.

21. Answer A. **Jobe test positive**
The Jobe test or empty can test involves testing the supraspinatus supplied by the suprascapular nerve. All the other features listed are preganglionic signs of BP injury.

Medial winging of the scapula is caused by weakness of the serratus anterior supplied by the long thoracic nerve.

The long thoracic nerve arises from the upper portion of the superior trunk of the brachial plexus C5 C6 C7. The long thoracic nerve forms as an upper portion originating from the C5 and C6 nerve roots and a lower portion coming from the C7 nerve root. The fusion of these two portions occurs in the axilla. Within the supraclavicular region, the upper division of the long thoracic nerve travels parallel to the brachial plexus near the suprascapular nerve. Due to its long, relatively superficial course, the long thoracic nerve is susceptible to damage during certain surgical procedures or through direct trauma or stretch.

Ptosis is part of Horner syndrome characterised by a drooping eyelid (ptosis), decreased pupil size (miosis) and dryness of the eye (anhidrosis). The syndrome results from damage to the sympathetic nerve supply to the eye. This is in the nearby vicinity of the BP and is usually taken as an absolute indicator of avulsions of the C8 and T1 ventral roots in the adult brachial plexus.

Decreases in upper limb function following BPI negatively affect postural control and balance, as observed by increases in body sway or reduced performance in dynamic balance tests.

A raised hemidiaphragm suggests a C4 nerve root injury. This can occur at the same time as C5.

22. Answer C. **Parsonage–Turner syndrome**
Clinical symptoms of Parsonage–Turner syndrome include abrupt and acute onset of significant pain within the shoulder girdle and upper arm followed by numbness and weakness within the upper arm. Symptoms are usually unilateral, and patients report a distinct sharp and radiating pain circulating within the arm-pit region. Onset of sharp and excruciating pain denotes the beginning of symptoms which then later transitions to weakness and numbness over the course of a few hours to days. The severe initial pain usually subsides after weakness or paralysis develops. This incidence and observation of pain translating to weakness is crucial to the accurate diagnosis of acute brachial plexus neuritis. Brachial neuritis is more prevalent in men between the ages of 30–70, is commonly diagnosed on the right side and following surgery.

Peripheral nervous system infections (Options A and B) are in the small print differential diagnosis.

Lyme disease (borreliosis) is an infection caused by *Borrelia burgdorferi* which is transmitted by the tick *Ixodes*. The primary stage of the disease is characterised by erythema migrans which begins 3–30 days after the tick bite. After 1 week to 3 months, a secondary stage which affects the neurological system can occur and can persist for several weeks or months. The tertiary stage with neurological symptoms ('late' neuroborreliosis) can start 6 months after the tick bite and can last for several years.

No mention of a tick bite or a preceding rash.

Again, no reason to suspect HIV infection and nothing in the history to point you towards this as the cause.

Distinction between post-operative PTS (brachial neuritis) and post-operative C5 palsy is very difficult. C5 palsy shortly after recent cervical decompression, due to migration of a graft or intraoperative root injury is well recognised. These would present earlier on post-operatively.

The history of intolerable pain, followed by weakness and improvement of pain highly suggestive of PTS. Another important discriminator is the fact that in case of PTS the weakness, sensory deficit and pain usually do not correspond to the same nerve root or peripheral nerve distribution. This is in sharp contrast with C5 palsy, where C5 motor symptoms predominate.

Thoracic outlet syndrome is in the DD, but nothing is given in the history to point you in this direction.

Comment: This SBA is too long to use in a real FRCS (Tr&Orth) exam. It would need to be cut down to about one-third in length. It is more in keeping with USA type SBA where there is a lot of clinical information contained within the stem.

Verhasselt S, Schelfaut S, Bataillie F, Moke L. Postsurgical Parsonage–Turner syndrome: a challenging diagnosis. *Acta Orthop Belg.* 2013;**79**:20–24.

23. Answer D. **Opposition of the thumb**

The lesion described is of a median nerve palsy. This must be worked out from the SBA.

The last muscles to the innervated from the median nerve are the first and second lumbricals. However, to make the question more difficult, the third and fourth lumbricals are included.

Adductor pollicis and the first dorsal interossei.

To make the SBA easier, we could have substituted pronator teres as one of the options. This is the first muscle to be innervated by the median nerve. Including the first and second lumbrical as an option might have made the question guessable to a streetwise candidate.

- FCR – flexion and abduction of the wrist.
- FDS – flexion at the PIP joint main finger.
- Abductor pollicis brevis – palmar abduction.
- Opposition of the thumb – opponens pollicis.
- Ring and little finger MCP joint flexion and IP joint extension – third and fourth lumbricals – ulnar nerve.

24. Answer B. **Weakness of index finger extension at the MCPJ and IPJs**

The extensor indicis proprius is the last muscle innervated by the PIN. Its action is to extend the index finger at the MCPJ and IPJ. It would be difficult to differentiate between abductor pollicis longus and extensor pollicis brevis.

EPL – extension of the IPJ thumb – PIN.

Extensor pollicis brevis – extension and abduction of the thumb at the MCPJ and CMCJ.

Abductor pollicis longus – abduction thumb at the CMC joint – PIN.

Supinator muscle-forearm supination – weakness unscrewing a jar – PIN.

25. Answer D. **Ulnar collateral ligament (UCL) tear**

The ulnar collateral ligament (UCL) is the primary structure responsible for stability of the elbow joint against the valgus forces associated with the throwing mechanism. The ligament complex is composed of three bundles: the anterior, posterior and transverse bundles, with the anterior bundle being the strongest component. The anterior bundle originates on the medial epicondyle of the humerus and inserts on the tubercle of the ulna. This bundle is crucial in the maintenance of joint stability during the late cocking and early acceleration phases of overhead throwing. The anterior bundle of the UCL is placed under the greatest amount of valgus stress during the throwing motion, between 20°

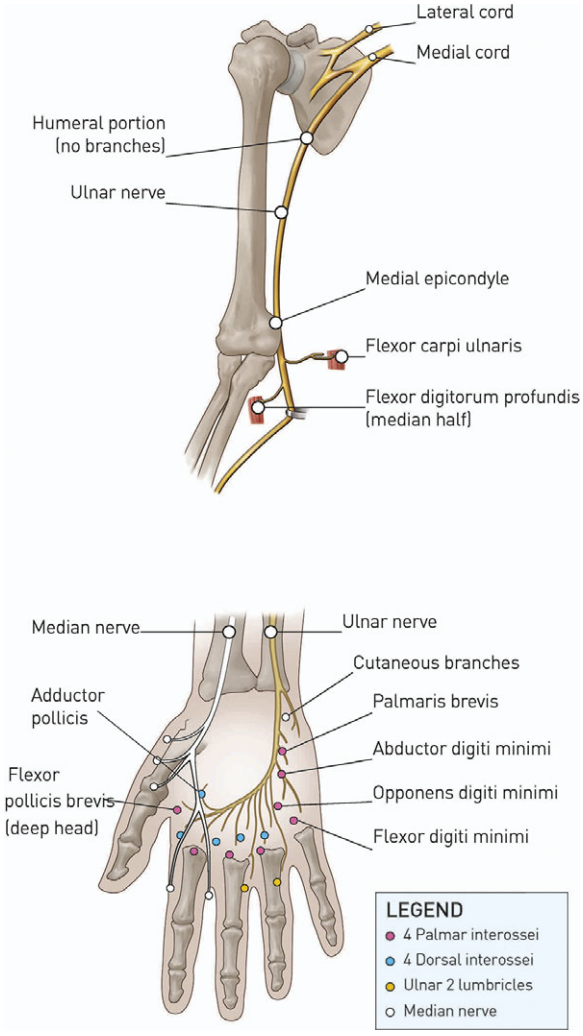


Figure 14.7 Ulnar nerve. Branches and anatomy

and 30° of elbow flexion as a result of the olecranon process unlocking from the olecranon fossa.

The valgus stress test for medial elbow joint instability can be used to detect joint space gapping. In addition, the milking manoeuvre technique can be performed. This involves the forearm being supinated fully and the elbow flexed beyond 90°. The thumb is then pulled laterally by the athlete's contralateral extremity, creating a valgus force on the elbow. Pain, instability or apprehension is indicative of injury to the UCL.

The most sensitive test is the moving valgus stress test. The patient's shoulder is placed in 90° abduction and externally rotated (palm up). A constant moderate valgus torque is applied to the fully flexed elbow and then the elbow is quickly extended. The test is positive if the medial elbow pain is reproduced at the medial collateral ligament and is at maximum between 120° and 70°.

26. Answer D. **Medial head of triceps**

With answer C, weakness of pinch is compensated for by a positive Froment's sign, which indicates proximal nerve compression rather than within Guyon's canal.

All other choices of sites of ulnar nerve compression are possible, but the clue is bodybuilding. With bodybuilders there is hypertrophy of the medial head of the triceps. This is an uncommon site of compression in the general population.

There are several sites of ulnar nerve compression around the elbow:

- Arcade of Struthers.
- Medial intermuscular septum.
- Medial head of triceps.
- Medial epicondyle.
- Arcuate ligament.
- Osbourne fascia.
- Epicondylar groove.
- Anconeus epitrochlearis.
- Deep flexor pronator aponeurosis.

27. Answer B. **Cut-off size for tears to be symptomatic is 2.5cm**

The presence of rotator cuff tears does not necessarily lead to clinical symptoms. A large number of rotator cuff tendon tears are asymptomatic, detected as incidental findings on radiological imaging.

Failure of a rotator cuff tear repair is common, seen in up to 30% of cases. However, some patients who have a failed repair may be pain free with good outcomes.

Physiotherapy along with activity modifications, anti-inflammatory and analgesic medications form the pillars of non-operative treatment.

Only around one-third of rotator cuff tears cause pain.

Curry et al. (2015) have shown that pain and functional status were not associated with tear size or thickness, fatty infiltration and muscle

atrophy. Instead, poor mental health, female sex and increased number of comorbidities were associated with greater disability scores. As such, pain and functional disability may have multiple causes and should not be purely related to the characteristics of the tear.

It is estimated 1 in 15 patients with a rotator cuff tear has surgery for symptoms only.

Hinsley et al. (2014) used ultrasound to evaluate cuff tendinopathy in a general population cohort. They reported 110 normal tendons, 217 abnormal tendons, 77 partial tears and 124 full-thickness tears. They reported that symptomatic shoulders had a larger median tear size than asymptomatic shoulders. When they looked at tear size as a predictor of the presence of pain (trying to decide the point at which full-thickness tears become increasingly likely to be symptomatic), they found the cut-off size to be 2.5cm; this would be consistent with the difference between single and multi-tendon tears and may signify the point at which altered shoulder biomechanics occur.

Charalambous CP. *The Shoulder Made Easy*. New York, NY: Springer; 2019.

Curry EJ et al. Structural characteristics are not associated with pain and function in rotator cuff tears: the row cohort study. *Orthop J Sports Med.* 2015;**3**(5).

Hinsley H et al. Classification of rotator cuff tendinopathy using high definition ultrasound. *Muscles Ligaments Tendons J.* 2014;**4**:391–397.

28. Answer A. **A fall onto the outstretched hand**
The majority of periprosthetic humeral fractures are caused by low-energy mechanisms such as a fall from standing or onto an outstretched hand. It is important to determine whether or not pain was present prior to the fracture, as that could be a sign of implant loosening or low virulence infection such as *Propionibacterium acnes*.

The treatment of post-operative fractures is based on fracture location, prosthesis type and stability, rotator cuff status and available bone stock.

The main risk factor is humeral osteopenia. Most patients are elderly females with a high incidence of rheumatoid disease.

Fram B, Elder A, Namdari S. Periprosthetic humeral fractures in shoulder arthroplasty. *JBJS Rev.* 2019;**7**:e6.

29. Answer A. **Injection of local anaesthetic into the subacromial space**
The history and clinical signs are of a classic rotator cuff tear of the shoulder. There is pain from subacromial impingement, muscle weakness and limited range of movement. After an injection of local anaesthetic into the subacromial space, the shoulder could be moved through a full range of movement, but actively there was still limitation of abduction and forward flexion to 50°. External rotation was still weak. This is highly suggestive of a rotator cuff tear.

No single test alone is sufficient to diagnose rotator cuff disease. Outpatient ultrasound scanning of the shoulder is simple, quick and affordable, and provides an immediate imaging method as an adjunct to clinical evaluation and a high rate of detection of full-thickness rotator cuff tears.

One difficulty is that it is highly operator dependent, and its accuracy in detecting rotator cuff tears may vary, depending on the level of expertise of the musculoskeletal radiologist and/or shoulder surgeon.

MRI provides an anatomical picture, demonstrates the quality of rotator cuff muscles and the degree of tendon retraction and shows other eventual intra-articular and extra-articular pathologies. However, MRI examinations are expensive to perform, have longer waiting periods and can be extremely problematic in claustrophobic patients.

Walton and Murrell (2012) reviewed 23 clinical examinations for rotator cuff tears and found that supraspinatus weakness, weakness of external rotation and impingement were the most useful indicators. If all three signs are positive, or if two signs are positive and the patient is at least 60 years old, the chance of partial- or full-thickness rotator cuff tear is 98%.

Radiographs of the shoulder may show spur formation on the undersurface of the acromioclavicular joint or a type III acromion, in which the anterior aspect of the acromion is hooked inferiorly and best seen on a supraspinatus outlet view (a modified Y view). Type III acromion has been associated with a higher prevalence of rotator cuff tears.

Murrell GA, Walton JR. Diagnosis of rotator cuff tears [letter]. *Lancet* 2001;**357**:769–770.

Walton JR, Murrell GA. Clinical tests diagnostic for rotator cuff tear. *J Shoulder Elbow Surg*. 2012;**13**:17–22.

30. Answer A. **Arthroscopic cuff repair**

The MRI demonstrates a full-thickness tear of the anterior part of the supraspinatus tendon. This should be amenable to surgical repair. Most studies show that both arthroscopic and mini open cuff repair techniques improve functional outcome, improve pain scores and shoulder range of movement. Reported advantages of arthroscopic rotator cuff repair include quicker recovery from surgery, less extreme pain scores, lower re-tear rates and better patient satisfaction.

The other treatment options deal with irreparable tears. Superior capsule reconstruction is a newish technique that involves either a fascia lata autograft or dermal allograft. A dermal allograft limits donor site morbidity. In a subset of patients with rotator cuff tears, the glenohumeral joint has minimal degenerative changes, and the rotator cuff tendon is either irreparable or very poor quality and unlikely to heal. Reverse shoulder arthroplasty (RSA) could be considered for these patients despite the lack of glenohumeral arthritis. However, due to concerns with functional outcome of RSA in a younger patient group, complication rates and concerns about implant longevity, a superior capsular reconstruction (SCR) is a possible alternative.

31. Answer E. **Total shoulder arthroplasty (TSA)**

The patient's radiographs demonstrate advanced glenohumeral osteoarthritis. The history implies a functioning rotator cuff; she has good overall health and will place acceptable functional demands on the shoulder. As such, a total shoulder arthroplasty is the most suitable option for her.

On examination an irreparable or chronic rotator cuff deficiency in an elderly patient would require a reverse shoulder arthroplasty (RSA). TSA results in significantly greater pain relief and internal rotation than shoulder hemiarthroplasty but is associated with increased cost, operating time and blood loss.

For low-demand patients lacking a functioning rotator cuff, hemiarthroplasty will relieve pain but is unlikely to improve functional range of movement.

Humeral head resurfacing is reserved for concentric osteoarthritis without glenoid erosions or rotator cuff damage. It has high rates of revisions at medium term due to glenoid attrition and rotator cuff problems.

A stemless shoulder prosthesis has its fixation in the metaphyseal part of the humerus, making it possible to restore shoulder joint anatomy without dissecting the diaphyseal part. This is a relatively new implant showing good early results but with no long-term follow up.

32. Answer C. **The carrying angle is defined as the angle between the long axis of the extended and supinated forearm as it lies lateral to the long axis of the arm**

This SBA is testing biomechanics of the elbow.

The carrying angle increases with age.

The opposite is true. The carrying angle decreases with elbow flexion.

The carrying angle is greater in females than males. The normal carrying angle is 11–14° in males and 13–16° in females.

Normal carrying angle is 10–15°.

The carrying angle allows the forearm to clear the hip when the upper limb is swinging, such as during walking. The axis of the arm is defined by the lateral border of the cranial surface of the acromion to the midpoint of the lateral and medial epicondyles of the humerus. The axis of the forearm is defined by the midpoint of the lateral and medial epicondyles of the humerus to the midpoint of the distal radial and ulnar styloid processes.

33. Answer D. **Medialising the joint centre of rotation increases the torque on the glenoid bone–implant interface and decreases the lengths of the deltoid abductor moment arm**

Increasing numbers of RTSA are being performed and indications for use are widening. As such, the biomechanics of RTSA is classic T +O basic science material.

Lateralising the joint centre of rotation increases the torque on the glenoid bone implant–interface and decreases the lengths of the deltoid abductor moment arm. Placing the centre of rotation further distal (inferior) also has an advantage in that it tensions the deltoid and improves the clearance of the humeral prosthesis inferiorly, reducing the incidence of inferior impingement and notching.

34. Answer A. **Allowing inferior overhang of the glenosphere**

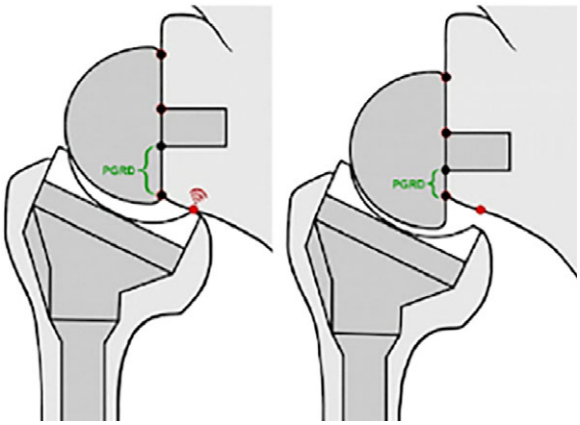


Figure 14.8 Biomechanics of the RTSA

This SBA concerns scapula notching. Scapular notching is thought to result from mechanical impingement of the superomedial humeral prosthesis against the inferior scapular neck during adduction (Figure 14.8). Rates of scapular notching are significant, occurring in up to two-thirds of patients within 2 years of reverse shoulder arthroplasty.

Eccentric glenosphere positioning resulting in inferior overhang of the glenosphere leads to the creation of a space between the scapular neck and the glenosphere. This decreases the incidence of scapular notching and reduces impingement of the humeral tuberosity against the acromion, resulting in increased range of motion.

Inferior inclination of the glenoid component, option D, has shown contradictory results. Cadaveric studies demonstrated increased impingement-free range of movements following RTSA that has not been validated by clinical studies.

Scapula notching is reduced by the following:

Eccentric (inferior) glenosphere position.

Increased lateral offset.

Increasing inclination (neck–shaft angle) of the humeral component.

Known predictors of scapular notching can be categorised into the following:

1. **Patient-specific risk factors**
   Rotator cuff tear arthropathy with a narrowed acromiohumeral distance (incidence 76% compared with 38% in post-traumatic cases).

   Glenoids with superior erosion (type E2 glenoid wear), and MRI evidence of grade 3 or 4 fatty infiltration of the infraspinatus muscle.
2. **Surgical technique**
   Anterosuperior approach has a higher incidence of scapular notching than deltopectoral interval (86% versus 56%).
   Increased risk of malpositioning with glenoid caudal or cranial tilt.

   Neutral or superiorly tilted baseplates increase the risk of scapular notching compared with inferior glenoid tilt.

   Allowing inferior overhang of the glenosphere improved impingement-free adduction and abduction angles.

   Baseplates implanted with a slight inferior tilt had the most compressive forces under the baseplate during loading with the least amount of tensile forces.

35. Answer E. **Supraspinatus, infraspinatus and teres minor**
'Hornblower's' sign occurs due to significant weakness in shoulder external rotation, specifically infraspinatus and teres minor. When the patient is asked to bring both hands to the mouth, they have difficulty doing so on the side with the rotator cuff injury. Instead, they compensate by abducting the injured arm and allowing it to fall into internal rotation, mimicking the position of a Hornblower.

The classic reference for this is Walch et al. (1998) where a Hornblower's sign indicated an irreparable tear of infraspinatus and teres minor. The companion sign is the 'dropping' sign. To perform this, the arm is held at the side (0° abduction) with the elbow flexed to 90°. The examiner passively externally rotates the arm to 45° and the patient is asked to hold this position. The dropping sign is positive when the patient is unable to do so, and the arm returns to neutral. The dropping sign indicated an irreparable infraspinatus tear; infraspinatus is the strongest external rotator when the arm is held by the side.

Walch G, Boulahia A, Calderone S, Robinson AH. The 'dropping' and 'hornblower's' signs in evaluation of rotator-cuff tears. *J Bone Joint Surg Br.* 1998;**80**:624–628.

36. Answer D. **Parsonage–Turner syndrome**
Each answer is possible and valid if we were to only look at specific parts of the history. A history of diabetes and the severity of symptoms raise the suspicion of adhesive capsulitis and septic arthritis. Entrapment of the suprascapular nerve in the supra-glenoid notch is associated with labral tears and would lead to wasting of supraspinatus and infraspinatus. Cervical radiculopathy (C5–6) should be on the list of differential diagnosis for those presenting with rotator cuff weakness and atrophy.

The discerning features are the near full range of passive movement (suggesting minimal pain inhibition) and unremarkable inflammatory markers. This helps us exclude adhesive capsulitis and more importantly, septic arthritis. Diabetes in this case has been used as a distractor for adhesive capsulitis. Cervical disc prolapse and associated radiculopathy is also unlikely as there is no mention of neck pain nor radiculopathy symptoms.

This leaves entrapment neuropathy and Parsonage–Turner syndrome (PTS). The acute onset and severity of pain coupled with risk factors (middle aged, male, post-surgery) make PTS the most likely diagnosis. PTS (also called idiopathic brachial plexopathy) is thought to be an immune-mediated disorder, characterised by acute, debilitating unilateral shoulder pain that is followed by paresis and atrophy of the shoulder girdle. It is known to present following surgery, often unrecognised and diagnosed late. The sudden loss of strength may not be noted immediately as the patient is reluctant to use the limb due to severe pain. Within a month, the weakness is usually fairly obvious and atrophic changes identifiable. Scapulothoracic nerve involvement, innervating the serratus anterior, may present with scapular winging. This could be missed if the patient is not adequately exposed during examination.

37. Answer B. **Close outpatient follow up**
Osteonecrosis is a very rare complication following paediatric fracture dislocations of the shoulder. Studies have demonstrated that revascularisation at long-term follow up occurs in the majority of cases without surgical intervention. Therefore, the most appropriate answer for this case is b.

Wang P Jr et al. Salter-Harris type III fracture-dislocation of the proximal humerus. *J Pediatr Orthop B.* 1997;**6**:219–222.

38. Answer D. **Infection**
Current evidence suggests the commonest mode of early failure following semi-constrained total elbow arthroplasty is infection. Apart from bushing failure, which is uncommon, the rest of the options are likely to occur in the intermediate/late term post-operatively.

Throckmorton T, Zarkadas P, Sanchez-Sotelo J, Morrey B. Failure patterns after linked semiconstrained total elbow arthroplasty for posttraumatic arthritis. *J Bone Joint Surg Am.* 2010;**92**:1432–1441.

39. Answer E. **Suprascapular nerve**
Establishing a posterior portal can put the axillary nerve and suprascapular nerve at risk. If the portal is established too inferior the axillary nerve is at risk vs a medial placement which runs the risk of a suprascapular nerve injury.

The musculocutaneous nerve is at risk if the anterior portal is positioned too inferior. The phrenic nerve is at risk if an interscalene block is performed.

40. Answer D. **Spinoglenoid notch and ligament**
This stem is testing your anatomical knowledge of the suprascapular nerve and potential compression sites. The stem describes a weakness of infraspinatus and isolated infraspinatus atrophy therefore the compression is likely at the distal compression site at the spinoglenoid notch. Supraspinatus strength would likely be normal in this case.

41. Answer D. **30° forward flexion, 30°abduction, 30° internal rotation**
The optimal position of fusion to maximise activities of daily living: think 30-30-30. 30° forward flexion, 30° abduction and 30° internal rotation. This will allow the patient to bring their hand to mouth and allow for self-care.

42. Answer C. **Lateral pivot shift-test**
This stem describes lateral ulnar collateral ligament injury (PLRI). The lateral pivot shift test is performed usually with the patient supine,

shoulder and elbow flexed to 90° with forearm supinated. While bringing the arm into extension a valgus stress is applied, a positive test would demonstrate prominence posterolaterally with skin dimpling. One may also elicit a palpable clunk as there may be subluxation of the radial head. Considering the prone push up test with the elbow flexed at 90° and forearm supinated, as the patient attempts to push up the patient would experience apprehension with a PLRI injury (87.5% sensitivity in isolation). Cozen's test is a provocation test for lateral epicondylitis. Varus stress testing is applicable for assessing varus instability. Answer D describes provocation testing for medial epicondylitis. Hyperpronation testing is specific for varus posteromedial rotatory instability.

Karbach LE, Elfar J. Elbow instability: anatomy, biomechanics, diagnostic maneuvers, and testing. *J Hand Surg Am.* 2017;**42**:118–126.

O'Driscoll SW, Bell DF, Morrey BF. Posterolateral rotatory instability of the elbow. *J Bone Joint Surg Am.* 1991;**73**:440–446.

43. Answer B. **Associated greater tuberosity fracture**

This stem is testing one's knowledge of the 'instability severity index score' described by Balg and Boileau (2007). They prospectively analysed patients who underwent an arthroscopic Bankart repair for recurrent anterior shoulder instability, specifically identifying predisposing factors for recurrent post operative instability. The following risk factors were identified and a scoring system applied. A score $\leq$6 points demonstrated an acceptable recurrence risk of 10% recurrence with arthroscopic stabilisation, while a score >6 points demonstrated an unacceptable recurrence risk of 70% and an open surgical stabilisation should be advised (Laterjet procedure).

Balg F, Boileau P. The instability severity index score: a simple pre-operative score to select patients for arthroscopic or open shoulder stabilisation. *J Bone Joint Surg Br.* 2007;**89**:1470–1477.

44. Answer A. **Syringomyelia**

Syringomyelia causes 25% of Charcot joints of the upper extremity. This is a rare condition with limited evidence within the literature, however one should be aware of the potential differentials and assessment and further management of neuropathic joint presentation. This is dependent on the underlying condition and clinical assessment. One should evaluate for a syrinx with MRI. There is an association with Arnold Chiari malformation as the most common cause of syringomyelia. Hansen's disease is the next most common cause of upper limb neuropathic arthropathy. In the presence of a syrinx, one should consult with the neurosurgical team for consideration of surgical decompression. Elbow arthrodesis is predominantly a salvage procedure once conservative options have failed. Total elbow arthroplasty is generally contraindicated for an underlying Charcot joint.

Jen CL, Tan JC. Neuropathic arthropathy of the elbow treated with double-plate arthrodesis and resection site bone graft. *Shoulder Elbow* 2016;**8**:48–53.

Table 14.1 Instability severity index score

Factor	Points
Age at Surgery	
$\leq$20	2
>20	0
Degree of sport participation	
Competitive	2
Recreational or none	0
Type of sport	
Contact or forced overhead	1
Other	0
Shoulder hyperlaxity	
Hyperlaxity	1
Normal	0
Hill-Sachs lesion on AP radiograph	
Visible on external rotation	2
Not visible on external rotation	0
Glenoid loss of contour on AP radiograph	
Loss of contour	2
No lesion	0

Chapter 15

Trauma I Structured SBA

Tim Brock and Rishi Dhir

TRAUMA I STRUCTURED SBA QUESTIONS

1. A 75-year-old female presents with a shoulder injury following a fall. Radiographs show a fractured proximal humerus (Figure 15.1).
   According to Hertel's study, which of the following is NOT a good predictor of humeral head ischaemia?
   A. Basic fracture pattern
   B. Calcar fragment <8mm
   C. Glenohumeral dislocation
   D. Integrity of the medial hinge
   E. Length of the metaphyseal head extension

2. A 35-year-old male sustains a closed proximal tibial fracture and elects to undergo intramedullary nailing. His radiographs are shown in Figure 15.2.
   Which of the following surgical techniques is used to prevent a valgus and procurvatum deformity?
   A. Place a coronal Poller (blocking) screw in the anterior half of the distal aspect of the proximal fragment
   B. Place a sagittal Poller (blocking) screw on the medial convex side of the distal aspect of the proximal fragment
   C. Suprapatellar nailing
   D. Use of a nail with a more distally based bend
   E. Using a more medial entry point

3. While playing rugby, a 30-year-old male sustained the injury seen in Figure 15.3, taken on presentation to the ED.
   Which of the following is true?
   A. If reduced and stable, it does not require extension splinting
   B. It can lead to a Swan neck deformity
   C. It has a positive Elson test
   D. It is associated with a volar plate injury
   E. It is the most common type of PIPJ dislocation

4. A 40-year-old roofer fell 10 feet off a ladder onto his left foot. Radiograph and CT scan are shown in Figure 15.4.
   Regarding this injury, which of the following is true?

(a)

(b)

Figure 15.1 (a) Anteroposterior (AP) and (b) lateral scapula view radiographs proximal humerus

(a)

(b)

Figure 15.2 (a) Anteroposterior (AP) and (b) lateral radiographs of the right tibia

Figure 15.3 Lateral radiograph finger

(a)

(b)

Figure 15.4 (a) Lateral radiograph calcaneum and (b) sagittal CT view calcaneum

A. A reduced angle of Gissane indicates collapse of the posterior facet
B. An enlarged Böhler's angle indicates collapse of the posterior facet
C. Sanders classification is based on the number of articular fragments on the sagittal CT image
D. The sustentaculum tali (anteromedial) fragment is referred to as the 'constant fragment'
E. Double density sign seen on lateral radiographs indicates a superiorly displaced calcaneus fracture/dislocation

5. **Regarding radiology for Lisfranc injuries, which of the following is false?**
   A. The 'fleck sign' is pathognomic and indicates avulsion of the Lisfranc ligament
   B. The 'step off sign' is caused by dorsal displacement of the 2nd metatarsal relative to the cuboid
   C. The gap between the 2nd metatarsal and medial cuneiform is <2mm
   D. The medial border of the cuboid should normally line up with the medial border of the 4th metatarsal on the oblique view
   E. The medial edge of the 2nd metatarsal should normally line up with the medial edge of the middle cuneiform on the AP radiograph

6. **Which of the following is incorrect concerning Lisfranc joint anatomy?**
   A. The 2nd tarsometatarsal joint produces the so-called 'keystone' in the 'Roman Arch'
   B. The dorsal ligaments are stronger than the plantar ligaments
   C. There is no intermetatarsal ligament between the 1st and 2nd metatarsals

D. The Lisfranc ligament runs from the first cuneiform to the medial base of the 2nd metatarsal
E. The Lisfranc joint is formed by the five metatarsals that articulate with the three cuneiform and cuboid bones

7. **Which mode of plating should be ideally used for the distal radius fracture pattern seen in Figure 15.5?**

Figure 15.5 Lateral radiograph distal radius

A. Buttress
B. Neutralisation
C. Bridging
D. Locking
E. Compression

8. **Which of the following techniques mainly produces healing by a high strain fracture environment?**

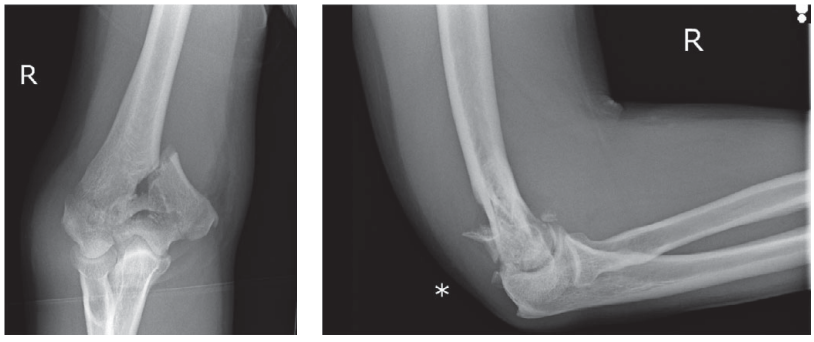
A. Overdrilling the near cortex to 3.5mm and the far cortex to 2.5mm in a Weber B ankle fracture
B. Using a partially threaded cancellous screw in a transverse medial malleolar fracture
C. Drilling an eccentric hole in an LCP plate
D. Using an articulated compression device
E. Using hybrid fixation for a periarticular fracture with metaphyseal comminution

9. **Regarding the injury shown in Figure 15.6, indications for urgent surgical treatment do NOT include which of the following?**

Figure 15.6 Lateral radiograph supracondylar fracture elbow

A. Absent radial pulse
B. Threatened skin viability
C. Capillary refill time of 5 seconds
D. Displacement greater than 100%
E. Pale hand

10. A 53-year-old male fell down 12 flights of steps onto his right elbow. His radiographs are shown in Figure 15.7.
Regarding his injury, which of the following is NOT a technical objective to achieve maximal fixation and stability?



(a) (b)

Figure 15.7 (a) Anteroposterior (AP) radiograph and (b) lateral radiographs fractured distal right humerus

A. Every screw in the distal fragments should pass through a plate
B. The screws in the distal fragments should lock together by interdigitation, creating a fixed-angle structure
C. Plates should be strong enough and stiff enough to resist breaking or bending
D. Each screw should be as long as possible
E. Lag screw to be used outside the plate to fix fracture fragments

11. A 24-year-old male sustains a type II odontoid fracture following a diving injury.
Regarding anterior pin placement for a Halo device, which of the following is true?
A. If the pins are placed more laterally, then there is a risk of injury to the orbicularis muscle
B. Should be placed 2cm above the lateral one-third of the eyebrow
C. Should be placed below the equator of the skull
D. Should be placed medial to the supraorbital nerve
E. The supraorbital nerve exits the skull at the level of the frontal sinus

12. A 26-year-old male patient fell directly on his right shoulder with the arm in an outstretched and overhead position. Pain and swelling were immediate and were associated with a 'step deformity'. The patient had limited right shoulder range of motion (ROM), strength and function.
Regarding this injury, which of the following statements is correct?
A. Type II injuries involve rupture of the AC ligament and a CC ligament sprain
B. Type III injuries involve posterior displacement of the lateral clavicle through the trapezius
C. Type IV injuries involve rupture of both AC and CC ligaments with increased CC distance of 25–100%
D. Type VI injuries involve increased CC distance from 100–300% of contralateral side
E. Type V injuries involve inferior dislocation of the lateral clavicle

13. A 20-year-old right-handed man sustained a displaced comminuted radial head fracture following a traffic accident.
Regarding fixation of radial head fractures, which of the following is correct?
A. Kocher's approach is in the interval between triceps and brachioradialis
B. PIN palsy causes weakness of wrist extension and abduction
C. Supination should be performed to protect the posterior interosseus nerve
D. The capsule should not be dissected too far posteriorly, as the PIN runs over the back of the posterolateral portion of the elbow capsule
E. The safe zone of fixation is between the radial styloid and Lister's tubercle

14. A 30-year-old patient falls off his motorbike and sustains the injury shown in Figure 15.8. He has a blood pressure of 90/60 and pulse of 110 on arrival in ED.

Figure 15.8 Anteroposterior (AP) radiograph pelvis

Which of the following would initial management NOT include?
A. Administer tranexamic acid
B. Apply an external fixator
C. Apply a pelvic binder
D. Give FFP and cryoprecipitate
E. Initiate a massive transfusion protocol

15. A 45-year-old woman has sustained a talar neck fracture following a motor vehicle accident. She has been added to the trauma list for ORIF. The CT1 on call at the time of admission has read up that the possibility of AVN developing in this fracture is high.

The blood supply to the talar neck does NOT include which of the following?

A. Anterior tibial artery
B. Artery to tarsal canal
C. Deltoid branches
D. Lateral plantar artery
E. Peroneal artery

16. A toddler was brought to the ED with irritability.
In an investigation of non-accidental injury, which of the following has a high specificity for NAI?

A. Complex skull fractures
B. Digital fractures
C. Femoral fracture in an ambulatory child
D. Metaphyseal fracture (junction of metaphysis and physis)
E. Vertebral body fractures

17. A 30-year-old, right hand-dominant man sustained an isolated injury to the right wrist after a fall from a height of approximately 15 feet. The patient reported that he fell on his outstretched hand with the wrist in extension. The right wrist was painful, swollen and tender to palpation. The hand was neurovascularly intact with no sensory deficit in the distribution of the median nerve. His radiographs are shown in Figure 15.9.
In the pathoanatomy of the injury, which of the following lists the events in the correct order?

A. Failure of lunocapitate ligament – failure of scapholunate ligament – failure of lunotriquetral ligament – lunate dislocates into carpal tunnel
B. Failure of lunotriquetral ligament – failure of lunocapitate ligament – failure of scapholunate ligament – lunate dislocates into carpal tunnel
C. Failure of lunotriquetral ligament – failure of scapholunate ligament – failure of lunocapitate ligament – lunate dislocates into carpal tunnel
D. Failure of scapholunate ligament – failure of lunocapitate ligament – failure of lunotriquetral ligament – lunate dislocates into carpal tunnel
E. Failure of scapholunate ligament – failure of lunotriquetral ligament- failure of lunocapitate ligament – lunate dislocates into carpal tunnel

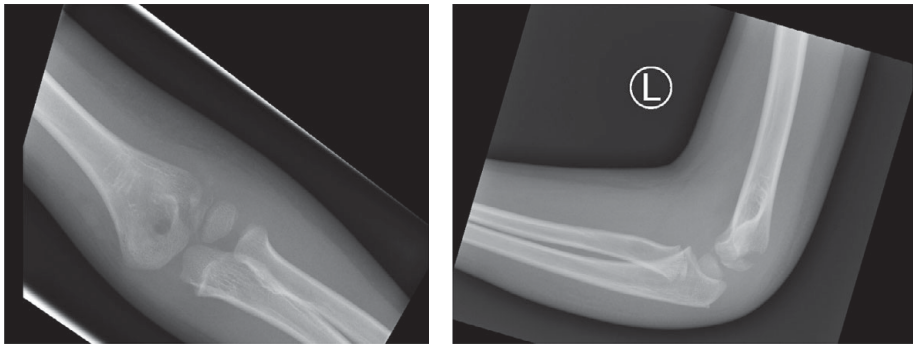
18. An 18-year-old tennis player attended the orthopaedic clinic complaining of radial-sided wrist pain after a fall on an outstretched hand. Radiographs have shown a displaced waist of scaphoid fracture.
Regarding the volar approach to the scaphoid, which of the following statement is false?

A. It is indicated in distal pole fractures
B. It is indicated in humpback flexion deformities
C. It is indicated in proximal pole fractures
D. It is indicated in waist fractures
E. It utilises the interval between FCR and the radial artery


(a)


(b)

Figure 15.9 (a) Anteroposterior (AP) and (b) lateral radiographs right wrist



(a) (b)

Figure 15.10 (a) Anteroposterior (AP) and (b) lateral radiograph child's elbow

19. **Which of the following is NOT a content of the anterior compartment of the leg?**
    - A. Extensor digitorum longus
    - B. Extensor hallucis longus
    - C. Peroneus longus
    - D. Peroneus tertius
    - E. Tibialis anterior

20. A 6-year-old boy falls off a trampoline onto his left elbow and sustains the injury noted on radiographs shown in Figure 15.10.
    Regarding the elbow fracture, which of the following statements is correct?
    - A. May be associated with wasting of the first dorsal interosseus
    - B. Minimally displaced fractures (<2mm gap) should be treated with open reduction internal fixation
    - C. The external oblique view is the most accurate view to show fracture displacement
    - D. The fracture fragment most often lies anterolateral
    - E. When fixed with K-wires, 2mm K-wires should be used

21. A 46-year-old motorcyclist sustains an isolated closed injury (Figure 15.11) after falling off his motorbike at high speed.
    Regarding the initial management of this injury, which of the following is correct?
    - A. Intramedullary nailing has better disability ratings at 6 months
    - B. Intramedullary nailing is more cost-effective compared with locking plates

Figure 15.11
Anteroposterior (AP) and lateral radiographs tibia

    - C. Recovery rates for IM nailing and locking plates are equivalent
    - D. There is a statistically higher infection rate when using locking plates compared with intramedullary nailing
    - E. There is no difference in further surgery between IM nailing and locking plates

22. **Principles of elastic (TENS) nails include all of the following except which?**
    - A. They can be used for comminuted forearm fractures
    - B. Nail diameter should be no more than 40% of the isthmus of the medullary canal
    - C. They should be pre-bent to three times the diameter of the isthmus

D. The apex of the bow of the elastic nail should be at the level of the fracture
E. The entry point for the nail should be 2.5–3cm proximal to the physis

23. **Which of the following increases the pull-out strength of a screw in bone?**
A. Decrease the cortex thickness
B. Decrease the outer diameter
C. Decrease the thread density (increased distance between threads)
D. Increase the inner diameter
E. Increase the outer diameter

24. **Undisplaced distal radius fractures are most associated with the rupture of which structure?**
A. Extensor digitorum communis
B. Extensor indicis proprius
C. Extensor pollicis longus
D. Flexor pollicis brevis
E. Flexor pollicis longus

25. A 30-year-old patient sustains an epileptic fit and attends the ED complaining of severe right shoulder pain. An anteroposterior (AP) shoulder radiograph is shown in Figure 15.12. It is irreducible in the ED.

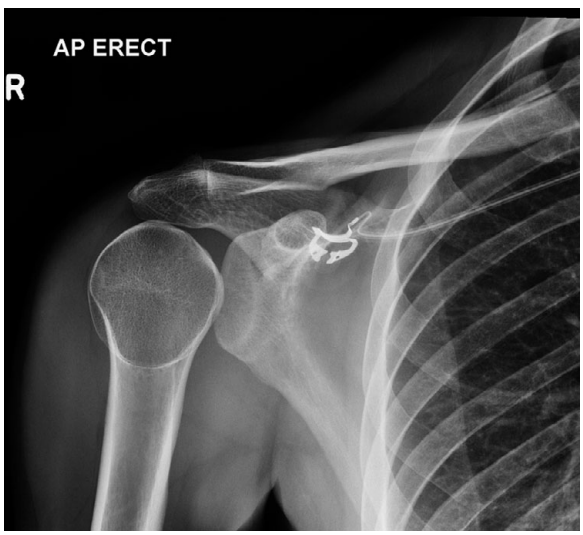


Figure 15.12 Anteroposterior (AP) radiograph right shoulder

Which of the following is NOT a recommended treatment option?
A. Femoral head allograft reconstruction
B. Reverse shoulder arthroplasty
C. Rotational osteotomy
D. Subscapularis transfer +/– lesser tuberosity
E. Emergency closed reduction under GA

26. A 35-year-old man is found 6 hours after sustaining a comminuted fracture of his right tibia secondary to a high-velocity gunshot wound. He has a systolic BP of 90 but responds well to fluids. He has a weak dorsalis pedis pulse but good capillary refill.
What is his MESS value?
A. 5
B. 6
C. 7
D. 8
E. 9

27. **Paediatric fractures occur through which layer of the physis?**
A. Maturation zone
B. Primary spongiosa
C. Proliferative zone
D. Reserve zone
E. Zone of provisional calcification

28. A 25-year-old male was resuscitated after coming off a motorbike at 50mph. He sustained an open humerus fracture, femur and tibia fracture and spinal fracture. His ISS score was 20. After he was resuscitated initially, the trauma team wanted to plan for fixation of his injuries.
In the Early Appropriate Care (EAC) protocol which of the following is incorrect regarding fracture fixation?
A. Base excess should be >5.5mmol/L
B. Definitive fixation should be performed within 36 h of injury
C. Lactate should be <4mmol/L
D. Patients should respond to resuscitation with pressor support
E. pH should be >7.25

29. A 74-year-old man falls downstairs while intoxicated and attends ED complaining of neck pain. Plain lateral radiograph cervical spine is shown in Figure 15.13. He is awake and alert.
Which of the following is the most appropriate initial management following resuscitation?
A. Closed reduction in Gardner–Wells tongs with serial traction

Figure 15.13 Lateral radiograph cervical spine

B. Immediate anterior discectomy and fusion
C. Halo application
D. MRI and urgent neurosurgical consult
E. Immediate posterior discectomy and fusion

30. An 80-year-old male presented to the ED with neck pain following a mechanical fall at home. Coronal CT image cervical spin is shown in Figure 15.14.

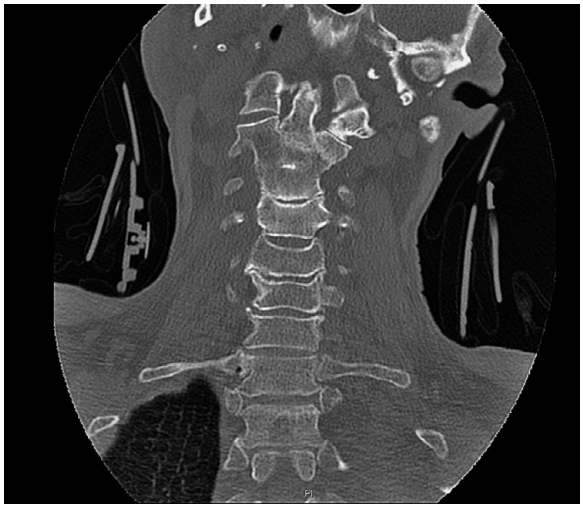


Figure 15.14 Coronal CT scan cervical spine

Which of the following statements is false in elderly patients with this injury pattern?

A. Anterior screw fixation is indicated with transverse or posterior oblique fracture lines
B. Posterior fusion has higher union rates than anterior fixation in type II fractures
C. Surgical stabilisation of type II fractures improves survival compared with non-surgical treatment in elderly patients (65–85 years)
D. The complication rate of non-surgical and surgical treatment of type II fractures in the elderly is higher
E. Type II fractures sit in a watershed area and have a greater risk of non-union

31. A 35-year-old male came off a motorbike. Following resuscitation, he complained of weakness in both legs and lower back pain. Clinical examination revealed bruising and swelling over his lumbar spine with M3 power in both legs and bilateral paraesthesia. Sagittal CT imaging is shown in Figure 15.15.

Figure 15.15 Sagittal CT image lumbar spine

What is the most appropriate management following initial resuscitation?

A. Mobilise with a spinal brace with flexion and extension views at 6 weeks
B. Mobilise with physiotherapy with no brace with flexion and extension views at 6 weeks
C. Prolonged bed rest with full spinal precautions
D. Surgical decompression
E. Surgical stabilisation


(a)


(b)

Figure 15.16 (a) Anteroposterior (AP) radiograph right humerus and (b) clinical photograph upper limb

32. A 33-year-old male falls down a flight of stairs, sustaining an injury to his right upper arm. Anteroposterior (AP) radiograph is shown in Figure 15.16(a) and clinical photograph is shown in Figure 15.16(b). The injury is isolated. On clinical examination, he is unable to dorsiflex his wrist and extend his fingers at the MCPJs.

The most appropriate next step in management would be which of the following?

A. Coaptation splint followed by functional brace
B. Humeral nailing
C. Open reduction, internal fixation and exploration of the median nerve
D. Open reduction, internal fixation and exploration of the radial nerve
E. Urgent nerve conduction studies and MRI upper limb

33. A 41-year-old woman undergoes a radial head fixation for a Mason II radial head fracture. The Kaplan approach is used.

Post-operatively, what complication is most likely?

A. Inability to abduct the fingers
B. Inability to extend the wrist in radial deviation
C. Inability to extend the wrist in ulnar deviation
D. Inability to flex the wrist in radial deviation
E. Inability to flex the wrist in ulnar deviation

34. A 77-year-old woman resident of a nursing home with limited functional ability falls onto concrete sustaining a closed injury. She has radiographs performed, which confirm the injury (Figure 15.17).

Figure 15.17 Lateral radiograph elbow

What is the most appropriate management option?

A. Total elbow replacement
B. Tension-band wiring of the olecranon
C. Conservative treatment
D. Open reduction, internal fixation with locking plate
E. Excision and triceps advancement

35. A 31-year-old man falls off his motorbike. sustaining the isolated injury shown in Figure 15.18. He is neurovascularly intact and is initially resuscitated in the ED.

What is the most appropriate definitive management?

A. Closed reduction, examination under anaesthetic and early range of motion
B. Radial head arthroplasty and coronoid open reduction internal fixation

Figure 15.18 Lateral radiograph elbow

C. Radial head arthroplasty, coronoid open reduction internal fixation and lateral collateral ligament repair
D. Radial head fixation and coronoid open reduction internal fixation
E. Radial head fixation, coronoid open reduction internal fixation and medial collateral ligament repair

36. A 63-year-old golfer falls awkwardly onto his left shoulder. He is neurovascularly intact. Anteroposterior (AP) radiograph demonstrates a three-part fracture of the proximal humerus involving the surgical neck and the greater tuberosity (Figure 15.19). There is posterior and superior displacement of the greater tuberosity by 1cm.

Figure 15.19 Anteroposterior radiograph (AP) shoulder

What is the most appropriate treatment?
A. Hemiarthroplasty
B. Open reduction and internal fixation
C. Reverse polarity total shoulder arthroplasty
D. Sling immobilisation and early mobilisation
E. Total shoulder replacement

37. A 39-year-old motorcyclist presents with continuing residue discomfort 4 months after intramedullary nailing of a midshaft tibial fracture. Inflammatory markers are normal. Radiographs are shown in Figure 15.20.

Figure 15.20 (a) Anteroposterior (AP) and (b) lateral radiographs right tibia

What is the next appropriate treatment?
A. Dynamisation of the tibial nail
B. Exchange tibial nailing
C. Functional bracing and observation
D. Low-intensity pulsed ultrasound
E. Nail removal and open reduction internal fixation

38. A 26-year-old cyclist falls over his handlebars at high speed. Following initial resuscitation, he is found to have the injury shown in Figure 15.21.
In the consent process, what statement is incorrect with regard to non-operative versus operative management?
A. Return to sport is quicker with operative management
B. There is a higher re-operative rate with operative management

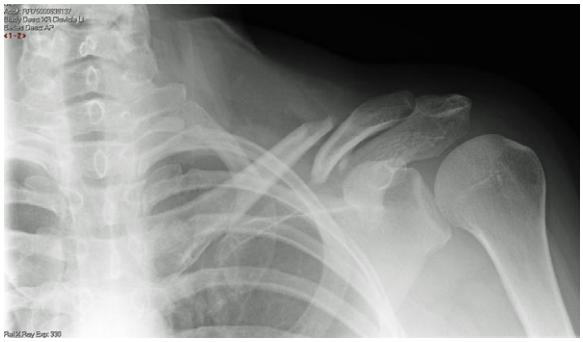


Figure 15.21 Lateral radiograph clavicle

C. There is a higher symptomatic mal-union rate in non-operative management
D. There is better short-term function with operative management
E. There is no difference between non-union rates

39. A 26-year-old undergoes scapula fixation following polytrauma via a Judet approach. He awakes with deep posterior shoulder pain and weakness with abduction.

During the approach, where is the nerve most likely to be damaged?

A. By inadvertently dissecting inferior to teres minor
B. During exposure of the posterior deltoid muscle belly
C. During retraction of infraspinatus
D. During retraction of teres minor
E. Inadvertently dissecting out the quadrangular space

40. A 7-year-old girl falls off a climbing frame, sustaining the injury shown in Figure 15.22. She sustains a neurological injury.

Figure 15.22 Lateral radiograph elbow

Based on her injury, what muscle(s) are most likely to be deficient?

A. 4th and 5th lumbricals
B. Abductor digiti minimi
C. Abductor pollicis longus
D. Extensor pollicis longus
E. Pronator quadratus

41. A 16-year-old male sustains the injury to his hip shown in Figure 15.23 following a motor vehicle accident. There is no neurovascular deficit and no other associated injuries. The on-call registrar is able to reduce the hip in the ED under sedation.

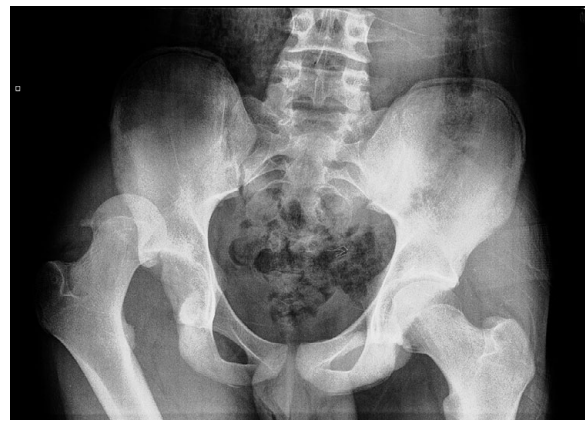


Figure 15.23 Anteroposterior (AP) radiograph hip

What is the next step in management?

A. Abduction brace
B. CT scan of pelvis
C. MRI scan of pelvis
D. Protected weight bearing
E. Skeletal traction

42. A 23-year-old man is brought into ED after a fall from a height of 6 feet. Following resuscitation, an anteroposterior (AP) radiograph demonstrates an isolated closed injury (Figure 15.24).

Which of the following is false in the management of this injury?

A. A Leadbetter manoeuvre may be performed to aid reduction
B. Open reduction relies on an internervous plane between the superior gluteal and femoral nerves
C. Quality of reduction is the most important factor in influencing outcome

Figure 15.24 Anteroposterior radiograph (AP) left hip

D. The lateral femoral cutaneous nerve is at risk during the approach
E. Time to surgery is the most important factor in influencing outcome

43. A 23-year-old footballer sustains a fracture-dislocation of his elbow (Figure 15.25). He has a pulseless white hand, despite reduction of the elbow in the ED. There are no imaging modalities available overnight, but the vascular team are present, and he is taken urgently to theatre.

Figure 15.25 Lateral radiograph elbow

What is the appropriate sequence in theatre?
A. On-table angiogram, definitive vascular reconstruction, skeletal stabilisation
B. On-table angiogram, skeletal stabilisation, definitive vascular reconstruction, forearm fasciotomies
C. On-table angiogram, temporary vascular shunt, definitive vascular reconstruction, skeletal stabilisation, forearm fasciotomies
D. On-table angiogram, temporary vascular shunt, skeletal stabilisation, definitive vascular reconstruction, forearm fasciotomies
E. On-table angiogram, temporary vascular shunt, skeletal stabilisation, definitive vascular reconstruction

44. **Line 5 in this radiograph of the left hemipelvis (Figure 15.26) indicates which of the following structures?**

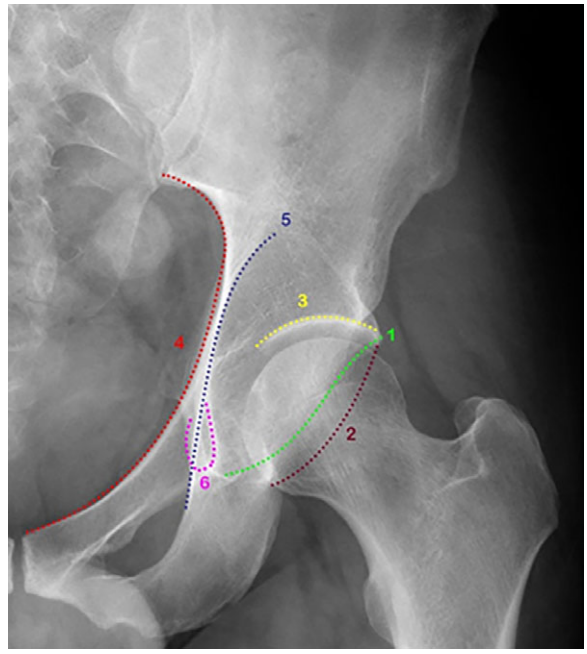


Figure 15.26 Anteroposterior (AP) pelvis radiograph

A. Acetabular true floor
B. Anterior column
C. Posterior column
D. Posterior wall
E. Weight bearing dome

45. An 80-year-old male falls at home and presents to the ED with a subtrochanteric hip fracture (Figure 15.27). He has been scheduled on the trauma list for an antegrade cephalomedullary nail.
Regarding the proximal bone fragment, what muscles are responsible for the ensuing

Figure 15.27 Anteroposterior (AP) radiograph hip

deformity of procurvatum (apex anterior) and varus?

A. Hip abductors and iliopsoas
B. Hip adductors and hamstrings
C. Iliopsoas and hamstrings
D. Iliopsoas and hip adductors
E. Quadriceps and short external rotators

46. Regarding traumatic knee dislocation, the ankle–brachial pressure index is a useful tool for assessing for an associated vascular injury.
What figure is associated with a vascular injury and warrants urgent arteriography?

A. <0.5
B. <0.6
C. <0.7
D. <0.8
E. <0.9

47. You see an 8-year-old in ED with the injury demonstrated in the radiograph in Figure 15.28.
When explaining the management plan to the parents, what is the most common complication that you should inform them of, regardless of your treatment modality?

A. Avascular necrosis
B. Knee stiffness
C. Non-union
D. Overgrowth
E. Refracture

48. An 84-year-old man has a fall and sustains the injury shown in Figure 15.29. Intraoperatively you notice the cement mantle is well fixed and overall the bone appears to be of good quality.

Figure 15.28 Lateral radiograph femur

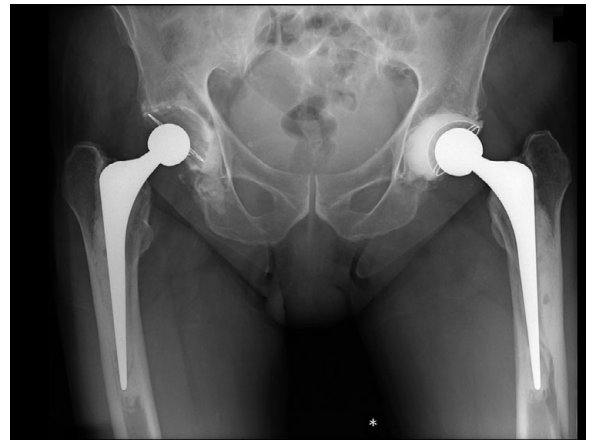


Figure 15.29 Anteroposterior (AP) radiograph left hip

What is the most appropriate treatment option?

A. ORIF using cerclage wire and locking plate
B. Proximal femoral replacement
C. Revision of cemented component to long cemented taper slip stem
D. Revision of cemented component to long porous-coated cementless stem and femoral allograft
E. Revision of cemented component to long porous-coated cementless stem and fixation of fracture

49. A 17-year-old falls 20 feet from a building. On arrival to the ED, he has a pulse of 125, blood

pressure of 70/40 and he is acting aggressively towards the staff.

What class of hypovolaemic shock is he in?

A. I
B. II
C. III
D. IV
E. V

50. A 57-year-old falls down the stairs intoxicated. On his pelvic radiographs, there is impaction of the superomedial roof of the left acetabulum (Figure 15.30).

Figure 15.30 Anteroposterior (AP) radiograph pelvis

What surgical approach is most appropriate?

A. Extended iliofemoral
B. Hardinge
C. Ilioinguinal
D. Kocher–Langenbeck
E. Modified Stoppa

51. A footballer attends the ED at 23.00h, having sustained an open tibial fracture (Figure 15.31) that evening during a football match after a tackle.

Which of the following is not a reason for an emergency operation in the middle of the night?

A. A wound size >10cm
B. Arterial injury which needs to be repaired
C. Compartment syndrome
D. Contamination with farmyard manure
E. He is going to theatre for a laparotomy and treatment of multiple other injuries

Figure 15.31 Open tibial fracture

52. A 27-year-old man falls from his motorbike. He has an open olecranon fracture and fractures of his hip, femur and tibia. He has a significant chest injury with pulmonary contusions and associated rib fractures.

What is the most sensitive indicator to determine whether he is adequately resuscitated?

A. Blood pressure
B. Gastric mucosal pH
C. Pulse rate
D. Serum lactate
E. Urine output

53. You are asked to put on an external fixator for a fracture dislocation of the ankle, which is very unstable with excessive swelling.

Which of these cannot be used to increase rigidity of your construct?

A. Decrease the distance between the bars and the skin
B. Increase pin diameter
C. Increase the number of multiplanar cross-links
D. Increase the working length
E. Reduce the fracture

54. A patient undergoes sacroiliac joint fixation with percutaneous screws for a lateral compression fracture. It was noted on the post-operative radiographs that one of the screws has penetrated the anterior cortex.

What symptom may the patient experience?

A. Bladder dysfunction
B. Paraesthesia over the dorsum of the foot
C. Paraesthesia over the popliteal fossa
D. Weakness with ankle plantar flexion
E. Weakness with quadriceps extension

55. Following a dislocated native knee joint, a 22-year-old male has an MRI that confirms a multi-ligament knee injury comprising the ACL, PCL, posterolateral corner and MCL.

Which of the following is true?

A. Treat ACL and PCL within 2 weeks and PLC and MCL operatively at 6 weeks
B. Treat ACL operatively within 2 weeks, PCL and PLC within 6 weeks and MCL conservatively in a brace
C. Treat ACL, PCL and PLC at 6 weeks once the swelling has subsided and MCL conservatively
D. Treat PCL and PLC operatively within 2 weeks, ACL within 6 weeks and MCL conservatively in a brace
E. Treat PCL and PLC operatively within 2 weeks, MCL within 6 weeks and ACL at 3 months

56. A 35-year-old male involved in a motorcycle versus car accident is brought into the resuscitation department with the following injuries after initial resuscitation: a 10cm open fracture of the tibia (which is severe but stable); moderate chest injury; minor facial injuries; and a minor head injury.

What is the Injury Severity Score?

A. 11
B. 14
C. 17
D. 18
E. 24

57. A 41-year-old male presents to the ED following a twisting left ankle injury. Anteroposterior (AP) ankle radiograph is shown in Figure 15.32.

Figure 15.32 Anteroposterior (AP) radiograph left ankle

According to the Lauge–Hansen classification for ankle fractures, how can the injury can be classified?

A. Pronation abduction
B. Pronation external rotation
C. Supination adduction type 2
D. Supination external rotation type 4
E. Supination external rotation type 4

58. **Regarding the LEAP study (Lower Extremity Assessment Project), which of the following is true?**

A. Absence of plantar sensation has the highest impact on a surgeon's decision-making process
B. Good outcomes were found for both reconstruction and amputation groups
C. Severe soft tissue injury has the highest impact on a surgeon's decision making
D. The least important factor in patient outcome is the ability to return to work
E. There is a significant improvement in return to work in reconstruction compared with amputation at 2 years

59. **Regarding principles of elastic nailing, which of the following is false?**

A. The apex of the nail crossover should be at the fracture site
B. The diameter of the nail should be 40% of the isthmus diameter
C. The entry point of a retrograde femoral elastic nail should be proximal to the physis

D. The nail diameter should be 60% of the isthmus diameter
E. The nails should be pre-bent to three times the diameter of the medullary canal

60. A 27-year-old man falls down three stairs whilst carrying some boxes. His ankle radiographs and CT images are shown in Figure 15.33.

Figure 15.33 Lateral radiograph ankle

In terms of surgical approach, which internervous plane is utilised for fixation?
A. Sural nerve and tibial nerve
B. Deep peroneal nerve and sural nerve
C. Superficial peroneal nerve and sural nerve
D. Saphenous nerve and tibial nerve
E. Superficial peroneal nerve and tibial nerve

61. A morbidly obese, diabetic patient with neuropathy falls when mobilising from her bed to the toilet. She normally walks with a frame. Her X-rays are shown in Figure 15.34. She has a large open medial wound that will close primarily.
What is the most appropriate method of management?
A. Primary ankle arthrodesis with hindfoot nail
B. Fibula nail
C. Open reduction fixation of ankle
D. External fixation
E. MUA and total contact cast

(a) (b)

Figure 15.34 (a) Anteroposterior (AP) and (b) lateral radiographs ankle

TRAUMA I STRUCTURED SBA ANSWERS

1. Answer C. **Glenohumeral dislocation**
Hertel et al.'s (2004) seminal paper evaluated predictors of humeral head ischaemia after intracapsular humerus fractures by drilling a borehole into the central part of the humeral head intraoperatively and observing backflow and measuring laser Doppler flowmetry.

They demonstrated the significance of metaphyseal head extension. Metaphyseal head extension is a radiographic measurement of the articular fragment from the head–neck junction to the inferior extent of the medial cortex.

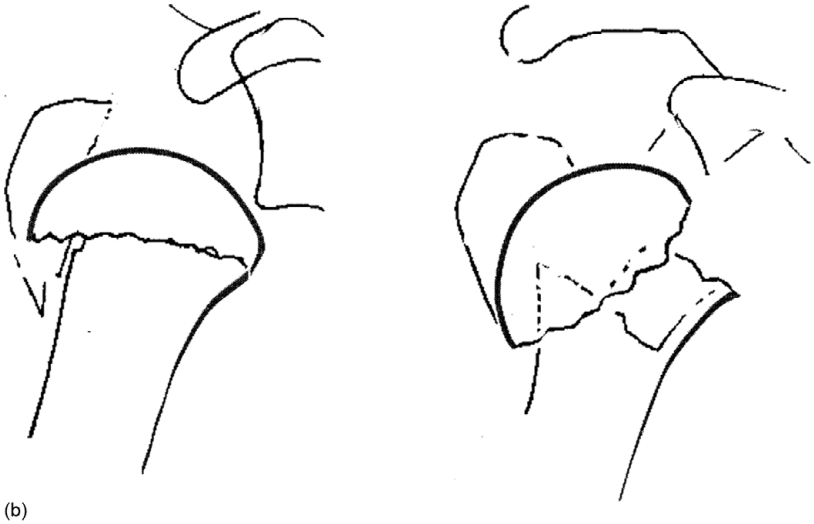
Good predictors of ischaemia were the length of the metaphyseal head extension (with a calcar fragment <8mm); the integrity of the medial hinge and certain basic fracture patterns (anatomical neck).

Poor predictors of ischaemia included glenohumeral dislocation, tuberosity displacement, angular displacement of the head and fractures consisting of three and four fragments (Figure 15.35 (a) and (b)).

Hertel R et al. Predictors of humeral head ischaemia after intracapsular fracture of the proximal humerus. *J Shoulder Elbow Surg.* 2004;**13**:427–433.

2. Answer C. **Suprapatellar nailing**
Proximal tibial fractures can be very challenging to treat with an intramedullary nail because of the tendency of the proximal fragment to extend (procurvatum) due to the patellar tendon, and distal

Figure 15.35(a) Metaphyseal head extension is a radiographic measurement of the articular fragment from the head–neck junction to the inferior extent of the medial cortex



(b)

Figure 15.35(b) Integrity of the hinge is a predictor of both ischaemia and practical feasibility of reduction

fragment, flex due to the hamstrings and possible valgus deformity. This particularly occurs during hyperflexion when using an infrapatellar nail to get the entry point. Therefore, using a semi-extended position, which a suprapatellar nail affords, helps to avoid this. Poller (blocking) screws can be used to block the pathway of the nail and guide it down a more 'favourable' route. In this case, a sagittal lateral blocking screw and coronal posterior blocking screw would guide the nail into a preferential anterior and lateral position in the metaphysis. Unicortical one-third tubular plates can be used as a temporising measure while making the entry point and passing the guide wire to reduce the fracture and prevent the procurvatum deformity. Finally, a more lateral entry point should be used to decrease the valgus deformity. A medial entry point would increase the valgus deformity.

Fractures that are proximal to nail bend will cause the proximal fracture fragment to translate anteriorly up to 1cm. It has been noted that the proximal bend in a nail acts as a wedge that displaces the proximal fragment anteriorly as the nail is driven distally. The use of a nail with a more proximally based bend has less of a wedging effect.

Hak DJ. Intramedullary nailing of proximal third tibial fractures: techniques to improve reduction. *Orthopedics* 2011;**34**:532–535.

3. Answer C. **It has a positive Elson test**
This is a radiograph of a volar PIPJ dislocation. It is the less common type of PIPJ dislocation (the most common being dorsal). It is associated with a central slip injury and therefore has a positive Elson test and causes a boutonnière deformity. By definition, it is an unstable injury and must be treated in a PIPJ hyperextension splint. A dorsal PIPJ dislocation is associated with a volar plate injury and causes a Swan neck deformity. It can be mobilised immediately if stable after reduction.

4. Answer D. **The sustentaculum tali (anteromedial) fragment is referred to as the 'constant fragment'**
Calcaneus fractures are the most common tarsal bone fracture and often have associated injuries including open fractures (17%), vertebral fractures, especially L1 (10%), and contralateral calcaneus fractures (10%).

The most important facet is the posterior facet (main weight-bearing facet). An increasing crucial angle of Gissane (normally 120–145°) or reduced Böhler's angle (normally 20–40°) indicates collapse of the posterior facet. The anteromedial fragment is known as the sustentaculum tali ('shelf of talus') and is known as the 'constant fragment' as it remains fixed or 'constant' due to the medial talocalcaneal and interosseus ligaments.

Classifications include Essex–Lopresti and Sanders, which is based on the number of articular fragments on a coronal CT image at the widest point of the posterior facet.

In most calcaneal fractures, the double density is the result of a depressed lateral fragment relative to the constant sustentaculum within the contour of the calcaneal body. With the 'locked-lateral' fracture dislocation variant, the lateral fragment is due to the superior dislocation of the fracture fragment, which is visible as a second density located superior to the sustentaculum overlapping with the talus.

Schepers T, Backes M, Schep NW, Goslings JC, Luitse JS. Functional outcome following a locked fracture-dislocation of the calcaneus. *Int Orthop*. 2013;**37**:1833–1838.

Rider CM, Olinger CR, Szatkowski JP, Richardson DR. 'Locked-lateral' calcaneal fracture-dislocation treated with primary subtalar fusion: a case report. *JBJS Case Connector* 2020;**10**: e0467.

5. Answer B. **The 'step off sign' is caused by dorsal displacement of the 2nd metatarsal relative to the cuboid**
Radiology for suspected Lisfranc injuries should include AP, lateral and oblique radiographs. On the AP view, we should see a 'fleck sign', which indicates avulsion of the Lisfranc ligament and is often pathognomic for Lisfranc injuries. The medial border of the 2nd metatarsal should normally line up with the medial border of the middle cuneiform on the AP view (Figure 15.36). On the oblique view, the medial border of the 4th metatarsal should normally line up with the medial border of the cuboid. On the lateral view, we should check for dorsal/plantar displacement of the metatarsals.

Figure 15.36 Anteroposterior foot X-ray demonstrating Lisfranc injury (the medial border of the 2nd metatarsal does not line up with that of the middle cuneiform)

Figure 15.37 Buttress plating in a volar Barton's fracture

The 'step off sign' is caused by dorsal displacement of the 2nd metatarsal relative to the medial cuneiform seen on a lateral weight bearing film.

6. Answer B. **The dorsal ligaments are stronger than the plantar ligaments**
The Lisfranc joint consists of the five metatarsals that articulate with the three cuneiforms and cuboid bones.

Bony stability is determined by the trapezoidal shape of the base of the first three metatarsals, with their respective cuneiform bones, forming a stable arch known as a 'Roman Arch' with the second TMTJ as the 'keystone'.

Ligamentous stabilisers include the dorsal and plantar TMT ligaments that cross each TMT joint, and the dorsal ligaments are weaker; hence, displacement is often dorsal.

Intermetatarsal ligaments join the 2nd to the 5th metatarsals, but there is no intermetatarsal ligament between the 1st and 2nd metatarsal.

Moracia-Ochagavia I, Rodriguez Merchan E. Lisfranc fracture-dislocations: current management. *EFORT Open Rev*. 2019;**4**:430–444.

7. Answer A. **Buttress**
A volar Barton's fracture is an example of a shear fracture treated by a buttress (anti-glide) plate, which works by trapping the apex of the fracture (Figure 15.37).

A compression plate is used, for example, in a forearm fracture, producing absolute stability.

A bridging plate works as an internal external fixator, for example, in a clavicle fracture, producing relative stability.

A neutralisation plate works by neutralising torsional forces, for example, after fixation by a lag screw in a Weber B fracture.

A locking plate is not a true mode of plating.

8. Answer E. **Using hybrid fixation for a periarticular fracture with metaphyseal comminution**
Primary fracture healing requires direct reduction and absolute stability. This requires increased fracture stability and a low fracture strain ($\leq$2%) environment. There is Harversian remodelling and no callus formation.

Secondary fracture healing requires indirect reduction and relative stability. This needs a high strain ($\geq$2%) fracture environment and occurs with endochondral/intramembranous ossification. The callus/cartilage becomes mineralised and replaced by bone.

Cutting cones are produced in primary bone healing. This relies on interfragmentary compression. This can be produced by the following techniques:

Lag screw technique (overdrilling the near cortex to 3.5mm, which becomes the 'glide hole' and drilling the far cortex to 2.5mm, which becomes the 'pilot hole'), e.g. in a Weber B ankle fracture.

Using a partially threaded cancellous screw in cancellous bone in a medial malleolar transverse fracture (lag screw technique); using a compression plate in a forearm fracture (by eccentric drilling).

Using an articulated compression device provides absolute stability with no callous formation.

An intramedullary nail, cast, external fixator and bridging plate produce relative stability, which produces callus for healing (secondary bone healing).

In reality, most fixations involve components of both types of healing.

Hybrid fixation involves a combination of absolute and relative stability principles. An example is a peri-articular distal femoral fracture with extensive meta-diaphyseal comminution, direct reduction and absolute stability for the articular block with bridge plating and relative stability for the meta-diaphysis.

9. Answer D. **Displacement greater than 100%**
In the BOAST guidelines for supracondylar fractures, indications for urgent (night-time) operating include absent radial pulse, threatened skin viability and evidence of impaired perfusion (including increased capillary refill time or a pale hand). Fracture displacement on its own is not an indication for urgent operating. Discussion with the vascular on-call team should take place if a child presents with an ischaemic limb.

10. Answer E. **Lag screw to be used outside the plate to fix fracture fragments** Failure of distal humerus intra-articular fractures, when it occurs, typically occurs at the supracondylar level through loss of fixation in the distal fragments. To prevent such failure and maximise the potential for union and full elbow mobility after a severely fractured distal humerus, according to O'Driscoll's seminal paper (2005), the following principles must be satisfied:
    1. Fixation in the distal fragment must be maximised.
    2. All fixation in distal fragments should contribute to stability between the distal fragments and the shaft.

    There are 8 technical objectives to achieve these principles:
    1. Every screw in the distal fragments should pass through a plate.
    2. Each screw should engage a fragment on the opposite on the opposite side that is also fixed to a plate.
    3. Place as many screws as possible in the distal fragments.
    4. Each screw should be as long as possible.
    5. Each screw should engage as many articular fragments as possible.
    6. The screws in the distal fragments should lock together by interdigitation, creating a fixed-angle fracture.
    7. Plates should be applied such that compression is achieved at the supracondylar level for both columns.
    8. The plates should be strong enough and stiff enough to resist breaking or bending before union occurs at the supracondylar level.

    O'Driscoll SW. Optimizing stability in distal humeral fracture fixation. *J Shoulder Elbow Surg.* 2005;**14**(1 Suppl. S):186S–194S.

11. Answer C. **Should be placed below the equator of the skull**
Four pins are used in a halo device: two anterior and two posterior.

    The two anterior pins should be placed in a safe zone, which is a 1cm region just above the lateral one-third of the orbit (eyebrow) at or below the equator of the skull (Figure 15.38). This is anterior and medial to the temporalis muscle.

    The two posterior pins are placed on the opposite side ring from the anterior pins.

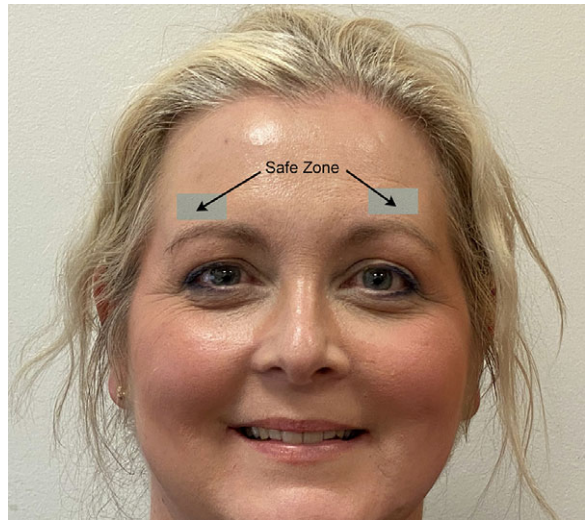


Figure 15.38 Safe zones for halo traction

The supraorbital nerve is a branch of the frontal nerve providing sensation to the upper eyelid and forehead/scalp. It emerges just above the medial one-third of the orbit and is at risk for injury if halo pins are placed too medial above the orbit.

The halo should be placed below the equator of the skull to prevent cephalic migration of the halo.

The supratrochlear nerve exits the skull at the level of the frontal sinus.

If the pins are placed more laterally, then there is a risk of injury to the temporalis muscle.

12. Answer A. **Type II injuries involve rupture of the AC ligament and a CC ligament sprain**
The SBA refers to Rockwood's classification of ACJ injuries. Despite the move away from asking about classification systems, it still useful to know especially the difference between type III and type V injury and also the controversy as to what to do with a type III injury.

Type I is a sprain of the AC ligament and normal CC ligament with no instability of the ACJ.

Type II is a torn AC ligament and sprained CC ligament with horizontal AC instability.

Type III is a torn AC and CC ligament with increased CC distance of 25–100%.

Type IV is posterior displacement of the lateral clavicle through the trapezius.

Type V is an increased CC distance 100–300% compared with the contralateral side

Type VI is inferior dislocation of the lateral clavicle.

C is incorrect, as this refers to type IV, not type III.

ACJ injury: Rockwood classification. In **Rockwood CA, Williams GR, Young DC**, eds. *Rockwood and Green's Fractures in Adults,* 4th Ed., 1341–1414. Philadelphia, PA: Lippincott-Raven; 1996.

13. Answer E. **The safe zone of fixation is between the radial styloid and Lister's tubercle**
Kocher's approach is often used to approach radial head fractures. This utilises an internervous plane between ECU (posterior interosseus nerve) and anconeus (radial nerve). The safe zone of fixation is between the radial styloid and Lister's tubercle. Full pronation of the forearm moves the PIN away from the operative field.

The PIN supplies motor innervation to all the extensor muscles of the wrist and digits: ECRB, supinator, ECU, EDM, EDC, APL, EPB, EPL and EIP, except for the extensor carpi radialis longus (ECRL). ECRL is supplied by a branch from the radial nerve prior to its division into the PIN and SRN. ECRL produces wrist extension and abduction.

The interval between triceps and brachioradialis is the lateral approach to the distal humerus.

The capsule should not be dissected too far anteriorly, as the PIN runs over the front of the anterolateral portion of the elbow capsule.

Caputo AE, Mazzocca AD, Santoro VM. The nonarticulating portion of the radial head: anatomic and clinical correlations for internal fixation. *J Hand Surg Am.* 1998;**23**:1082–1090.

14. Answer B. **Apply an external fixator**
This patient is in hypovolaemic shock and haemodynamically unstable. Primary resuscitative measures include application of a pelvic binder (haemostatic device), tranexamic acid (according to CRASH-2 protocol), initiating a massive transfusion protocol (comprising red blood cells, platelets, FFP and cryoprecipitate) and practising permissive hypotension (aiming at systolic of 90). Secondary resuscitative measures include angiographic embolisation and pelvic packing, but these are not initial measures.

External fixators are not very practical to use in the ED, are often applied incorrectly and are associated with a high rate of complications.

A pelvic binder should have been applied in a prehospital setting and is a rapid, safe alternative for haemorrhage control, and equally has benefits as a simple method for use by the junior surgeons. If not already applied, this should be done in the ED as per ATLS protocol.

If an external fixator is to be applied, this is best performed in theatre under image intensifier (II) control.

15. Answer D. **Lateral plantar artery**
The blood supply to the talar neck comes from three main sources (Figure 15.39):

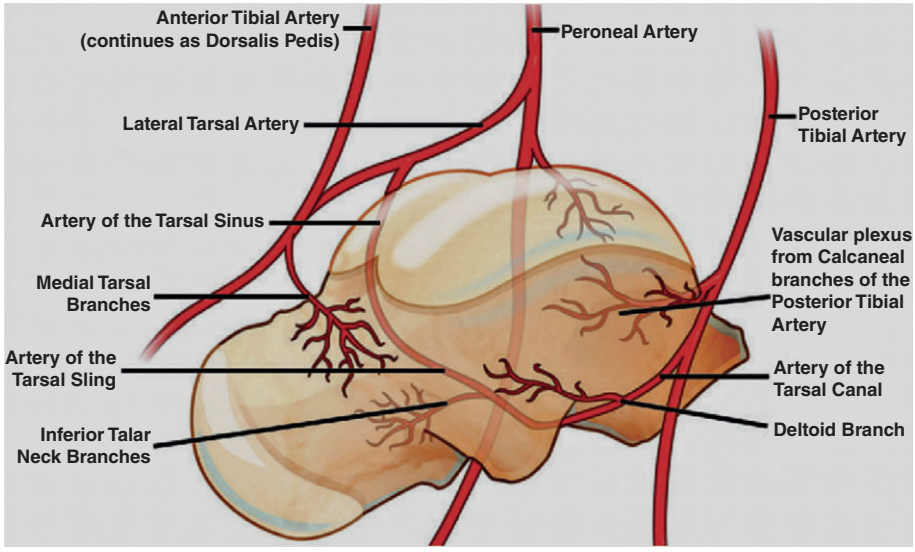


Figure 15.39 Blood supply of the talus

1. **Posterior tibial artery**
   - Via artery of tarsal canal (dominant supply) and supplies majority of talar body.
   - Deltoid branch of posterior tibial artery, which supplies medial portion of talar body and may be only remaining blood supply with a displaced fracture.
2. **Anterior tibial artery**
   - Supplies head and neck.
3. Perforating **peroneal artery** via artery of tarsal sinus.
   - Supplies head and neck.

The lateral plantar artery does not supply the talar neck.

16. Answer D. **Metaphyseal fracture (junction of metaphysis and physis)**
Pathognomic injuries (high specificity) for non-accidental injury include metaphyseal fractures, posterior rib fractures and femoral fractures in a non-ambulatory child.

The classic metaphyseal lesion (CML)is a fracture at the junction of metaphysis and physis (primary spongiosa) (Figure 15.40). The fracture is regarded as highly specific for NAI.

These microfractures occur in immature mineralised bone almost entirely in children under the age of 2 years because:

Figure 15.40 Metaphyseal corner fracture

- they are small enough to be shaken
- they cannot protect their limbs.

Variants include a corner fracture and bucket handle fracture.

A corner fracture is a discrete avulsion of the metaphysis.

A bucket handle fracture is a horizontal avulsion fracture; the central and peripheral components give the appearance of a bucket handle.

17. Answer D. **Failure of scapholunate ligament – failure of lunocapitate ligament – failure of lunotriquetral ligament – lunate dislocates into carpal tunnel**
The injury is a lunate dislocation. Be able to recognise this injury on plain radiographs.

There is a misalignment of the first Gilula arc in which the lunate 'overlaps' the capitate and the scaphoid. The lunate bone has a triangular appearance on AP projection, with displacement and volar rotation on the lateral film. There is also a diffuse reduction of bone attenuation.

This SBA is testing Mayfield's classification system, which refers to the predictable sequence of pathoanatomy (in which the injury occurs to the carpal bones) (Figure 15.41).

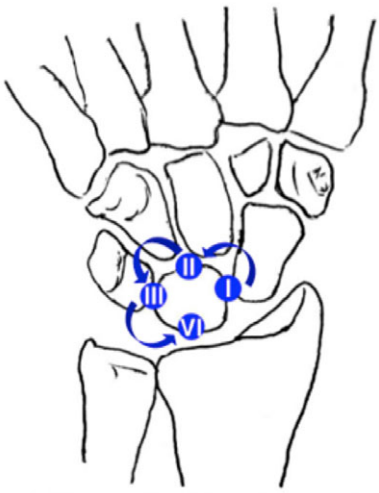


Figure 15.41
Mayfield radiocarpal injury

- Mayfield I: Failure of scapholunate ligament.
- Mayfield II: Failure of lunocapitate ligament.
- Mayfield III: Failure of lunotriquetral ligament ('perilunate').
- Mayfield IV: Lunate dislocates usually into carpal tunnel ('lunate dislocation').

Mayfield JK, Johnson RP, Kilcoyne RK. Carpal dislocations: pathomechanics and progressive perilunar instability. *J Hand Surg Am.* 1980;5:226–241.

18. Answer C. **It is indicated in proximal pole fractures**
The volar approach between FCR and the radial artery can be used for waist and distal pole fractures and also those with humpback flexion deformities. Proximal pole fractures ideally should be approached via a dorsal approach, as the trajectory of the screw implant is easier via a dorsal approach.

19. Answer C. **Peroneus longus**
This SBA is testing anatomy (Figure 15.42). There are four compartments of the leg: (1) anterior, (2) lateral, (3) posterior superficial and (4) posterior deep.

Contents of the anterior compartment include:

- Tibialis anterior.
- Extensor hallucis longus.
- Extensor digitorum longus.
- Peroneus tertius.

Peroneus longus is a content of the lateral compartment, not anterior compartment.

Lezak B, Summers S. *Anatomy, Bony Pelvis and Lower Limb, Leg Anterior Compartment.* Treasure Island, FL: StatPearls Publishing; 2020.

20. Answer A. **May be associated with wasting of the first dorsal interosseus**
Lateral condyle fractures are the second most common fracture in the paediatric elbow, with a higher risk of non-union, malunion and AVN than other paediatric elbow fractures. The internal oblique view is the best view to visualise fracture displacement, as the fracture fragment is most commonly lying posterolateral.

A number of classification systems, including Milch and Weiss, are used. The Weiss classification system (types I–III) states that type I fractures (<2mm with an intact cartilaginous hinge) can be treated in a cast; type II (>2mm but <4mm displacement with intact articular cartilage on arthrogram) can be treated by closed reduction and fixation; type III (>4mm displacement with disrupted articular cartilage on arthrogram) should be treated by open reduction internal fixation. Typically, 1.6mm K-wires in a laterally placed divergent configuration are used. One of the reported complications (10%) due to lateral physeal arrest is cubitus valgus, which may be associated with a tardy ulnar palsy, one of the features of which is wasting of the first dorsal interosseus.

21. Answer B. **Intramedullary nailing is more cost-effective compared with locking plates**
This is an extra-articular distal tibial fracture. The fixDT trial published by Costa et al.

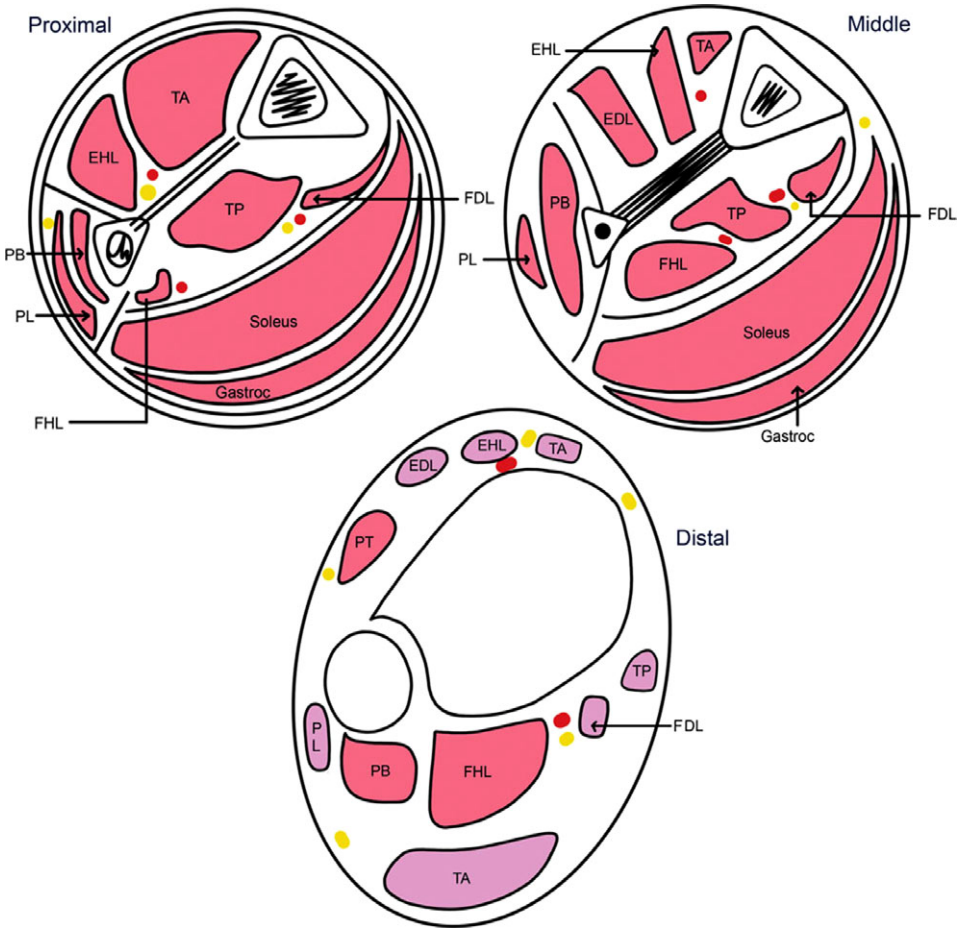


Figure 15.42 Cross anatomy diagram lower leg

(2018), which was conducted in 28 UK acute trauma centres from 2013–2017, recruited 321 adult patients and randomised them to fixation by intramedullary nailing or plating. The primary outcome measure was the Disability Rating Index (DRI) score and secondary outcomes were the Olerud-Molander Ankle Score (OMAS), quality of life index (EQ-5D) and complications such as infection and further surgery.

There were similar disability ratings at 6 months and no difference in infection rates but recovery rates were greater for intramedullary nailing and costs were lower (intramedullary nailing was more cost-effective). Further surgery was also more common in the locked plate group (12% compared with 8% at 12 months).

Costa M et al. Intramedullary nail fixation versus locking plate fixation for adults with a fracture of the distal tibia: the UK FixDT RCT. *Health Technol Assess.* 2018;**22**:1–148.

22. Answer A. **They can be used for comminuted forearm fractures**

Principles of elastic nails include:

- Use for length stable fractures, e.g. transverse fractures. They are contraindicated for length unstable fractures, e.g. comminuted or long spiral fractures.
- Entry point of the nail should be 2.5–3cm proximal to the physis.
- The apex of the bow of the elastic nails should be at the level of the fracture.
- They should be pre-bent to three times the diameter of the isthmus.

Slongo TF. Fracture treatment in childhood. *Injury* 2005;**36**(Suppl. 1):A1.

23. Answer E. **Increase the outer diameter**
The pull-out strength of a screw can be increased by increasing the difference between the outer and inner core diameter (increase the outer, decrease the inner), decrease the pitch (increased thread density) or increase cortex thickness.

Törnkvist H, Hearn TC, Schatzker J. The strength of plate fixation in relation to the number and spacing of bone screws. *J Orthop Trauma.* 1996;**10**:204–208.

24. Answer C. **Extensor pollicis longus**
EPL (extensor pollicis longus) tendon ruptures occur in up to 9% of distal radius fractures. Treatment typically consists of a tendon transfer of the extensor indicis proprius as the tear is attritional, which makes repair impractical.

Roth KM et al. Incidence of extensor pollicis longus tendon rupture after nondisplaced distal radius fractures. *J Hand Surg A.* 2012;**37**:942–947.

25. Answer E. **Emergency closed reduction under GA**
This is a locked posterior dislocation until proven otherwise because of a Hill–Sachs lesion (reverse). This is likely to be a missed chronic injury. Closed reduction can potentially cause a proximal humerus fracture and should not be attempted as an emergency. A scheduled closed reduction can be attempted under general anaesthesia. The reduction manoeuvres must be done gently and carefully. Most dislocations have a chance to reduce with closed manipulation, if the injury is <6 weeks old. The prognosis is good if the reverse Hill–Sachs lesion is <25% of the humeral head articular surface.

A CT scan should also be done. Treatments depend on the size of the defect and may include a McClaughlin procedure (subscapularis tenotomy +/– lesser tuberosity), femoral head allograft reconstruction, rotational osteotomy or reverse shoulder arthroplasty as a final salvage.

Aydin N, Kayaalp M, Asansu M, Karaismailoglu B. Treatment options for locked posterior shoulder dislocations and clinical outcomes. *EFORT Open Rev.* 2019;**4**:194–200.

26. Answer C. **7**.
Age: 1 (30–50).

Shock group: 1 (shock group 2 – BP unstable in field but responds to fluids).

Energy of injury: 3 – high (gunshot wound: high velocity).

Ischaemia: 2 – Diminished pulses without ischaemia.

This results in a score of 7.

Mangled Extremity Severity Score (MESS)

Vascularity/Limb ischaemia

- Poor pulse 1
- Pulseless and poor CR 2
- Totally avascular 3
- Score doubled for ischaemia >6/24

Injury Skeletal/Soft tissue

- Low Energy 1
- Medium Energy 2
- High Energy 3
- Very High Energy 4

Shock

- Systolic BP >90mmHg 0
- Hypotensive transiently 1
- Persistent hypotension 2

Age (Years)

- <30 0
- 30–50 1
- >50 2

27. Answer E. **Zone of provisional calcification**
Physeal fractures typically occur in the hypertrophic zone, specifically in the zone of provisional calcification, as this is an area with large cells but small amounts of matrix and is potentially weak.

28. Answer D. **Patients should respond to resuscitation with pressor support**
Vallier et al.'s (2005) seminal paper on Early Appropriate Care (EAC) recommends the following: fractures should be definitively fixed within 36 h of injury, providing lactate <4, pH >7.25, Base Excess >5.5mmol/L and patients must respond to resuscitation without pressor support.

Vallier H et al. Complications are reduced with a protocol to standardise timing of fixation based on response to resuscitation. *J Orthop Surg Res.* 2015;**10**:155.

29. Answer D. **MRI and urgent neurosurgical consult**

A unifacet or bifacet dislocation is a surgical emergency and requires immediate in-line triple immobilisation and full spinal precautions while resuscitation is occurring. Following this, an MRI should be obtained and early discussion had with the regional neurosurgical unit regarding potential transfer. In the neurosurgical unit, if no disc is present on MRI (which must be excluded due to the risk of cord transection with closed reduction), a halo can be applied, or Gardner–Wells tongs and traction applied under image intensifier and clinical monitoring for neurology.

If this fails or a disc is present, open reduction is performed, followed by definitive fixation.

There is controversy over whether to just proceed with serial traction weight to reduce the dislocation without obtaining a prior MRI. This has been shown to be safe when used with an awake patient. Rapid decompression of the cervical spine may improve recovery as opposed to the delay that will occur waiting to obtain an MRI. Closed reduction is recognised as a challenging procedure for surgeons, particularly those in non-spinal centres that only occasionally face this clinical scenario.

A study investigating delays to decompression of cervical spine cord injury at centres throughout Australia and New Zealand noted that median time to open decompression was 22 h compared with 6 h for closed reduction. They concluded that closed reduction was effective in minimising time to decompression. Neurological improvement was greatest in those patients reduced within 4–8 h from injury with no cases of neurological worsening.

Star AM, Jones AA, Cotler JM, Balderston RA, Sinha R. Immediate closed reduction of cervical spine dislocations using traction. *Spine* 1990;**15**:1068–1072.

Storey RN, Singhal R, Inglis T, Kieser D, Schouten R. Urgent closed reduction of the dislocated cervical spine in New Zealand. *ANZ J Surg*. 2018;**88**:56–61.

30. Answer D. **The complication rate of non-surgical and surgical treatment of type II fractures in the elderly is higher**

Type II fractures sit in a watershed area between the internal carotid and vertebral artery and therefore are at higher risk of non-union. There is an increasing body of evidence that surgical treatment is better for type II fractures in the elderly, especially those with risk factors for non-union. A fibrous non-union can be managed reasonably well, but symptomatic non-union can be associated with high rates of morbidity including atlantoaxial subluxation. The complication profile of non-surgical and surgical treatment is equivalent.

Atlantoaxial mobility is preserved in odontoid screw fixation through an anterior approach. It is indicated in cases with transverse or posterior oblique fracture lines. However, in the presence of a comminuted odontoid fracture, anterior oblique fracture, transverse ligament rupture, osteoporosis, cervicothoracic kyphosis or delayed fracture (>6 months), anterior odontoid screw fixation is contraindicated. In these cases, a posterior approach is recommended.

Iyer S, Hurlbert RJ, Albert T. Management of odontoid fractures in the elderly: a review of the literature and an evidence-based treatment algorithm. *Neurosurgery* 2018;**82**:419–430.

Robinson Y, Robinson A, Olerud C. Systematic review on surgical and nonsurgical treatment of type II odontoid fractures in the elderly. *Biomed Res Int.* 2014;**2014**:231948.

31. Answer E. **Surgical stabilisation**

Management of spinal fractures is determined by the Thoracolumbar Injury Classification score (TLICS) by Vaccaro et al. (2005), which looks at three parameters: fracture morphology, neurology and PLL (posterior longitudinal ligament) injury. A final score of 0–3 is treated non-operatively; 4 can be treated operatively or non-operatively and >4 is treated operatively. Bony chance fractures with stable posterior elements (no PLL injury), no neurological deficits and less than 15° kyphosis can be treated conservatively with immobilisation in a thoracolumbar orthosis in extension with 2-week follow-up for non-union and degree of kyphosis. Ligamentous chance fractures and unstable posterior elements with neurological deficits should be treated by emergent open reduction and stabilisation surgery. Decompression surgery is inadequate for stabilising the spine. Traditionally, this was three

levels above and two levels below, but modern pedicle screw techniques have changed this to one level above and one level below.

In this particular case, the fracture is a chance fracture (flexion-distraction), which scores 4 for morphology; there is incomplete neurology, which scores 3; and there is possibly a posterior ligamentous injury. Therefore, he is scoring at least 7 or possibly more, which should be treated operatively.

AlJallaf M, AlDelail H, Hussein L. Let's review Chance fracture. *BMJ Case Rep.* 2015. doi:10.1136/bcr-2014-206924.

Vaccaro AR et al. A new classification of thoracolumbar injuries: the importance of injury morphology, the integrity of the posterior ligamentous complex and neurological status. *Spine* 2005;**30**:2325–2333.

32. Answer A. **Coaptation splint followed by functional brace**

This patient presents with a radial nerve palsy following a closed humeral shaft fracture. The fracture is within the criteria for acceptable alignment ($<20^{o}$ anterior angulation, $<30^{o}$ varus/valgus angulation, <3cm shortening). In terms of the fracture itself, it does not require surgical treatment.

The overall incidence of radial nerve injuries after humeral shaft fractures is 11.8%, but controversy exists on treatment of these injuries. Absolute indications for early exploration are open fractures or iatrogenic injury (e.g. after humeral bracing). Relative indications are polytrauma or floating elbow.

The majority of nerve palsies (85–90%) recover spontaneously without intervention in 3 months.

In the answer options, the median nerve is not affected in this case, and nerve conduction studies are not meaningful before 6 weeks (as there is a latency period). Exploration of the radial nerve and fixation is not required unless it is an open fracture, iatrogenic injury, polytrauma, floating elbow or the fracture mandates it. Humeral nailing should not be done in the presence of a radial nerve injury, as there is a high risk of injury to the nerve.

Rocchi M et al. Humerus shaft fracture complicated by radial nerve palsy: is surgical exploration necessary? *Musculoskelet Surg.* 2016;**100** (Suppl. 1): S53–S60.

33. Answer C. **Inability to extend the wrist in ulnar deviation**

The Kaplan's approach to the elbow is a more anterior approach and occurs between ECRB and EDC (Figure 15.43). It is not a true internervous plane, as both are innervated by the posterior interosseus nerve (although some cadaveric studies have shown that in 15% of cases ECRB is innervated by the radial nerve proper). The posterior interosseous nerve (PIN) is at risk during this approach and during plating of radial head fractures. The bicipital tuberosity marks the distal limit of plate placement before endangering the nerve. The wrist does not extend in ulnar deviation due to extensor carpi ulnaris being innervated by the PIN. The extensor carpi radialis longus is supplied by the radial nerve proper and therefore will still allow wrist extension with radial deviation. Flexion and abduction are not caused by the posterior interosseus nerve.

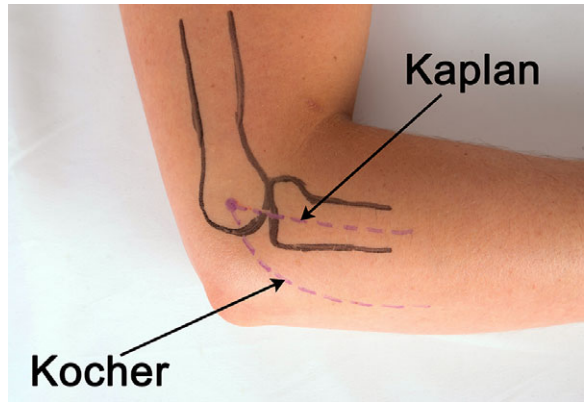


Figure 15.43 Surgical approach elbow

34. Answer C. **Conservative treatment**

The radiograph shows a displaced olecranon fracture with possible comminution. A ran-domised controlled trial of displaced olecranon fractures in the over-75-years group found no difference in DASH scores at 6 weeks, 3 months, 6 months and 1-year post-injury between non-operative and operative management. There was an unacceptably high complication rate associated with surgery in this age group; therefore, in the elderly patient, particularly low demand olecranon fractures should be managed non-operatively regardless of displacement or comminution.

Duckworth AD et al. Prospective randomised trial of non-operative versus operative management of olecranon fractures in the elderly. *Bone Joint J*. 2017;**99-B**:964–972.

35. Answer C. **Radial head arthroplasty, coronoid open reduction internal fixation and lateral collateral ligament repair**
This injury refers to the terrible triad of elbow dislocation, coronoid fracture and radial head fracture. This injury is inherently unstable as there is loss of both the primary (ulnohumeral joint via the coronoid), medial and lateral collateral ligaments and secondary stabilisers (radiohumeral joint via radial head, flexor and extensor muscles). This is described as O'Driscoll's fortress. Therefore, such an injury mandates surgical intervention.

Operative fixation is complicated. A CT scan of the elbow should be performed to assess the suitability of radial and coronoid fractures for repair or replacement.

The sequence of events is to approach the radial head, which can be fixed or replaced depending on the comminution; fix the lateral collateral ligament (LUCL) using suture anchors or transosseous sutures and then check the stability. If unstable, the coronoid is repaired using either sutures, anchors or screws, depending on the size of the fragment and exposure. The fixation should be solid enough to allow an early range of movement without instability.

If the elbow is unstable after repair of the coronoid, radial head ORIF or replacement and LCL repair, then the MCL can be repaired. Some surgeons advocate prophylactic decompression of the ulnar nerve at this stage. The use of a hinged external fixator in persistent instability has been shown to improve outcome.

O'Driscoll JB, Jupiter JB, King GJ, Hotchkiss RN, Morrey BF. The unstable elbow. *Instr Course Lect.* 2001;**50**:89–102.

36. Answer B. **Open reduction and internal fixation**
Supraspinatus, infraspinatus and teres minor externally rotate the greater tuberosity. Indications for open reduction and internal fixation include displacement of the greater tuberosity of more than 5mm. Non-operative treatment is likely to cause impingement with abduction and also defunction the cuff. More complex fracture configurations are more likely to have complications with fixation. Reverse polarity total shoulder arthroplasty is indicated in lower-demand individuals or older patients with non-reconstructable tuberosities (as the cuff is effectively defunctioned). Younger patients with non-reconstructable configurations may favour hemiarthroplasty.

37. Answer A. **Dynamisation of the tibial nail**
The patient may go onto a hypertrophic non-union. The most appropriate option at this stage is to dynamise the nail, which may just tip the balance to allow the fracture to heal by reducing the gap at the fracture site.

In this situation, the interfragmentary strain (movement at the fracture site) is excessive; hence, there is no progression through the different stages of Perren's theory of secondary bone healing, and bony bridging by hard callus is not possible.

38. Answer E. **There is no difference between non-union rates**
There is often controversy over management of midshaft clavicle fractures. Numerous studies, including the Canadian Orthopaedic Trauma Society (COTS) trial, have shown higher union rates in displaced clavicle fractures with operative treatment. There is a quicker return to work and sport with operative treatment. In the short-term, clinical outcomes are better in operative cases but there is little evidence to suggest this is long term. Patients who undergo surgery may require implant removal at a later date due to irritation hence there is a higher re-operation rate.

Altamimi SA, McKee MD. Nonoperative treatment compared with plate fixation of displaced midshaft clavicular fractures: surgical technique. *J Bone Joint Surg Am*. 2008;**90**(Suppl. 2 pt 1):1–8.

39. Answer C. **During retraction of infraspinatus**
The Judet approach to the scapular involves the internervous plane between the suprascapular (infraspinatus) and axillary (teres minor) nerves. This patient presents with a suprascapular nerve palsy. This is most commonly caused during forceful retraction of the infraspinatus muscle.

Retracting the infraspinatus superiorly reduces the likelihood of this.

40. Answer E. **Pronator quadratus**
The injury displayed is an extension-type supracondylar fracture of the humerus. The anterior interosseus nerve, which is a branch of the median nerve, is most commonly injured with this type of fracture. It supplies pronator quadratus, flexor digitorum profundus (index and middle fingers) and flexor pollicis longus.

In terms of the other answers, extensor pollicis longus and abductor pollicis longus are supplied by the posterior interosseus nerve; 4th and 5th lumbricals and abductor digiti minimi are supplied by the ulnar nerve. The majority of supracondylar fracture nerve injuries are neurapraxias that resolve spontaneously.

41. Answer B. **CT scan of pelvis**
All hip dislocations should have a post-reduction CT scan. This is to evaluate the reduction and to ensure that there are no associated fractures or loose bodies and to assess for marginal impaction. The radiograph does show a small bony fragment projected over the femoral neck most likely representing the posterior lip of the acetabulum.

42. Answer E. **Time to surgery is the most important factor in influencing outcome**
Previously it was believed that time to surgery was the most important factor in preserving the blood supply following displaced intracapsular neck of femur fractures in young patients and thus operating within 6 h was recommended, but now it is recognised that the quality of the reduction (and thus an anatomical reduction is needed) is the most important factor in influencing outcome. Some surgeons will try and obtain an anatomical reduction using a Leadbetter manoeuvre, which can be remembered by the mnemonic **FATI CAR**: **F**lexion (to relax the muscles); **A**dduction (along with flexion 'books open' the fracture); **T**raction (to gain length); **I**nternal rotation (relaxes the Y ligament); **C**ircumduction; **A**bduction and **R**eduction check. This fracture often requires an open reduction (Smith–Petersen) approach, which relies upon an internervous plane between the femoral and superior gluteal nerves. The lateral femoral cutaneous nerve is most at risk in this approach.

43. Answer D. **On-table angiogram, temporary vascular shunt, skeletal stabilisation, definitive vascular reconstruction, forearm fasciotomies**
Imaging modalities should not delay reperfusion surgery. On-table angiogram is the most viable imaging option in this case. Reperfusion should be obtained with a temporary shunt, followed by skeletal stabilisation using an external fixator. Typically, the pins are put in before the shunt, but the external fixator is not applied until afterwards. Thereafter, definitive vascular reconstruction using autologous vein grafts can be performed. Following reperfusion, the surgeon should have a low threshold for performing fasciotomy as the rate of compartment syndrome secondary to reperfusion injury is high.

British Orthopaedic Association Standards for Trauma (BOAST 6). Management of arterial injuries associated with fractures and dislocations. https://www.boa.ac.uk/resource/boast-6-pdf.html.

44. Answer D. **Posterior wall**
This a straightforward, either-you-know-or-don't-know SBA that is testing anatomical interpretation of plain anteroposterior pelvis radiographs.

Line 1 indicates the anterior wall of the acetabulum.

Line 2 indicates the posterior wall of the acetabulum.

Line 3 indicates the weight-bearing dome.

Line 4 is the iliopectineal line and indicates structural integrity of the anterior column of acetabulum.

Line 5 is the ilioischial line and indicates integrity of the posterior column.

Line 6 is the teardrop, which indicates the acetabular true floor.

45. Answer A. **Hip abductors and iliopsoas**
The iliopsoas muscle causes the proximal fragment to flex, whereas the hip abductors cause the fragment to externally rotate (Figure 15.44). Distally, the hip adductors cause the distal fragment to medialise. This can make it difficult to

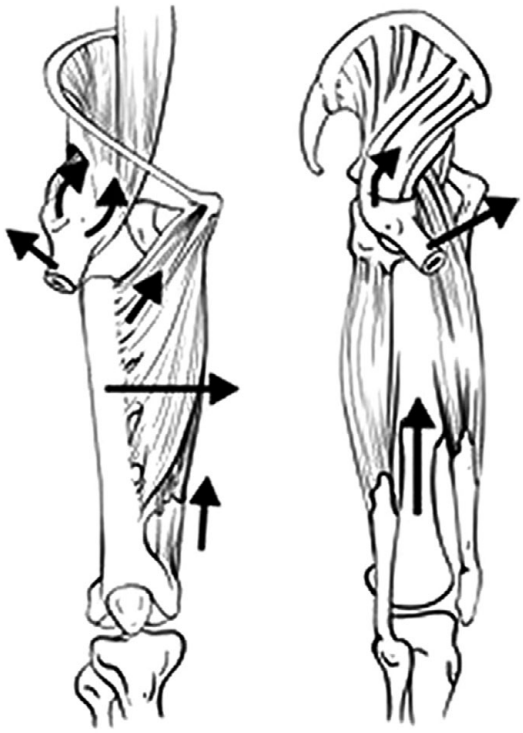


Figure 15.44 Deforming muscle forces on the proximal femur

get an anatomical reduction in these cases. As a result, the most common post-operative deformity is the procurvatum and varus.

46. Answer E. **<0.9**
Patients with an ABPI of <0.9 should be referred to vascular intervention for an urgent consultation and further imaging. In a study of 38 patients, 11 who had an ABPI of <0.9 all had an arterial injury requiring surgical treatment. The remaining 27 patients had an ABPI of 0.90 or higher and none had a vascular injury detectable by serial clinical examination or duplex ultrasonography.

Mills WJ, Barei DP. McNair P. The value of the ankle–brachial index for diagnosing arterial injury after knee dislocation: a prospective study. *J Trauma*. 2004;**56**:1261–1265.

47. Answer D. **Overgrowth**
Overgrowth is the most common complication following femoral shaft fracture in this age group. In children under 10 years old, it is common to have overgrowth of between 1.0 and 2.5cm, which occurs predominantly in the first 2 years after injury, and the parents should be counselled appropriately about this.

Wessel L, Seyfriedt C. Leg length inequality after childhood femoral fractures – permanent or temporary phenomenon? [Article in German] *Unfallchirurg*. 1996;**99**:275–282.

48. Answer A. **ORIF using cerclage wire and locking plate**
The Vancouver classification is useful in allowing an effective treatment algorithm following periprosthetic fracture. The B type is a fracture around the stem. If the implant is not loose (type B1), this can be treated by ORIF using cerclage wires and a locking plate.

If a cemented stem is loose but with good bone stock this can be managed with cerclarge cables and open reduction internal fixation provided the reduction is anatomical. Otherwise a long, porous-coated cementless stem is utilised. Generally patients in this cohort are frail with multiple comorbidities. Fixation over revision surgery is associated with a lower incidence of complications and should be the desired treatment in this patient group. With regards to uncemented stems, revision with a long, porous-coated cementless stem is recommended.

If there is poor bone stock (type B3), the femur is revised to either a long, porous-coated cementless stem with proximal femoral allograft or a proximal femoral replacement. It is sometimes difficult to fully differentiate between a B1and B2 fracture on plain radiographs and so further imaging with a CT scan may be helpful, although implant stability may only truly be appreciated during the time of surgery.

Powell-Bowns MFR et al. Vancouver B periprosthetic fractures involving the Exeter cemented stem. *Bone Joint J*. 2021;**103-B**:309–320.

49. Answer C. **III**
This SBA is good revision for the Advanced Trauma Life Support® (ATLS®) classification of shock (Table 15.1). Class III shock represents blood loss of 1500–2000ml (30–40% blood volume). Respiratory rate is >30 and urine output is 10–20ml/h. Values are represented in Table 15.1. There is no class V.

Table 15.1 ATLS® classification of shock

	Class I	Class II	Class III	Class IV
Blood loss (% volume loss)	<750ml (<15%)	750–1500ml (15–30%)	1500ml–2000ml (30–40%)	2000ml+ (>40%)
Pulse	<100	>100	>120	>140
Blood pressure	No change	Normal systolic BP, raised diastolic BP	Reduced	Reduced/ unrecordable
Pulse pressure	↔	↓	↓	↓
Respiratory rate	<20	>20	>30	>40
Urine output (ml/h)	↔	↔	↓	↓↓
GCS	↔	↔	↓	↓
Base deficit	0 to –2 mEq/L	–2 to –6 mEq/L	–6 to –10 mEq/L	–10 mEq/L or less
Need for blood products	Monitor	Possible	Yes	Massive Transfusion Protocol

50. Answer D. **Kocher-Langenbeck**

A gull sign is present on pelvic radiograph (Figure 15.45). This sign was first described in 1965 by Berkebile et al. (1965). It is used for variations of posterior column fractures where the posterior column displaces and takes the hind portion of acetabular roof; therefore, the posterior segment loses its normal relationship with the segment still attached to anterior column and forms 'an image like a gull in flight'. This sign is pathognomonic of posterior wall fractures of the acetabulum.

To confuse matters, another hip fracture that has been called the 'gull wing sign' is a medially displaced fracture of the acetabular roof where the medially displaced impacted fragment of the acetabulum and the lateral part together also form a seagull outline. This fracture is seen in elderly osteoporotic patients and is associated with a poor prognosis, with debate in the surgical literature discussing whether surgical fixation or total hip replacement is the appropriate choice of management

The posterior Kocher-Langenbeck approach is most suited to posterior-based fractures of the acetabulum. The iliofemoral approach allows visualisation of both columns, whereas the ilioinguinal approach is more suited to anterior wall and column fractures. The modified stoppa allows access to the quadrilateral plate.

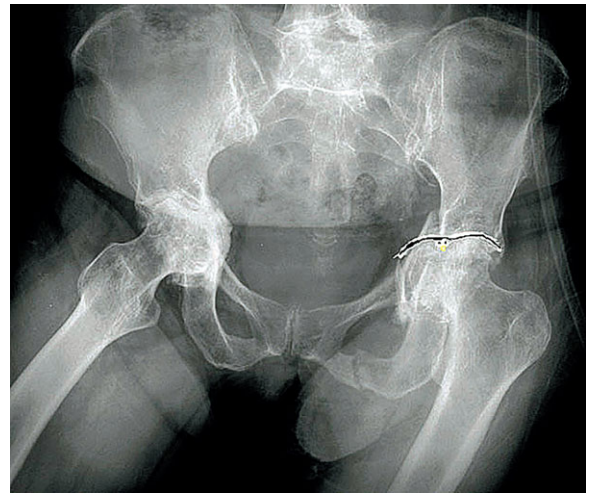


Figure 15.45 Gull sign

Berkebile RD, Fischer D, Albrecht LF. The Gull-wing sign. *Radiology* 1965;**84**:937–939.

Anglen JO, Burd TA, Hendricks KJ, Harrison P. The 'Gull sign': a harbinger of failure for internal fixation of geriatric acetabular fractures. *J Orthop Trauma.* 2003;**17**:625–634.

51. Answer A. **A wound size >10cm**

The BOAST (British Orthopaedic Standards for Trauma) 4 guidelines for management of open fractures state that there are four reasons for emergent operating in the middle of the night:

compartment syndrome, arterial injury requiring repair, gross contamination with marine or agricultural waste and polytrauma. Otherwise, these injuries should be treated in daylight hours by combined senior orthoplastics teams in conjunction.

BOAST 4: British Orthopaedic Association and British Association of Plastic, Reconstructive and Aesthetic Surgeons Audit Standards for Trauma: Open Fractures. https://www.boa.ac.uk/resource/boast-4-pdf.html.

52. Answer D. **Serum lactate**
The serum lactate is the most sensitive indicator of adequate perfusion. A normal value is <2.5mmol/L. According to Vallier et al. (2013), <4 can be used as an indicator of resuscitation.

Vallier HA, Wang X, Moore TA, Wilber JH, Como JJ. Timing of orthopaedic surgery in multiple trauma patients: development of a protocol for early appropriate care. *J Orthop Trauma.* 2013;**27**:543–551.

53. Answer D. **Increase the working length**
Rigidity refers to the resistance of a structure to deformation. There are a number of factors that can be used to increase rigidity, the most important of which is reducing the fracture. Pin factors include increasing the pin diameter and number of pins. Bar factors include cross-linking and reducing the distance between the bars and the skin. Working length refers to the distance between the pins either side of the fracture. Decreasing rather than increasing the working length increases rigidity.

54. Answer B. **Paraesthesia over the dorsum of the foot**
The L5 nerve root crosses the sacral ala. It is at risk if the sacroiliac screw is directed more than 20° laterally and penetrates the anterior cortex. For this reason, bicortical screw fixation is not recommended.

55. Answer D. **Treat PCL and PLC operatively within 2 weeks, ACL within 6 weeks and MCL conservatively in a brace**
Multi-ligament injuries are common after a knee dislocation and it is recommended that the PCL and PLC are operated within 2 weeks and ACL at 6 weeks once the swelling has subsided. The MCL can be treated conservatively in a brace

56. Answer B. **14**
The Injury Severity Score (ISS) is made up of the sum of the squares for the highest Abbreviated Injury Scale (AIS) grades in the three most severely injured regions. The ISS is based on scores of nine anatomical regions:
1. Head.
2. Face.
3. Neck.
4. Thorax.
5. Abdominal and pelvic region.
6. Spine.
7. Upper extremity.
8. Lower extremity.
9. External.

In this case the three highest scores are 3 (severe for lower extremity); 2 (moderate for chest injury); and 1 (mild for face). The squares are $3^2 + 2^2 + 1^2 = 9 + 4 + 1 = 14$

57. Answer C. **Supination adduction type 2**
Lauge-Hansen classification looks at the mechanism of injury and foot position at the time of injury. The radiograph in Figure 15.32 shows a supination adduction type 2 injury and must be treated with a buttress plate.

58. Answer C. **Severe soft tissue injury has the highest impact on a surgeon's decision making**
The Lower Extremity Assessment Project (LEAP) was a multicentre study of severe lower extremity trauma in the US civilian population. Severe soft tissue trauma has the highest impact on a surgeon's decision-making process and absence of plantar sensation has the second highest impact on a surgeon's decision making. Poor outcomes were found for both reconstruction and amputation groups. The most important factor in patient outcome is the ability to return to work.

MacKenzie EJ, Bosse MJ. Factors influencing outcome following limb-threatening lower limb trauma: lessons learned from the Lower Extremity Assessment Project (LEAP). *J Am Acad Orthop Surg.* 2006;**14**:S205S210.

59. Answer D. **The nail diameter should be 60% of the isthmus diameter**
Elastic nailing is used in children up to 50kg. The nails should be 40% the diameter of the isthmus, and the nails should be pre-bent to three times the diameter of the medullary canal. The apex of nail crossover should be at the fracture site, and the entry point of a retrograde femoral nail should be proximal to the physis.

60. Answer E. **Superficial peroneal nerve and tibial nerve**
The posterolateral approach utilises the internervous plane between the peroneal muscles (superficial peroneal nerve) and flexor hallucis longus (tibial nerve). The posterolateral approach can be performed in the lateral or prone position.

61. Answer A. **Primary ankle arthrodesis with hindfoot nail**
The patient is high risk of complications from surgery and is low demand. The operation is salvage surgery and to prevent amputation of her lower leg. The medial malleolus can be removed and her ankle joint prepared for fusion via her open ankle wound which is then closed. The hindfoot nail can be compressed to allow fusion in this instance (Figure 15.46).

Figure 15.46 Anteroposterior (AP) radiograph ankle and distal tibia following nailing

Fadhel WB et al. Outcomes after primary ankle arthrodesis in recent fractures of the distal end of the tibia in the elderly: a systematic review. *International Orthopaedics (SICOT)* 2022;**46**:1405–1412.

Chapter 15

Trauma I Structured SBA

Tim Brock and Rishi Dhir

TRAUMA I STRUCTURED SBA QUESTIONS

1. A 75-year-old female presents with a shoulder injury following a fall. Radiographs show a fractured proximal humerus (Figure 15.1).
   According to Hertel's study, which of the following is NOT a good predictor of humeral head ischaemia?
   A. Basic fracture pattern
   B. Calcar fragment <8mm
   C. Glenohumeral dislocation
   D. Integrity of the medial hinge
   E. Length of the metaphyseal head extension

2. A 35-year-old male sustains a closed proximal tibial fracture and elects to undergo intramedullary nailing. His radiographs are shown in Figure 15.2.
   Which of the following surgical techniques is used to prevent a valgus and procurvatum deformity?
   A. Place a coronal Poller (blocking) screw in the anterior half of the distal aspect of the proximal fragment
   B. Place a sagittal Poller (blocking) screw on the medial convex side of the distal aspect of the proximal fragment
   C. Suprapatellar nailing
   D. Use of a nail with a more distally based bend
   E. Using a more medial entry point

3. While playing rugby, a 30-year-old male sustained the injury seen in Figure 15.3, taken on presentation to the ED.
   Which of the following is true?
   A. If reduced and stable, it does not require extension splinting
   B. It can lead to a Swan neck deformity
   C. It has a positive Elson test
   D. It is associated with a volar plate injury
   E. It is the most common type of PIPJ dislocation

4. A 40-year-old roofer fell 10 feet off a ladder onto his left foot. Radiograph and CT scan are shown in Figure 15.4.
   Regarding this injury, which of the following is true?

(a)

(b)

Figure 15.1 (a) Anteroposterior (AP) and (b) lateral scapula view radiographs proximal humerus

(a)

(b)

Figure 15.2 (a) Anteroposterior (AP) and (b) lateral radiographs of the right tibia

Figure 15.3 Lateral radiograph finger

(a)

(b)

Figure 15.4 (a) Lateral radiograph calcaneum and (b) sagittal CT view calcaneum

A. A reduced angle of Gissane indicates collapse of the posterior facet
B. An enlarged Böhler's angle indicates collapse of the posterior facet
C. Sanders classification is based on the number of articular fragments on the sagittal CT image
D. The sustentaculum tali (anteromedial) fragment is referred to as the 'constant fragment'
E. Double density sign seen on lateral radiographs indicates a superiorly displaced calcaneus fracture/dislocation

5. **Regarding radiology for Lisfranc injuries, which of the following is false?**
   A. The 'fleck sign' is pathognomic and indicates avulsion of the Lisfranc ligament
   B. The 'step off sign' is caused by dorsal displacement of the 2nd metatarsal relative to the cuboid
   C. The gap between the 2nd metatarsal and medial cuneiform is <2mm
   D. The medial border of the cuboid should normally line up with the medial border of the 4th metatarsal on the oblique view
   E. The medial edge of the 2nd metatarsal should normally line up with the medial edge of the middle cuneiform on the AP radiograph

6. **Which of the following is incorrect concerning Lisfranc joint anatomy?**
   A. The 2nd tarsometatarsal joint produces the so-called 'keystone' in the 'Roman Arch'
   B. The dorsal ligaments are stronger than the plantar ligaments
   C. There is no intermetatarsal ligament between the 1st and 2nd metatarsals

D. The Lisfranc ligament runs from the first cuneiform to the medial base of the 2nd metatarsal
E. The Lisfranc joint is formed by the five metatarsals that articulate with the three cuneiform and cuboid bones

7. **Which mode of plating should be ideally used for the distal radius fracture pattern seen in Figure 15.5?**

Figure 15.5 Lateral radiograph distal radius

A. Buttress
B. Neutralisation
C. Bridging
D. Locking
E. Compression

8. **Which of the following techniques mainly produces healing by a high strain fracture environment?**

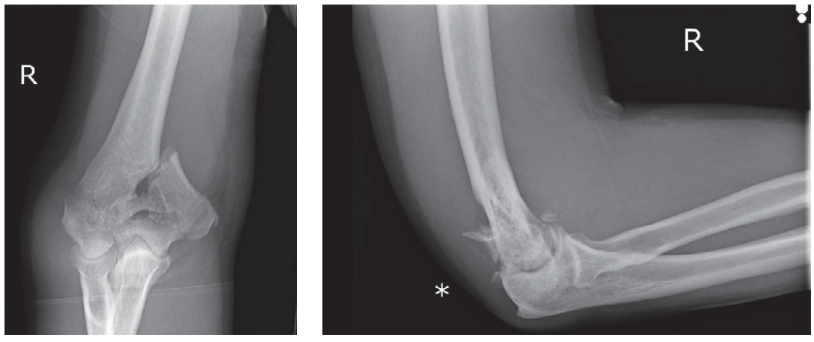
A. Overdrilling the near cortex to 3.5mm and the far cortex to 2.5mm in a Weber B ankle fracture
B. Using a partially threaded cancellous screw in a transverse medial malleolar fracture
C. Drilling an eccentric hole in an LCP plate
D. Using an articulated compression device
E. Using hybrid fixation for a periarticular fracture with metaphyseal comminution

9. **Regarding the injury shown in Figure 15.6, indications for urgent surgical treatment do NOT include which of the following?**

Figure 15.6 Lateral radiograph supracondylar fracture elbow

A. Absent radial pulse
B. Threatened skin viability
C. Capillary refill time of 5 seconds
D. Displacement greater than 100%
E. Pale hand

10. A 53-year-old male fell down 12 flights of steps onto his right elbow. His radiographs are shown in Figure 15.7.
Regarding his injury, which of the following is NOT a technical objective to achieve maximal fixation and stability?



(a) (b)

Figure 15.7 (a) Anteroposterior (AP) radiograph and (b) lateral radiographs fractured distal right humerus

A. Every screw in the distal fragments should pass through a plate
B. The screws in the distal fragments should lock together by interdigitation, creating a fixed-angle structure
C. Plates should be strong enough and stiff enough to resist breaking or bending
D. Each screw should be as long as possible
E. Lag screw to be used outside the plate to fix fracture fragments

11. A 24-year-old male sustains a type II odontoid fracture following a diving injury.
Regarding anterior pin placement for a Halo device, which of the following is true?
A. If the pins are placed more laterally, then there is a risk of injury to the orbicularis muscle
B. Should be placed 2cm above the lateral one-third of the eyebrow
C. Should be placed below the equator of the skull
D. Should be placed medial to the supraorbital nerve
E. The supraorbital nerve exits the skull at the level of the frontal sinus

12. A 26-year-old male patient fell directly on his right shoulder with the arm in an outstretched and overhead position. Pain and swelling were immediate and were associated with a 'step deformity'. The patient had limited right shoulder range of motion (ROM), strength and function.
Regarding this injury, which of the following statements is correct?
A. Type II injuries involve rupture of the AC ligament and a CC ligament sprain
B. Type III injuries involve posterior displacement of the lateral clavicle through the trapezius
C. Type IV injuries involve rupture of both AC and CC ligaments with increased CC distance of 25–100%
D. Type VI injuries involve increased CC distance from 100–300% of contralateral side
E. Type V injuries involve inferior dislocation of the lateral clavicle

13. A 20-year-old right-handed man sustained a displaced comminuted radial head fracture following a traffic accident.
Regarding fixation of radial head fractures, which of the following is correct?
A. Kocher's approach is in the interval between triceps and brachioradialis
B. PIN palsy causes weakness of wrist extension and abduction
C. Supination should be performed to protect the posterior interosseus nerve
D. The capsule should not be dissected too far posteriorly, as the PIN runs over the back of the posterolateral portion of the elbow capsule
E. The safe zone of fixation is between the radial styloid and Lister's tubercle

14. A 30-year-old patient falls off his motorbike and sustains the injury shown in Figure 15.8. He has a blood pressure of 90/60 and pulse of 110 on arrival in ED.

Figure 15.8 Anteroposterior (AP) radiograph pelvis

Which of the following would initial management NOT include?
A. Administer tranexamic acid
B. Apply an external fixator
C. Apply a pelvic binder
D. Give FFP and cryoprecipitate
E. Initiate a massive transfusion protocol

15. A 45-year-old woman has sustained a talar neck fracture following a motor vehicle accident. She has been added to the trauma list for ORIF. The CT1 on call at the time of admission has read up that the possibility of AVN developing in this fracture is high.

The blood supply to the talar neck does NOT include which of the following?

A. Anterior tibial artery
B. Artery to tarsal canal
C. Deltoid branches
D. Lateral plantar artery
E. Peroneal artery

16. A toddler was brought to the ED with irritability.
In an investigation of non-accidental injury, which of the following has a high specificity for NAI?

A. Complex skull fractures
B. Digital fractures
C. Femoral fracture in an ambulatory child
D. Metaphyseal fracture (junction of metaphysis and physis)
E. Vertebral body fractures

17. A 30-year-old, right hand-dominant man sustained an isolated injury to the right wrist after a fall from a height of approximately 15 feet. The patient reported that he fell on his outstretched hand with the wrist in extension. The right wrist was painful, swollen and tender to palpation. The hand was neurovascularly intact with no sensory deficit in the distribution of the median nerve. His radiographs are shown in Figure 15.9.
In the pathoanatomy of the injury, which of the following lists the events in the correct order?

A. Failure of lunocapitate ligament – failure of scapholunate ligament – failure of lunotriquetral ligament – lunate dislocates into carpal tunnel
B. Failure of lunotriquetral ligament – failure of lunocapitate ligament – failure of scapholunate ligament – lunate dislocates into carpal tunnel
C. Failure of lunotriquetral ligament – failure of scapholunate ligament – failure of lunocapitate ligament – lunate dislocates into carpal tunnel
D. Failure of scapholunate ligament – failure of lunocapitate ligament – failure of lunotriquetral ligament – lunate dislocates into carpal tunnel
E. Failure of scapholunate ligament – failure of lunotriquetral ligament- failure of lunocapitate ligament – lunate dislocates into carpal tunnel

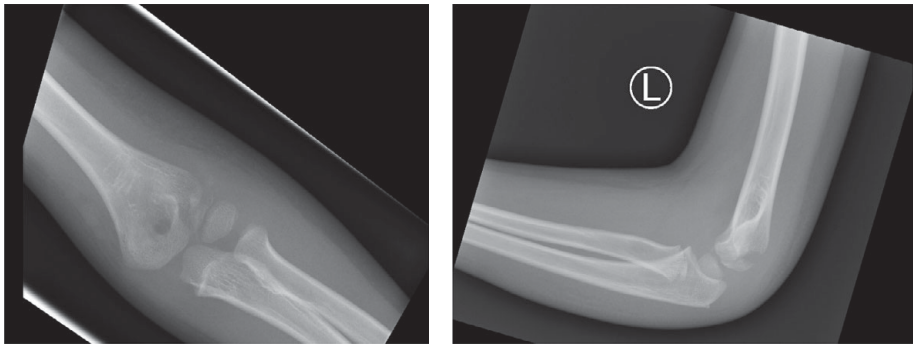
18. An 18-year-old tennis player attended the orthopaedic clinic complaining of radial-sided wrist pain after a fall on an outstretched hand. Radiographs have shown a displaced waist of scaphoid fracture.
Regarding the volar approach to the scaphoid, which of the following statement is false?

A. It is indicated in distal pole fractures
B. It is indicated in humpback flexion deformities
C. It is indicated in proximal pole fractures
D. It is indicated in waist fractures
E. It utilises the interval between FCR and the radial artery


(a)


(b)

Figure 15.9 (a) Anteroposterior (AP) and (b) lateral radiographs right wrist



(a) (b)

Figure 15.10 (a) Anteroposterior (AP) and (b) lateral radiograph child's elbow

19. **Which of the following is NOT a content of the anterior compartment of the leg?**
    - A. Extensor digitorum longus
    - B. Extensor hallucis longus
    - C. Peroneus longus
    - D. Peroneus tertius
    - E. Tibialis anterior

20. A 6-year-old boy falls off a trampoline onto his left elbow and sustains the injury noted on radiographs shown in Figure 15.10.
    Regarding the elbow fracture, which of the following statements is correct?
    - A. May be associated with wasting of the first dorsal interosseus
    - B. Minimally displaced fractures (<2mm gap) should be treated with open reduction internal fixation
    - C. The external oblique view is the most accurate view to show fracture displacement
    - D. The fracture fragment most often lies anterolateral
    - E. When fixed with K-wires, 2mm K-wires should be used

21. A 46-year-old motorcyclist sustains an isolated closed injury (Figure 15.11) after falling off his motorbike at high speed.
    Regarding the initial management of this injury, which of the following is correct?
    - A. Intramedullary nailing has better disability ratings at 6 months
    - B. Intramedullary nailing is more cost-effective compared with locking plates

Figure 15.11
Anteroposterior (AP) and lateral radiographs tibia

    - C. Recovery rates for IM nailing and locking plates are equivalent
    - D. There is a statistically higher infection rate when using locking plates compared with intramedullary nailing
    - E. There is no difference in further surgery between IM nailing and locking plates

22. **Principles of elastic (TENS) nails include all of the following except which?**
    - A. They can be used for comminuted forearm fractures
    - B. Nail diameter should be no more than 40% of the isthmus of the medullary canal
    - C. They should be pre-bent to three times the diameter of the isthmus

D. The apex of the bow of the elastic nail should be at the level of the fracture
E. The entry point for the nail should be 2.5–3cm proximal to the physis

23. **Which of the following increases the pull-out strength of a screw in bone?**
A. Decrease the cortex thickness
B. Decrease the outer diameter
C. Decrease the thread density (increased distance between threads)
D. Increase the inner diameter
E. Increase the outer diameter

24. **Undisplaced distal radius fractures are most associated with the rupture of which structure?**
A. Extensor digitorum communis
B. Extensor indicis proprius
C. Extensor pollicis longus
D. Flexor pollicis brevis
E. Flexor pollicis longus

25. A 30-year-old patient sustains an epileptic fit and attends the ED complaining of severe right shoulder pain. An anteroposterior (AP) shoulder radiograph is shown in Figure 15.12. It is irreducible in the ED.

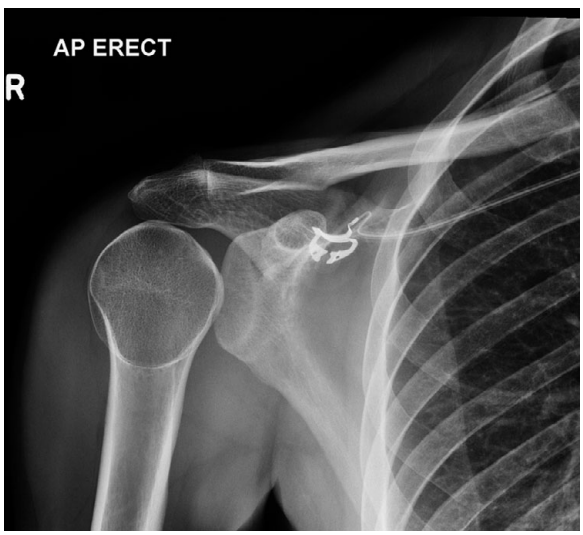


Figure 15.12 Anteroposterior (AP) radiograph right shoulder

Which of the following is NOT a recommended treatment option?
A. Femoral head allograft reconstruction
B. Reverse shoulder arthroplasty
C. Rotational osteotomy
D. Subscapularis transfer +/– lesser tuberosity
E. Emergency closed reduction under GA

26. A 35-year-old man is found 6 hours after sustaining a comminuted fracture of his right tibia secondary to a high-velocity gunshot wound. He has a systolic BP of 90 but responds well to fluids. He has a weak dorsalis pedis pulse but good capillary refill.
What is his MESS value?
A. 5
B. 6
C. 7
D. 8
E. 9

27. **Paediatric fractures occur through which layer of the physis?**
A. Maturation zone
B. Primary spongiosa
C. Proliferative zone
D. Reserve zone
E. Zone of provisional calcification

28. A 25-year-old male was resuscitated after coming off a motorbike at 50mph. He sustained an open humerus fracture, femur and tibia fracture and spinal fracture. His ISS score was 20. After he was resuscitated initially, the trauma team wanted to plan for fixation of his injuries.
In the Early Appropriate Care (EAC) protocol which of the following is incorrect regarding fracture fixation?
A. Base excess should be >5.5mmol/L
B. Definitive fixation should be performed within 36 h of injury
C. Lactate should be <4mmol/L
D. Patients should respond to resuscitation with pressor support
E. pH should be >7.25

29. A 74-year-old man falls downstairs while intoxicated and attends ED complaining of neck pain. Plain lateral radiograph cervical spine is shown in Figure 15.13. He is awake and alert.
Which of the following is the most appropriate initial management following resuscitation?
A. Closed reduction in Gardner–Wells tongs with serial traction

Figure 15.13 Lateral radiograph cervical spine

B. Immediate anterior discectomy and fusion
C. Halo application
D. MRI and urgent neurosurgical consult
E. Immediate posterior discectomy and fusion

30. An 80-year-old male presented to the ED with neck pain following a mechanical fall at home. Coronal CT image cervical spin is shown in Figure 15.14.

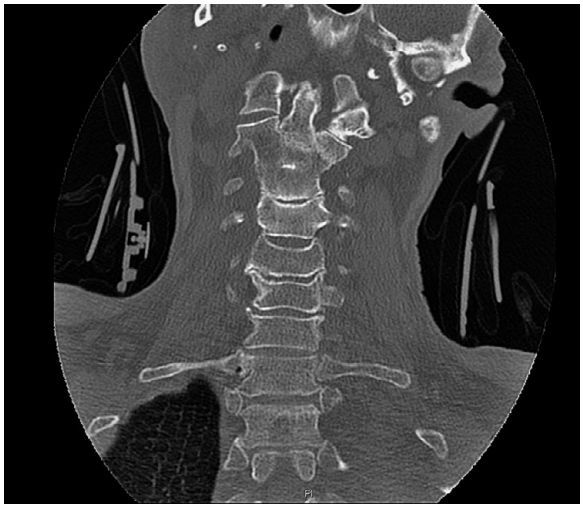


Figure 15.14 Coronal CT scan cervical spine

Which of the following statements is false in elderly patients with this injury pattern?

A. Anterior screw fixation is indicated with transverse or posterior oblique fracture lines
B. Posterior fusion has higher union rates than anterior fixation in type II fractures
C. Surgical stabilisation of type II fractures improves survival compared with non-surgical treatment in elderly patients (65–85 years)
D. The complication rate of non-surgical and surgical treatment of type II fractures in the elderly is higher
E. Type II fractures sit in a watershed area and have a greater risk of non-union

31. A 35-year-old male came off a motorbike. Following resuscitation, he complained of weakness in both legs and lower back pain. Clinical examination revealed bruising and swelling over his lumbar spine with M3 power in both legs and bilateral paraesthesia. Sagittal CT imaging is shown in Figure 15.15.

Figure 15.15 Sagittal CT image lumbar spine

What is the most appropriate management following initial resuscitation?

A. Mobilise with a spinal brace with flexion and extension views at 6 weeks
B. Mobilise with physiotherapy with no brace with flexion and extension views at 6 weeks
C. Prolonged bed rest with full spinal precautions
D. Surgical decompression
E. Surgical stabilisation


(a)


(b)

Figure 15.16 (a) Anteroposterior (AP) radiograph right humerus and (b) clinical photograph upper limb

32. A 33-year-old male falls down a flight of stairs, sustaining an injury to his right upper arm. Anteroposterior (AP) radiograph is shown in Figure 15.16(a) and clinical photograph is shown in Figure 15.16(b). The injury is isolated. On clinical examination, he is unable to dorsiflex his wrist and extend his fingers at the MCPJs.

The most appropriate next step in management would be which of the following?

A. Coaptation splint followed by functional brace
B. Humeral nailing
C. Open reduction, internal fixation and exploration of the median nerve
D. Open reduction, internal fixation and exploration of the radial nerve
E. Urgent nerve conduction studies and MRI upper limb

33. A 41-year-old woman undergoes a radial head fixation for a Mason II radial head fracture. The Kaplan approach is used.

Post-operatively, what complication is most likely?

A. Inability to abduct the fingers
B. Inability to extend the wrist in radial deviation
C. Inability to extend the wrist in ulnar deviation
D. Inability to flex the wrist in radial deviation
E. Inability to flex the wrist in ulnar deviation

34. A 77-year-old woman resident of a nursing home with limited functional ability falls onto concrete sustaining a closed injury. She has radiographs performed, which confirm the injury (Figure 15.17).

Figure 15.17 Lateral radiograph elbow

What is the most appropriate management option?

A. Total elbow replacement
B. Tension-band wiring of the olecranon
C. Conservative treatment
D. Open reduction, internal fixation with locking plate
E. Excision and triceps advancement

35. A 31-year-old man falls off his motorbike. sustaining the isolated injury shown in Figure 15.18. He is neurovascularly intact and is initially resuscitated in the ED.

What is the most appropriate definitive management?

A. Closed reduction, examination under anaesthetic and early range of motion
B. Radial head arthroplasty and coronoid open reduction internal fixation

Figure 15.18 Lateral radiograph elbow

C. Radial head arthroplasty, coronoid open reduction internal fixation and lateral collateral ligament repair
D. Radial head fixation and coronoid open reduction internal fixation
E. Radial head fixation, coronoid open reduction internal fixation and medial collateral ligament repair

36. A 63-year-old golfer falls awkwardly onto his left shoulder. He is neurovascularly intact. Anteroposterior (AP) radiograph demonstrates a three-part fracture of the proximal humerus involving the surgical neck and the greater tuberosity (Figure 15.19). There is posterior and superior displacement of the greater tuberosity by 1cm.

Figure 15.19 Anteroposterior radiograph (AP) shoulder

What is the most appropriate treatment?
A. Hemiarthroplasty
B. Open reduction and internal fixation
C. Reverse polarity total shoulder arthroplasty
D. Sling immobilisation and early mobilisation
E. Total shoulder replacement

37. A 39-year-old motorcyclist presents with continuing residue discomfort 4 months after intramedullary nailing of a midshaft tibial fracture. Inflammatory markers are normal. Radiographs are shown in Figure 15.20.

Figure 15.20 (a) Anteroposterior (AP) and (b) lateral radiographs right tibia

What is the next appropriate treatment?
A. Dynamisation of the tibial nail
B. Exchange tibial nailing
C. Functional bracing and observation
D. Low-intensity pulsed ultrasound
E. Nail removal and open reduction internal fixation

38. A 26-year-old cyclist falls over his handlebars at high speed. Following initial resuscitation, he is found to have the injury shown in Figure 15.21.
In the consent process, what statement is incorrect with regard to non-operative versus operative management?
A. Return to sport is quicker with operative management
B. There is a higher re-operative rate with operative management

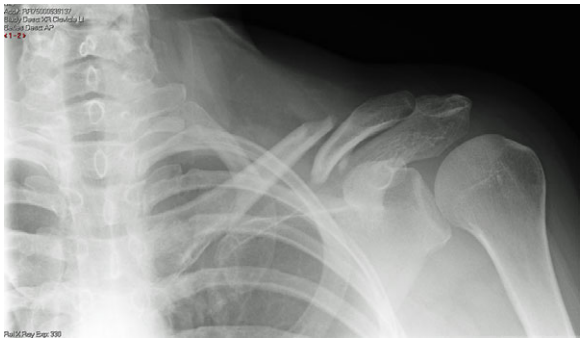


Figure 15.21 Lateral radiograph clavicle

C. There is a higher symptomatic mal-union rate in non-operative management
D. There is better short-term function with operative management
E. There is no difference between non-union rates

39. A 26-year-old undergoes scapula fixation following polytrauma via a Judet approach. He awakes with deep posterior shoulder pain and weakness with abduction.

During the approach, where is the nerve most likely to be damaged?

A. By inadvertently dissecting inferior to teres minor
B. During exposure of the posterior deltoid muscle belly
C. During retraction of infraspinatus
D. During retraction of teres minor
E. Inadvertently dissecting out the quadrangular space

40. A 7-year-old girl falls off a climbing frame, sustaining the injury shown in Figure 15.22. She sustains a neurological injury.

Figure 15.22 Lateral radiograph elbow

Based on her injury, what muscle(s) are most likely to be deficient?

A. 4th and 5th lumbricals
B. Abductor digiti minimi
C. Abductor pollicis longus
D. Extensor pollicis longus
E. Pronator quadratus

41. A 16-year-old male sustains the injury to his hip shown in Figure 15.23 following a motor vehicle accident. There is no neurovascular deficit and no other associated injuries. The on-call registrar is able to reduce the hip in the ED under sedation.

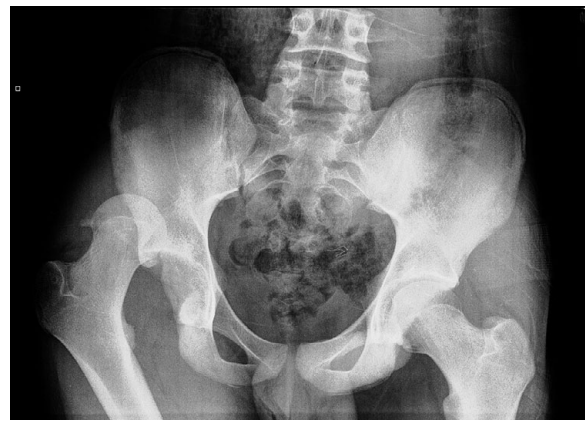


Figure 15.23 Anteroposterior (AP) radiograph hip

What is the next step in management?

A. Abduction brace
B. CT scan of pelvis
C. MRI scan of pelvis
D. Protected weight bearing
E. Skeletal traction

42. A 23-year-old man is brought into ED after a fall from a height of 6 feet. Following resuscitation, an anteroposterior (AP) radiograph demonstrates an isolated closed injury (Figure 15.24).

Which of the following is false in the management of this injury?

A. A Leadbetter manoeuvre may be performed to aid reduction
B. Open reduction relies on an internervous plane between the superior gluteal and femoral nerves
C. Quality of reduction is the most important factor in influencing outcome

Figure 15.24 Anteroposterior radiograph (AP) left hip

D. The lateral femoral cutaneous nerve is at risk during the approach
E. Time to surgery is the most important factor in influencing outcome

43. A 23-year-old footballer sustains a fracture-dislocation of his elbow (Figure 15.25). He has a pulseless white hand, despite reduction of the elbow in the ED. There are no imaging modalities available overnight, but the vascular team are present, and he is taken urgently to theatre.

Figure 15.25 Lateral radiograph elbow

What is the appropriate sequence in theatre?
A. On-table angiogram, definitive vascular reconstruction, skeletal stabilisation
B. On-table angiogram, skeletal stabilisation, definitive vascular reconstruction, forearm fasciotomies
C. On-table angiogram, temporary vascular shunt, definitive vascular reconstruction, skeletal stabilisation, forearm fasciotomies
D. On-table angiogram, temporary vascular shunt, skeletal stabilisation, definitive vascular reconstruction, forearm fasciotomies
E. On-table angiogram, temporary vascular shunt, skeletal stabilisation, definitive vascular reconstruction

44. **Line 5 in this radiograph of the left hemipelvis (Figure 15.26) indicates which of the following structures?**

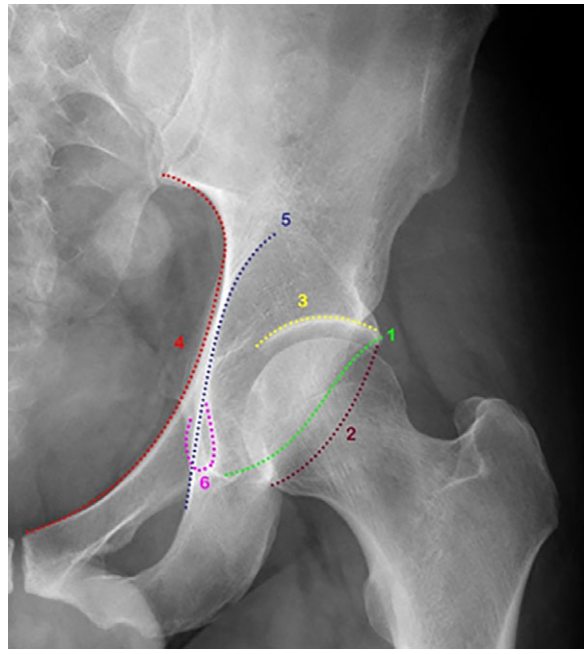


Figure 15.26 Anteroposterior (AP) pelvis radiograph

A. Acetabular true floor
B. Anterior column
C. Posterior column
D. Posterior wall
E. Weight bearing dome

45. An 80-year-old male falls at home and presents to the ED with a subtrochanteric hip fracture (Figure 15.27). He has been scheduled on the trauma list for an antegrade cephalomedullary nail.
Regarding the proximal bone fragment, what muscles are responsible for the ensuing

Figure 15.27 Anteroposterior (AP) radiograph hip

deformity of procurvatum (apex anterior) and varus?

A. Hip abductors and iliopsoas
B. Hip adductors and hamstrings
C. Iliopsoas and hamstrings
D. Iliopsoas and hip adductors
E. Quadriceps and short external rotators

46. Regarding traumatic knee dislocation, the ankle–brachial pressure index is a useful tool for assessing for an associated vascular injury.
What figure is associated with a vascular injury and warrants urgent arteriography?

A. <0.5
B. <0.6
C. <0.7
D. <0.8
E. <0.9

47. You see an 8-year-old in ED with the injury demonstrated in the radiograph in Figure 15.28.
When explaining the management plan to the parents, what is the most common complication that you should inform them of, regardless of your treatment modality?

A. Avascular necrosis
B. Knee stiffness
C. Non-union
D. Overgrowth
E. Refracture

48. An 84-year-old man has a fall and sustains the injury shown in Figure 15.29. Intraoperatively you notice the cement mantle is well fixed and overall the bone appears to be of good quality.

Figure 15.28 Lateral radiograph femur

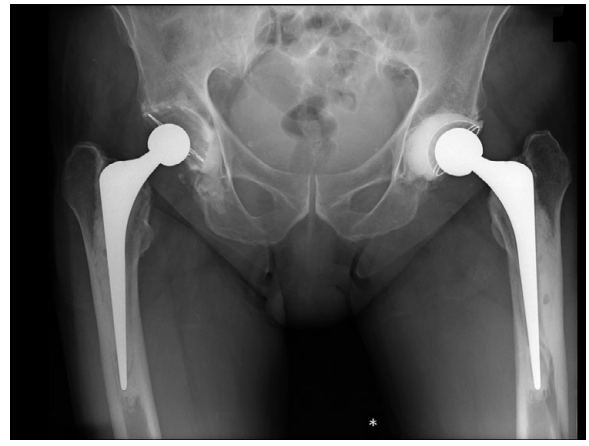


Figure 15.29 Anteroposterior (AP) radiograph left hip

What is the most appropriate treatment option?

A. ORIF using cerclage wire and locking plate
B. Proximal femoral replacement
C. Revision of cemented component to long cemented taper slip stem
D. Revision of cemented component to long porous-coated cementless stem and femoral allograft
E. Revision of cemented component to long porous-coated cementless stem and fixation of fracture

49. A 17-year-old falls 20 feet from a building. On arrival to the ED, he has a pulse of 125, blood

pressure of 70/40 and he is acting aggressively towards the staff.

What class of hypovolaemic shock is he in?

A. I
B. II
C. III
D. IV
E. V

50. A 57-year-old falls down the stairs intoxicated. On his pelvic radiographs, there is impaction of the superomedial roof of the left acetabulum (Figure 15.30).

Figure 15.30 Anteroposterior (AP) radiograph pelvis

What surgical approach is most appropriate?

A. Extended iliofemoral
B. Hardinge
C. Ilioinguinal
D. Kocher–Langenbeck
E. Modified Stoppa

51. A footballer attends the ED at 23.00h, having sustained an open tibial fracture (Figure 15.31) that evening during a football match after a tackle.

Which of the following is not a reason for an emergency operation in the middle of the night?

A. A wound size >10cm
B. Arterial injury which needs to be repaired
C. Compartment syndrome
D. Contamination with farmyard manure
E. He is going to theatre for a laparotomy and treatment of multiple other injuries

Figure 15.31 Open tibial fracture

52. A 27-year-old man falls from his motorbike. He has an open olecranon fracture and fractures of his hip, femur and tibia. He has a significant chest injury with pulmonary contusions and associated rib fractures.

What is the most sensitive indicator to determine whether he is adequately resuscitated?

A. Blood pressure
B. Gastric mucosal pH
C. Pulse rate
D. Serum lactate
E. Urine output

53. You are asked to put on an external fixator for a fracture dislocation of the ankle, which is very unstable with excessive swelling.

Which of these cannot be used to increase rigidity of your construct?

A. Decrease the distance between the bars and the skin
B. Increase pin diameter
C. Increase the number of multiplanar cross-links
D. Increase the working length
E. Reduce the fracture

54. A patient undergoes sacroiliac joint fixation with percutaneous screws for a lateral compression fracture. It was noted on the post-operative radiographs that one of the screws has penetrated the anterior cortex.

What symptom may the patient experience?

A. Bladder dysfunction
B. Paraesthesia over the dorsum of the foot
C. Paraesthesia over the popliteal fossa
D. Weakness with ankle plantar flexion
E. Weakness with quadriceps extension

55. Following a dislocated native knee joint, a 22-year-old male has an MRI that confirms a multi-ligament knee injury comprising the ACL, PCL, posterolateral corner and MCL.

Which of the following is true?

A. Treat ACL and PCL within 2 weeks and PLC and MCL operatively at 6 weeks
B. Treat ACL operatively within 2 weeks, PCL and PLC within 6 weeks and MCL conservatively in a brace
C. Treat ACL, PCL and PLC at 6 weeks once the swelling has subsided and MCL conservatively
D. Treat PCL and PLC operatively within 2 weeks, ACL within 6 weeks and MCL conservatively in a brace
E. Treat PCL and PLC operatively within 2 weeks, MCL within 6 weeks and ACL at 3 months

56. A 35-year-old male involved in a motorcycle versus car accident is brought into the resuscitation department with the following injuries after initial resuscitation: a 10cm open fracture of the tibia (which is severe but stable); moderate chest injury; minor facial injuries; and a minor head injury.

What is the Injury Severity Score?

A. 11
B. 14
C. 17
D. 18
E. 24

57. A 41-year-old male presents to the ED following a twisting left ankle injury. Anteroposterior (AP) ankle radiograph is shown in Figure 15.32.

Figure 15.32 Anteroposterior (AP) radiograph left ankle

According to the Lauge–Hansen classification for ankle fractures, how can the injury can be classified?

A. Pronation abduction
B. Pronation external rotation
C. Supination adduction type 2
D. Supination external rotation type 4
E. Supination external rotation type 4

58. **Regarding the LEAP study (Lower Extremity Assessment Project), which of the following is true?**

A. Absence of plantar sensation has the highest impact on a surgeon's decision-making process
B. Good outcomes were found for both reconstruction and amputation groups
C. Severe soft tissue injury has the highest impact on a surgeon's decision making
D. The least important factor in patient outcome is the ability to return to work
E. There is a significant improvement in return to work in reconstruction compared with amputation at 2 years

59. **Regarding principles of elastic nailing, which of the following is false?**

A. The apex of the nail crossover should be at the fracture site
B. The diameter of the nail should be 40% of the isthmus diameter
C. The entry point of a retrograde femoral elastic nail should be proximal to the physis

D. The nail diameter should be 60% of the isthmus diameter
E. The nails should be pre-bent to three times the diameter of the medullary canal

60. A 27-year-old man falls down three stairs whilst carrying some boxes. His ankle radiographs and CT images are shown in Figure 15.33.

Figure 15.33 Lateral radiograph ankle

In terms of surgical approach, which internervous plane is utilised for fixation?
A. Sural nerve and tibial nerve
B. Deep peroneal nerve and sural nerve
C. Superficial peroneal nerve and sural nerve
D. Saphenous nerve and tibial nerve
E. Superficial peroneal nerve and tibial nerve

61. A morbidly obese, diabetic patient with neuropathy falls when mobilising from her bed to the toilet. She normally walks with a frame. Her X-rays are shown in Figure 15.34. She has a large open medial wound that will close primarily.
What is the most appropriate method of management?
A. Primary ankle arthrodesis with hindfoot nail
B. Fibula nail
C. Open reduction fixation of ankle
D. External fixation
E. MUA and total contact cast

(a) (b)

Figure 15.34 (a) Anteroposterior (AP) and (b) lateral radiographs ankle

TRAUMA I STRUCTURED SBA ANSWERS

1. Answer C. **Glenohumeral dislocation**
Hertel et al.'s (2004) seminal paper evaluated predictors of humeral head ischaemia after intracapsular humerus fractures by drilling a borehole into the central part of the humeral head intraoperatively and observing backflow and measuring laser Doppler flowmetry.

They demonstrated the significance of metaphyseal head extension. Metaphyseal head extension is a radiographic measurement of the articular fragment from the head–neck junction to the inferior extent of the medial cortex.

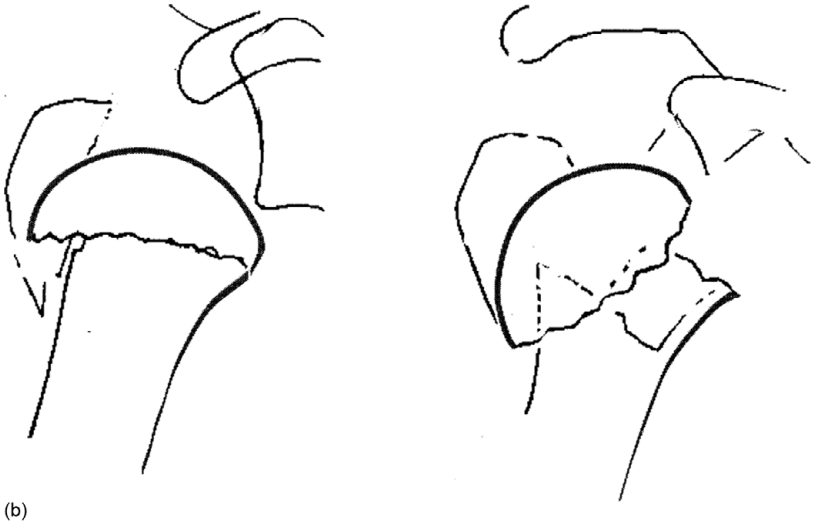
Good predictors of ischaemia were the length of the metaphyseal head extension (with a calcar fragment <8mm); the integrity of the medial hinge and certain basic fracture patterns (anatomical neck).

Poor predictors of ischaemia included glenohumeral dislocation, tuberosity displacement, angular displacement of the head and fractures consisting of three and four fragments (Figure 15.35 (a) and (b)).

Hertel R et al. Predictors of humeral head ischaemia after intracapsular fracture of the proximal humerus. *J Shoulder Elbow Surg.* 2004;**13**:427–433.

2. Answer C. **Suprapatellar nailing**
Proximal tibial fractures can be very challenging to treat with an intramedullary nail because of the tendency of the proximal fragment to extend (procurvatum) due to the patellar tendon, and distal

Figure 15.35(a) Metaphyseal head extension is a radiographic measurement of the articular fragment from the head–neck junction to the inferior extent of the medial cortex



(b)

Figure 15.35(b) Integrity of the hinge is a predictor of both ischaemia and practical feasibility of reduction

fragment, flex due to the hamstrings and possible valgus deformity. This particularly occurs during hyperflexion when using an infrapatellar nail to get the entry point. Therefore, using a semi-extended position, which a suprapatellar nail affords, helps to avoid this. Poller (blocking) screws can be used to block the pathway of the nail and guide it down a more 'favourable' route. In this case, a sagittal lateral blocking screw and coronal posterior blocking screw would guide the nail into a preferential anterior and lateral position in the metaphysis. Unicortical one-third tubular plates can be used as a temporising measure while making the entry point and passing the guide wire to reduce the fracture and prevent the procurvatum deformity. Finally, a more lateral entry point should be used to decrease the valgus deformity. A medial entry point would increase the valgus deformity.

Fractures that are proximal to nail bend will cause the proximal fracture fragment to translate anteriorly up to 1cm. It has been noted that the proximal bend in a nail acts as a wedge that displaces the proximal fragment anteriorly as the nail is driven distally. The use of a nail with a more proximally based bend has less of a wedging effect.

Hak DJ. Intramedullary nailing of proximal third tibial fractures: techniques to improve reduction. *Orthopedics* 2011;**34**:532–535.

3. Answer C. **It has a positive Elson test**
This is a radiograph of a volar PIPJ dislocation. It is the less common type of PIPJ dislocation (the most common being dorsal). It is associated with a central slip injury and therefore has a positive Elson test and causes a boutonnière deformity. By definition, it is an unstable injury and must be treated in a PIPJ hyperextension splint. A dorsal PIPJ dislocation is associated with a volar plate injury and causes a Swan neck deformity. It can be mobilised immediately if stable after reduction.

4. Answer D. **The sustentaculum tali (anteromedial) fragment is referred to as the 'constant fragment'**
Calcaneus fractures are the most common tarsal bone fracture and often have associated injuries including open fractures (17%), vertebral fractures, especially L1 (10%), and contralateral calcaneus fractures (10%).

The most important facet is the posterior facet (main weight-bearing facet). An increasing crucial angle of Gissane (normally 120–145°) or reduced Böhler's angle (normally 20–40°) indicates collapse of the posterior facet. The anteromedial fragment is known as the sustentaculum tali ('shelf of talus') and is known as the 'constant fragment' as it remains fixed or 'constant' due to the medial talocalcaneal and interosseus ligaments.

Classifications include Essex–Lopresti and Sanders, which is based on the number of articular fragments on a coronal CT image at the widest point of the posterior facet.

In most calcaneal fractures, the double density is the result of a depressed lateral fragment relative to the constant sustentaculum within the contour of the calcaneal body. With the 'locked-lateral' fracture dislocation variant, the lateral fragment is due to the superior dislocation of the fracture fragment, which is visible as a second density located superior to the sustentaculum overlapping with the talus.

Schepers T, Backes M, Schep NW, Goslings JC, Luitse JS. Functional outcome following a locked fracture-dislocation of the calcaneus. *Int Orthop*. 2013;**37**:1833–1838.

Rider CM, Olinger CR, Szatkowski JP, Richardson DR. 'Locked-lateral' calcaneal fracture-dislocation treated with primary subtalar fusion: a case report. *JBJS Case Connector* 2020;**10**: e0467.

5. Answer B. **The 'step off sign' is caused by dorsal displacement of the 2nd metatarsal relative to the cuboid**
Radiology for suspected Lisfranc injuries should include AP, lateral and oblique radiographs. On the AP view, we should see a 'fleck sign', which indicates avulsion of the Lisfranc ligament and is often pathognomic for Lisfranc injuries. The medial border of the 2nd metatarsal should normally line up with the medial border of the middle cuneiform on the AP view (Figure 15.36). On the oblique view, the medial border of the 4th metatarsal should normally line up with the medial border of the cuboid. On the lateral view, we should check for dorsal/plantar displacement of the metatarsals.

Figure 15.36 Anteroposterior foot X-ray demonstrating Lisfranc injury (the medial border of the 2nd metatarsal does not line up with that of the middle cuneiform)

Figure 15.37 Buttress plating in a volar Barton's fracture

The 'step off sign' is caused by dorsal displacement of the 2nd metatarsal relative to the medial cuneiform seen on a lateral weight bearing film.

6. Answer B. **The dorsal ligaments are stronger than the plantar ligaments**
The Lisfranc joint consists of the five metatarsals that articulate with the three cuneiforms and cuboid bones.

Bony stability is determined by the trapezoidal shape of the base of the first three metatarsals, with their respective cuneiform bones, forming a stable arch known as a 'Roman Arch' with the second TMTJ as the 'keystone'.

Ligamentous stabilisers include the dorsal and plantar TMT ligaments that cross each TMT joint, and the dorsal ligaments are weaker; hence, displacement is often dorsal.

Intermetatarsal ligaments join the 2nd to the 5th metatarsals, but there is no intermetatarsal ligament between the 1st and 2nd metatarsal.

Moracia-Ochagavia I, Rodriguez Merchan E. Lisfranc fracture-dislocations: current management. *EFORT Open Rev*. 2019;**4**:430–444.

7. Answer A. **Buttress**
A volar Barton's fracture is an example of a shear fracture treated by a buttress (anti-glide) plate, which works by trapping the apex of the fracture (Figure 15.37).

A compression plate is used, for example, in a forearm fracture, producing absolute stability.

A bridging plate works as an internal external fixator, for example, in a clavicle fracture, producing relative stability.

A neutralisation plate works by neutralising torsional forces, for example, after fixation by a lag screw in a Weber B fracture.

A locking plate is not a true mode of plating.

8. Answer E. **Using hybrid fixation for a periarticular fracture with metaphyseal comminution**
Primary fracture healing requires direct reduction and absolute stability. This requires increased fracture stability and a low fracture strain ($\leq$2%) environment. There is Harversian remodelling and no callus formation.

Secondary fracture healing requires indirect reduction and relative stability. This needs a high strain ($\geq$2%) fracture environment and occurs with endochondral/intramembranous ossification. The callus/cartilage becomes mineralised and replaced by bone.

Cutting cones are produced in primary bone healing. This relies on interfragmentary compression. This can be produced by the following techniques:

Lag screw technique (overdrilling the near cortex to 3.5mm, which becomes the 'glide hole' and drilling the far cortex to 2.5mm, which becomes the 'pilot hole'), e.g. in a Weber B ankle fracture.

Using a partially threaded cancellous screw in cancellous bone in a medial malleolar transverse fracture (lag screw technique); using a compression plate in a forearm fracture (by eccentric drilling).

Using an articulated compression device provides absolute stability with no callous formation.

An intramedullary nail, cast, external fixator and bridging plate produce relative stability, which produces callus for healing (secondary bone healing).

In reality, most fixations involve components of both types of healing.

Hybrid fixation involves a combination of absolute and relative stability principles. An example is a peri-articular distal femoral fracture with extensive meta-diaphyseal comminution, direct reduction and absolute stability for the articular block with bridge plating and relative stability for the meta-diaphysis.

9. Answer D. **Displacement greater than 100%**
In the BOAST guidelines for supracondylar fractures, indications for urgent (night-time) operating include absent radial pulse, threatened skin viability and evidence of impaired perfusion (including increased capillary refill time or a pale hand). Fracture displacement on its own is not an indication for urgent operating. Discussion with the vascular on-call team should take place if a child presents with an ischaemic limb.

10. Answer E. **Lag screw to be used outside the plate to fix fracture fragments** Failure of distal humerus intra-articular fractures, when it occurs, typically occurs at the supracondylar level through loss of fixation in the distal fragments. To prevent such failure and maximise the potential for union and full elbow mobility after a severely fractured distal humerus, according to O'Driscoll's seminal paper (2005), the following principles must be satisfied:
    1. Fixation in the distal fragment must be maximised.
    2. All fixation in distal fragments should contribute to stability between the distal fragments and the shaft.

    There are 8 technical objectives to achieve these principles:
    1. Every screw in the distal fragments should pass through a plate.
    2. Each screw should engage a fragment on the opposite on the opposite side that is also fixed to a plate.
    3. Place as many screws as possible in the distal fragments.
    4. Each screw should be as long as possible.
    5. Each screw should engage as many articular fragments as possible.
    6. The screws in the distal fragments should lock together by interdigitation, creating a fixed-angle fracture.
    7. Plates should be applied such that compression is achieved at the supracondylar level for both columns.
    8. The plates should be strong enough and stiff enough to resist breaking or bending before union occurs at the supracondylar level.

    O'Driscoll SW. Optimizing stability in distal humeral fracture fixation. *J Shoulder Elbow Surg.* 2005;**14**(1 Suppl. S):186S–194S.

11. Answer C. **Should be placed below the equator of the skull**
Four pins are used in a halo device: two anterior and two posterior.

    The two anterior pins should be placed in a safe zone, which is a 1cm region just above the lateral one-third of the orbit (eyebrow) at or below the equator of the skull (Figure 15.38). This is anterior and medial to the temporalis muscle.

    The two posterior pins are placed on the opposite side ring from the anterior pins.

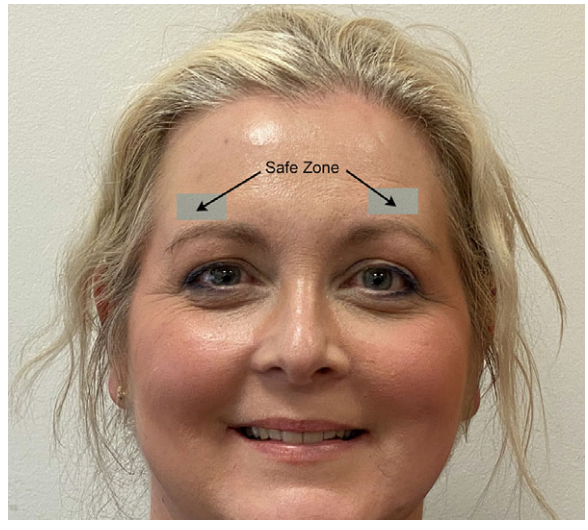


Figure 15.38 Safe zones for halo traction

The supraorbital nerve is a branch of the frontal nerve providing sensation to the upper eyelid and forehead/scalp. It emerges just above the medial one-third of the orbit and is at risk for injury if halo pins are placed too medial above the orbit.

The halo should be placed below the equator of the skull to prevent cephalic migration of the halo.

The supratrochlear nerve exits the skull at the level of the frontal sinus.

If the pins are placed more laterally, then there is a risk of injury to the temporalis muscle.

12. Answer A. **Type II injuries involve rupture of the AC ligament and a CC ligament sprain**
The SBA refers to Rockwood's classification of ACJ injuries. Despite the move away from asking about classification systems, it still useful to know especially the difference between type III and type V injury and also the controversy as to what to do with a type III injury.

Type I is a sprain of the AC ligament and normal CC ligament with no instability of the ACJ.

Type II is a torn AC ligament and sprained CC ligament with horizontal AC instability.

Type III is a torn AC and CC ligament with increased CC distance of 25–100%.

Type IV is posterior displacement of the lateral clavicle through the trapezius.

Type V is an increased CC distance 100–300% compared with the contralateral side

Type VI is inferior dislocation of the lateral clavicle.

C is incorrect, as this refers to type IV, not type III.

ACJ injury: Rockwood classification. In **Rockwood CA, Williams GR, Young DC**, eds. *Rockwood and Green's Fractures in Adults,* 4th Ed., 1341–1414. Philadelphia, PA: Lippincott-Raven; 1996.

13. Answer E. **The safe zone of fixation is between the radial styloid and Lister's tubercle**
Kocher's approach is often used to approach radial head fractures. This utilises an internervous plane between ECU (posterior interosseus nerve) and anconeus (radial nerve). The safe zone of fixation is between the radial styloid and Lister's tubercle. Full pronation of the forearm moves the PIN away from the operative field.

The PIN supplies motor innervation to all the extensor muscles of the wrist and digits: ECRB, supinator, ECU, EDM, EDC, APL, EPB, EPL and EIP, except for the extensor carpi radialis longus (ECRL). ECRL is supplied by a branch from the radial nerve prior to its division into the PIN and SRN. ECRL produces wrist extension and abduction.

The interval between triceps and brachioradialis is the lateral approach to the distal humerus.

The capsule should not be dissected too far anteriorly, as the PIN runs over the front of the anterolateral portion of the elbow capsule.

Caputo AE, Mazzocca AD, Santoro VM. The nonarticulating portion of the radial head: anatomic and clinical correlations for internal fixation. *J Hand Surg Am.* 1998;**23**:1082–1090.

14. Answer B. **Apply an external fixator**
This patient is in hypovolaemic shock and haemodynamically unstable. Primary resuscitative measures include application of a pelvic binder (haemostatic device), tranexamic acid (according to CRASH-2 protocol), initiating a massive transfusion protocol (comprising red blood cells, platelets, FFP and cryoprecipitate) and practising permissive hypotension (aiming at systolic of 90). Secondary resuscitative measures include angiographic embolisation and pelvic packing, but these are not initial measures.

External fixators are not very practical to use in the ED, are often applied incorrectly and are associated with a high rate of complications.

A pelvic binder should have been applied in a prehospital setting and is a rapid, safe alternative for haemorrhage control, and equally has benefits as a simple method for use by the junior surgeons. If not already applied, this should be done in the ED as per ATLS protocol.

If an external fixator is to be applied, this is best performed in theatre under image intensifier (II) control.

15. Answer D. **Lateral plantar artery**
The blood supply to the talar neck comes from three main sources (Figure 15.39):

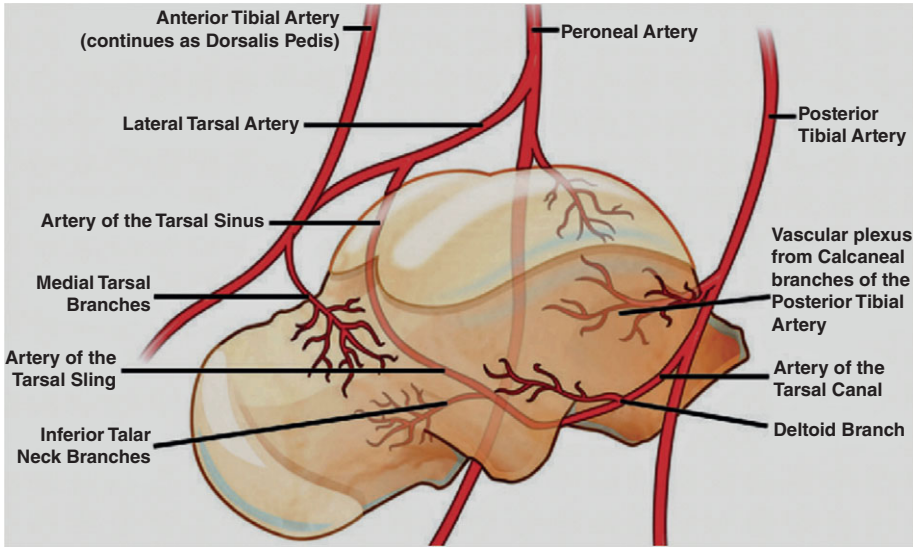


Figure 15.39 Blood supply of the talus

1. **Posterior tibial artery**
   - Via artery of tarsal canal (dominant supply) and supplies majority of talar body.
   - Deltoid branch of posterior tibial artery, which supplies medial portion of talar body and may be only remaining blood supply with a displaced fracture.
2. **Anterior tibial artery**
   - Supplies head and neck.
3. Perforating **peroneal artery** via artery of tarsal sinus.
   - Supplies head and neck.

The lateral plantar artery does not supply the talar neck.

16. Answer D. **Metaphyseal fracture (junction of metaphysis and physis)**
Pathognomic injuries (high specificity) for non-accidental injury include metaphyseal fractures, posterior rib fractures and femoral fractures in a non-ambulatory child.

The classic metaphyseal lesion (CML)is a fracture at the junction of metaphysis and physis (primary spongiosa) (Figure 15.40). The fracture is regarded as highly specific for NAI.

These microfractures occur in immature mineralised bone almost entirely in children under the age of 2 years because:

Figure 15.40 Metaphyseal corner fracture

- they are small enough to be shaken
- they cannot protect their limbs.

Variants include a corner fracture and bucket handle fracture.

A corner fracture is a discrete avulsion of the metaphysis.

A bucket handle fracture is a horizontal avulsion fracture; the central and peripheral components give the appearance of a bucket handle.

17. Answer D. **Failure of scapholunate ligament – failure of lunocapitate ligament – failure of lunotriquetral ligament – lunate dislocates into carpal tunnel**
The injury is a lunate dislocation. Be able to recognise this injury on plain radiographs.

There is a misalignment of the first Gilula arc in which the lunate 'overlaps' the capitate and the scaphoid. The lunate bone has a triangular appearance on AP projection, with displacement and volar rotation on the lateral film. There is also a diffuse reduction of bone attenuation.

This SBA is testing Mayfield's classification system, which refers to the predictable sequence of pathoanatomy (in which the injury occurs to the carpal bones) (Figure 15.41).

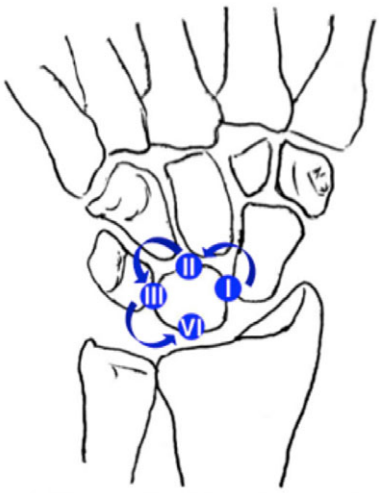


Figure 15.41
Mayfield radiocarpal injury

- Mayfield I: Failure of scapholunate ligament.
- Mayfield II: Failure of lunocapitate ligament.
- Mayfield III: Failure of lunotriquetral ligament ('perilunate').
- Mayfield IV: Lunate dislocates usually into carpal tunnel ('lunate dislocation').

Mayfield JK, Johnson RP, Kilcoyne RK. Carpal dislocations: pathomechanics and progressive perilunar instability. *J Hand Surg Am.* 1980;5:226–241.

18. Answer C. **It is indicated in proximal pole fractures**
The volar approach between FCR and the radial artery can be used for waist and distal pole fractures and also those with humpback flexion deformities. Proximal pole fractures ideally should be approached via a dorsal approach, as the trajectory of the screw implant is easier via a dorsal approach.

19. Answer C. **Peroneus longus**
This SBA is testing anatomy (Figure 15.42). There are four compartments of the leg: (1) anterior, (2) lateral, (3) posterior superficial and (4) posterior deep.

Contents of the anterior compartment include:

- Tibialis anterior.
- Extensor hallucis longus.
- Extensor digitorum longus.
- Peroneus tertius.

Peroneus longus is a content of the lateral compartment, not anterior compartment.

Lezak B, Summers S. *Anatomy, Bony Pelvis and Lower Limb, Leg Anterior Compartment.* Treasure Island, FL: StatPearls Publishing; 2020.

20. Answer A. **May be associated with wasting of the first dorsal interosseus**
Lateral condyle fractures are the second most common fracture in the paediatric elbow, with a higher risk of non-union, malunion and AVN than other paediatric elbow fractures. The internal oblique view is the best view to visualise fracture displacement, as the fracture fragment is most commonly lying posterolateral.

A number of classification systems, including Milch and Weiss, are used. The Weiss classification system (types I–III) states that type I fractures (<2mm with an intact cartilaginous hinge) can be treated in a cast; type II (>2mm but <4mm displacement with intact articular cartilage on arthrogram) can be treated by closed reduction and fixation; type III (>4mm displacement with disrupted articular cartilage on arthrogram) should be treated by open reduction internal fixation. Typically, 1.6mm K-wires in a laterally placed divergent configuration are used. One of the reported complications (10%) due to lateral physeal arrest is cubitus valgus, which may be associated with a tardy ulnar palsy, one of the features of which is wasting of the first dorsal interosseus.

21. Answer B. **Intramedullary nailing is more cost-effective compared with locking plates**
This is an extra-articular distal tibial fracture. The fixDT trial published by Costa et al.

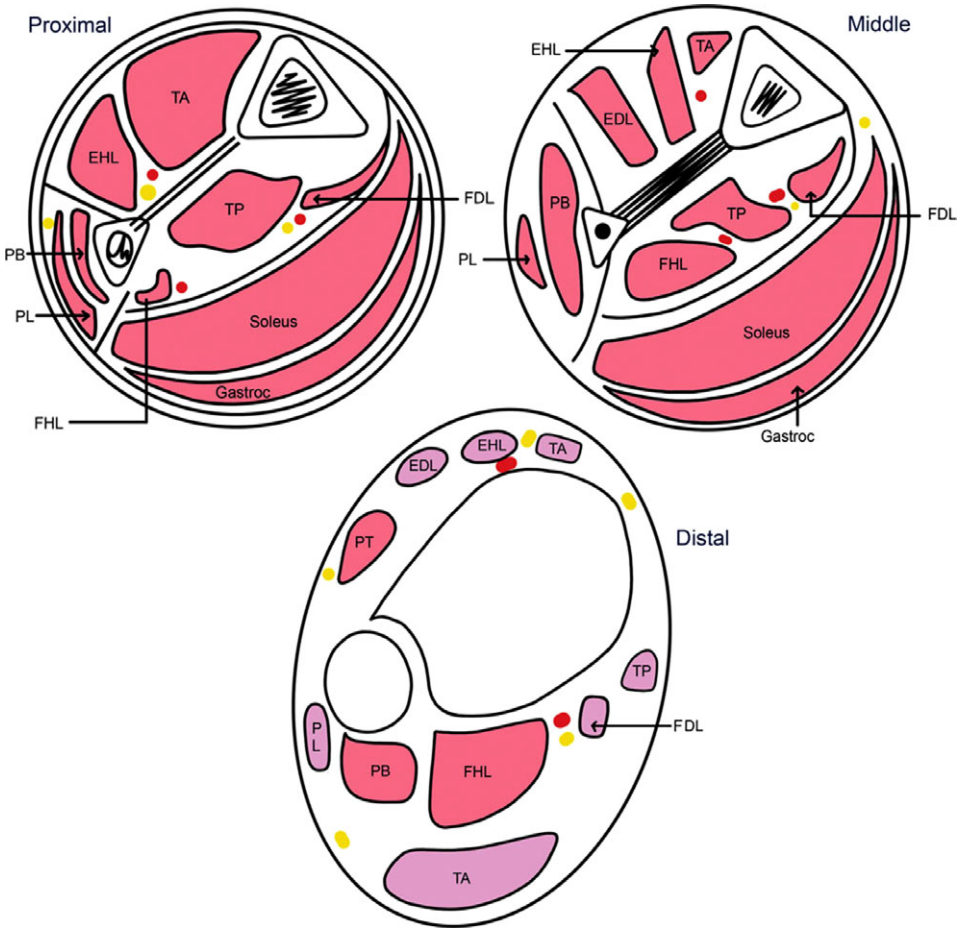


Figure 15.42 Cross anatomy diagram lower leg

(2018), which was conducted in 28 UK acute trauma centres from 2013–2017, recruited 321 adult patients and randomised them to fixation by intramedullary nailing or plating. The primary outcome measure was the Disability Rating Index (DRI) score and secondary outcomes were the Olerud-Molander Ankle Score (OMAS), quality of life index (EQ-5D) and complications such as infection and further surgery.

There were similar disability ratings at 6 months and no difference in infection rates but recovery rates were greater for intramedullary nailing and costs were lower (intramedullary nailing was more cost-effective). Further surgery was also more common in the locked plate group (12% compared with 8% at 12 months).

Costa M et al. Intramedullary nail fixation versus locking plate fixation for adults with a fracture of the distal tibia: the UK FixDT RCT. *Health Technol Assess.* 2018;**22**:1–148.

22. Answer A. **They can be used for comminuted forearm fractures**

Principles of elastic nails include:

- Use for length stable fractures, e.g. transverse fractures. They are contraindicated for length unstable fractures, e.g. comminuted or long spiral fractures.
- Entry point of the nail should be 2.5–3cm proximal to the physis.
- The apex of the bow of the elastic nails should be at the level of the fracture.
- They should be pre-bent to three times the diameter of the isthmus.

Slongo TF. Fracture treatment in childhood. *Injury* 2005;**36**(Suppl. 1):A1.

23. Answer E. **Increase the outer diameter**
The pull-out strength of a screw can be increased by increasing the difference between the outer and inner core diameter (increase the outer, decrease the inner), decrease the pitch (increased thread density) or increase cortex thickness.

Törnkvist H, Hearn TC, Schatzker J. The strength of plate fixation in relation to the number and spacing of bone screws. *J Orthop Trauma.* 1996;**10**:204–208.

24. Answer C. **Extensor pollicis longus**
EPL (extensor pollicis longus) tendon ruptures occur in up to 9% of distal radius fractures. Treatment typically consists of a tendon transfer of the extensor indicis proprius as the tear is attritional, which makes repair impractical.

Roth KM et al. Incidence of extensor pollicis longus tendon rupture after nondisplaced distal radius fractures. *J Hand Surg A.* 2012;**37**:942–947.

25. Answer E. **Emergency closed reduction under GA**
This is a locked posterior dislocation until proven otherwise because of a Hill–Sachs lesion (reverse). This is likely to be a missed chronic injury. Closed reduction can potentially cause a proximal humerus fracture and should not be attempted as an emergency. A scheduled closed reduction can be attempted under general anaesthesia. The reduction manoeuvres must be done gently and carefully. Most dislocations have a chance to reduce with closed manipulation, if the injury is <6 weeks old. The prognosis is good if the reverse Hill–Sachs lesion is <25% of the humeral head articular surface.

A CT scan should also be done. Treatments depend on the size of the defect and may include a McClaughlin procedure (subscapularis tenotomy +/– lesser tuberosity), femoral head allograft reconstruction, rotational osteotomy or reverse shoulder arthroplasty as a final salvage.

Aydin N, Kayaalp M, Asansu M, Karaismailoglu B. Treatment options for locked posterior shoulder dislocations and clinical outcomes. *EFORT Open Rev.* 2019;**4**:194–200.

26. Answer C. **7**.
Age: 1 (30–50).

Shock group: 1 (shock group 2 – BP unstable in field but responds to fluids).

Energy of injury: 3 – high (gunshot wound: high velocity).

Ischaemia: 2 – Diminished pulses without ischaemia.

This results in a score of 7.

Mangled Extremity Severity Score (MESS)

Vascularity/Limb ischaemia

- Poor pulse 1
- Pulseless and poor CR 2
- Totally avascular 3
- Score doubled for ischaemia >6/24

Injury Skeletal/Soft tissue

- Low Energy 1
- Medium Energy 2
- High Energy 3
- Very High Energy 4

Shock

- Systolic BP >90mmHg 0
- Hypotensive transiently 1
- Persistent hypotension 2

Age (Years)

- <30 0
- 30–50 1
- >50 2

27. Answer E. **Zone of provisional calcification**
Physeal fractures typically occur in the hypertrophic zone, specifically in the zone of provisional calcification, as this is an area with large cells but small amounts of matrix and is potentially weak.

28. Answer D. **Patients should respond to resuscitation with pressor support**
Vallier et al.'s (2005) seminal paper on Early Appropriate Care (EAC) recommends the following: fractures should be definitively fixed within 36 h of injury, providing lactate <4, pH >7.25, Base Excess >5.5mmol/L and patients must respond to resuscitation without pressor support.

Vallier H et al. Complications are reduced with a protocol to standardise timing of fixation based on response to resuscitation. *J Orthop Surg Res.* 2015;**10**:155.

29. Answer D. **MRI and urgent neurosurgical consult**

A unifacet or bifacet dislocation is a surgical emergency and requires immediate in-line triple immobilisation and full spinal precautions while resuscitation is occurring. Following this, an MRI should be obtained and early discussion had with the regional neurosurgical unit regarding potential transfer. In the neurosurgical unit, if no disc is present on MRI (which must be excluded due to the risk of cord transection with closed reduction), a halo can be applied, or Gardner–Wells tongs and traction applied under image intensifier and clinical monitoring for neurology.

If this fails or a disc is present, open reduction is performed, followed by definitive fixation.

There is controversy over whether to just proceed with serial traction weight to reduce the dislocation without obtaining a prior MRI. This has been shown to be safe when used with an awake patient. Rapid decompression of the cervical spine may improve recovery as opposed to the delay that will occur waiting to obtain an MRI. Closed reduction is recognised as a challenging procedure for surgeons, particularly those in non-spinal centres that only occasionally face this clinical scenario.

A study investigating delays to decompression of cervical spine cord injury at centres throughout Australia and New Zealand noted that median time to open decompression was 22 h compared with 6 h for closed reduction. They concluded that closed reduction was effective in minimising time to decompression. Neurological improvement was greatest in those patients reduced within 4–8 h from injury with no cases of neurological worsening.

Star AM, Jones AA, Cotler JM, Balderston RA, Sinha R. Immediate closed reduction of cervical spine dislocations using traction. *Spine* 1990;**15**:1068–1072.

Storey RN, Singhal R, Inglis T, Kieser D, Schouten R. Urgent closed reduction of the dislocated cervical spine in New Zealand. *ANZ J Surg*. 2018;**88**:56–61.

30. Answer D. **The complication rate of non-surgical and surgical treatment of type II fractures in the elderly is higher**

Type II fractures sit in a watershed area between the internal carotid and vertebral artery and therefore are at higher risk of non-union. There is an increasing body of evidence that surgical treatment is better for type II fractures in the elderly, especially those with risk factors for non-union. A fibrous non-union can be managed reasonably well, but symptomatic non-union can be associated with high rates of morbidity including atlantoaxial subluxation. The complication profile of non-surgical and surgical treatment is equivalent.

Atlantoaxial mobility is preserved in odontoid screw fixation through an anterior approach. It is indicated in cases with transverse or posterior oblique fracture lines. However, in the presence of a comminuted odontoid fracture, anterior oblique fracture, transverse ligament rupture, osteoporosis, cervicothoracic kyphosis or delayed fracture (>6 months), anterior odontoid screw fixation is contraindicated. In these cases, a posterior approach is recommended.

Iyer S, Hurlbert RJ, Albert T. Management of odontoid fractures in the elderly: a review of the literature and an evidence-based treatment algorithm. *Neurosurgery* 2018;**82**:419–430.

Robinson Y, Robinson A, Olerud C. Systematic review on surgical and nonsurgical treatment of type II odontoid fractures in the elderly. *Biomed Res Int.* 2014;**2014**:231948.

31. Answer E. **Surgical stabilisation**

Management of spinal fractures is determined by the Thoracolumbar Injury Classification score (TLICS) by Vaccaro et al. (2005), which looks at three parameters: fracture morphology, neurology and PLL (posterior longitudinal ligament) injury. A final score of 0–3 is treated non-operatively; 4 can be treated operatively or non-operatively and >4 is treated operatively. Bony chance fractures with stable posterior elements (no PLL injury), no neurological deficits and less than 15° kyphosis can be treated conservatively with immobilisation in a thoracolumbar orthosis in extension with 2-week follow-up for non-union and degree of kyphosis. Ligamentous chance fractures and unstable posterior elements with neurological deficits should be treated by emergent open reduction and stabilisation surgery. Decompression surgery is inadequate for stabilising the spine. Traditionally, this was three

levels above and two levels below, but modern pedicle screw techniques have changed this to one level above and one level below.

In this particular case, the fracture is a chance fracture (flexion-distraction), which scores 4 for morphology; there is incomplete neurology, which scores 3; and there is possibly a posterior ligamentous injury. Therefore, he is scoring at least 7 or possibly more, which should be treated operatively.

AlJallaf M, AlDelail H, Hussein L. Let's review Chance fracture. *BMJ Case Rep.* 2015. doi:10.1136/bcr-2014-206924.

Vaccaro AR et al. A new classification of thoracolumbar injuries: the importance of injury morphology, the integrity of the posterior ligamentous complex and neurological status. *Spine* 2005;**30**:2325–2333.

32. Answer A. **Coaptation splint followed by functional brace**

This patient presents with a radial nerve palsy following a closed humeral shaft fracture. The fracture is within the criteria for acceptable alignment ($<20^{o}$ anterior angulation, $<30^{o}$ varus/valgus angulation, <3cm shortening). In terms of the fracture itself, it does not require surgical treatment.

The overall incidence of radial nerve injuries after humeral shaft fractures is 11.8%, but controversy exists on treatment of these injuries. Absolute indications for early exploration are open fractures or iatrogenic injury (e.g. after humeral bracing). Relative indications are polytrauma or floating elbow.

The majority of nerve palsies (85–90%) recover spontaneously without intervention in 3 months.

In the answer options, the median nerve is not affected in this case, and nerve conduction studies are not meaningful before 6 weeks (as there is a latency period). Exploration of the radial nerve and fixation is not required unless it is an open fracture, iatrogenic injury, polytrauma, floating elbow or the fracture mandates it. Humeral nailing should not be done in the presence of a radial nerve injury, as there is a high risk of injury to the nerve.

Rocchi M et al. Humerus shaft fracture complicated by radial nerve palsy: is surgical exploration necessary? *Musculoskelet Surg.* 2016;**100** (Suppl. 1): S53–S60.

33. Answer C. **Inability to extend the wrist in ulnar deviation**

The Kaplan's approach to the elbow is a more anterior approach and occurs between ECRB and EDC (Figure 15.43). It is not a true internervous plane, as both are innervated by the posterior interosseus nerve (although some cadaveric studies have shown that in 15% of cases ECRB is innervated by the radial nerve proper). The posterior interosseous nerve (PIN) is at risk during this approach and during plating of radial head fractures. The bicipital tuberosity marks the distal limit of plate placement before endangering the nerve. The wrist does not extend in ulnar deviation due to extensor carpi ulnaris being innervated by the PIN. The extensor carpi radialis longus is supplied by the radial nerve proper and therefore will still allow wrist extension with radial deviation. Flexion and abduction are not caused by the posterior interosseus nerve.

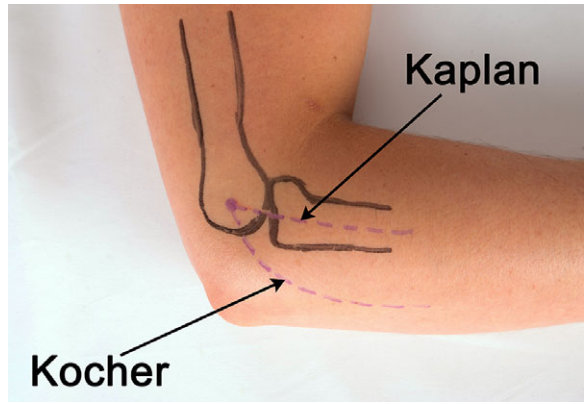


Figure 15.43 Surgical approach elbow

34. Answer C. **Conservative treatment**

The radiograph shows a displaced olecranon fracture with possible comminution. A ran-domised controlled trial of displaced olecranon fractures in the over-75-years group found no difference in DASH scores at 6 weeks, 3 months, 6 months and 1-year post-injury between non-operative and operative management. There was an unacceptably high complication rate associated with surgery in this age group; therefore, in the elderly patient, particularly low demand olecranon fractures should be managed non-operatively regardless of displacement or comminution.

Duckworth AD et al. Prospective randomised trial of non-operative versus operative management of olecranon fractures in the elderly. *Bone Joint J*. 2017;**99-B**:964–972.

35. Answer C. **Radial head arthroplasty, coronoid open reduction internal fixation and lateral collateral ligament repair**
This injury refers to the terrible triad of elbow dislocation, coronoid fracture and radial head fracture. This injury is inherently unstable as there is loss of both the primary (ulnohumeral joint via the coronoid), medial and lateral collateral ligaments and secondary stabilisers (radiohumeral joint via radial head, flexor and extensor muscles). This is described as O'Driscoll's fortress. Therefore, such an injury mandates surgical intervention.

Operative fixation is complicated. A CT scan of the elbow should be performed to assess the suitability of radial and coronoid fractures for repair or replacement.

The sequence of events is to approach the radial head, which can be fixed or replaced depending on the comminution; fix the lateral collateral ligament (LUCL) using suture anchors or transosseous sutures and then check the stability. If unstable, the coronoid is repaired using either sutures, anchors or screws, depending on the size of the fragment and exposure. The fixation should be solid enough to allow an early range of movement without instability.

If the elbow is unstable after repair of the coronoid, radial head ORIF or replacement and LCL repair, then the MCL can be repaired. Some surgeons advocate prophylactic decompression of the ulnar nerve at this stage. The use of a hinged external fixator in persistent instability has been shown to improve outcome.

O'Driscoll JB, Jupiter JB, King GJ, Hotchkiss RN, Morrey BF. The unstable elbow. *Instr Course Lect.* 2001;**50**:89–102.

36. Answer B. **Open reduction and internal fixation**
Supraspinatus, infraspinatus and teres minor externally rotate the greater tuberosity. Indications for open reduction and internal fixation include displacement of the greater tuberosity of more than 5mm. Non-operative treatment is likely to cause impingement with abduction and also defunction the cuff. More complex fracture configurations are more likely to have complications with fixation. Reverse polarity total shoulder arthroplasty is indicated in lower-demand individuals or older patients with non-reconstructable tuberosities (as the cuff is effectively defunctioned). Younger patients with non-reconstructable configurations may favour hemiarthroplasty.

37. Answer A. **Dynamisation of the tibial nail**
The patient may go onto a hypertrophic non-union. The most appropriate option at this stage is to dynamise the nail, which may just tip the balance to allow the fracture to heal by reducing the gap at the fracture site.

In this situation, the interfragmentary strain (movement at the fracture site) is excessive; hence, there is no progression through the different stages of Perren's theory of secondary bone healing, and bony bridging by hard callus is not possible.

38. Answer E. **There is no difference between non-union rates**
There is often controversy over management of midshaft clavicle fractures. Numerous studies, including the Canadian Orthopaedic Trauma Society (COTS) trial, have shown higher union rates in displaced clavicle fractures with operative treatment. There is a quicker return to work and sport with operative treatment. In the short-term, clinical outcomes are better in operative cases but there is little evidence to suggest this is long term. Patients who undergo surgery may require implant removal at a later date due to irritation hence there is a higher re-operation rate.

Altamimi SA, McKee MD. Nonoperative treatment compared with plate fixation of displaced midshaft clavicular fractures: surgical technique. *J Bone Joint Surg Am*. 2008;**90**(Suppl. 2 pt 1):1–8.

39. Answer C. **During retraction of infraspinatus**
The Judet approach to the scapular involves the internervous plane between the suprascapular (infraspinatus) and axillary (teres minor) nerves. This patient presents with a suprascapular nerve palsy. This is most commonly caused during forceful retraction of the infraspinatus muscle.

Retracting the infraspinatus superiorly reduces the likelihood of this.

40. Answer E. **Pronator quadratus**
The injury displayed is an extension-type supracondylar fracture of the humerus. The anterior interosseus nerve, which is a branch of the median nerve, is most commonly injured with this type of fracture. It supplies pronator quadratus, flexor digitorum profundus (index and middle fingers) and flexor pollicis longus.

In terms of the other answers, extensor pollicis longus and abductor pollicis longus are supplied by the posterior interosseus nerve; 4th and 5th lumbricals and abductor digiti minimi are supplied by the ulnar nerve. The majority of supracondylar fracture nerve injuries are neurapraxias that resolve spontaneously.

41. Answer B. **CT scan of pelvis**
All hip dislocations should have a post-reduction CT scan. This is to evaluate the reduction and to ensure that there are no associated fractures or loose bodies and to assess for marginal impaction. The radiograph does show a small bony fragment projected over the femoral neck most likely representing the posterior lip of the acetabulum.

42. Answer E. **Time to surgery is the most important factor in influencing outcome**
Previously it was believed that time to surgery was the most important factor in preserving the blood supply following displaced intracapsular neck of femur fractures in young patients and thus operating within 6 h was recommended, but now it is recognised that the quality of the reduction (and thus an anatomical reduction is needed) is the most important factor in influencing outcome. Some surgeons will try and obtain an anatomical reduction using a Leadbetter manoeuvre, which can be remembered by the mnemonic **FATI CAR**: **F**lexion (to relax the muscles); **A**dduction (along with flexion 'books open' the fracture); **T**raction (to gain length); **I**nternal rotation (relaxes the Y ligament); **C**ircumduction; **A**bduction and **R**eduction check. This fracture often requires an open reduction (Smith–Petersen) approach, which relies upon an internervous plane between the femoral and superior gluteal nerves. The lateral femoral cutaneous nerve is most at risk in this approach.

43. Answer D. **On-table angiogram, temporary vascular shunt, skeletal stabilisation, definitive vascular reconstruction, forearm fasciotomies**
Imaging modalities should not delay reperfusion surgery. On-table angiogram is the most viable imaging option in this case. Reperfusion should be obtained with a temporary shunt, followed by skeletal stabilisation using an external fixator. Typically, the pins are put in before the shunt, but the external fixator is not applied until afterwards. Thereafter, definitive vascular reconstruction using autologous vein grafts can be performed. Following reperfusion, the surgeon should have a low threshold for performing fasciotomy as the rate of compartment syndrome secondary to reperfusion injury is high.

British Orthopaedic Association Standards for Trauma (BOAST 6). Management of arterial injuries associated with fractures and dislocations. https://www.boa.ac.uk/resource/boast-6-pdf.html.

44. Answer D. **Posterior wall**
This a straightforward, either-you-know-or-don't-know SBA that is testing anatomical interpretation of plain anteroposterior pelvis radiographs.

Line 1 indicates the anterior wall of the acetabulum.

Line 2 indicates the posterior wall of the acetabulum.

Line 3 indicates the weight-bearing dome.

Line 4 is the iliopectineal line and indicates structural integrity of the anterior column of acetabulum.

Line 5 is the ilioischial line and indicates integrity of the posterior column.

Line 6 is the teardrop, which indicates the acetabular true floor.

45. Answer A. **Hip abductors and iliopsoas**
The iliopsoas muscle causes the proximal fragment to flex, whereas the hip abductors cause the fragment to externally rotate (Figure 15.44). Distally, the hip adductors cause the distal fragment to medialise. This can make it difficult to

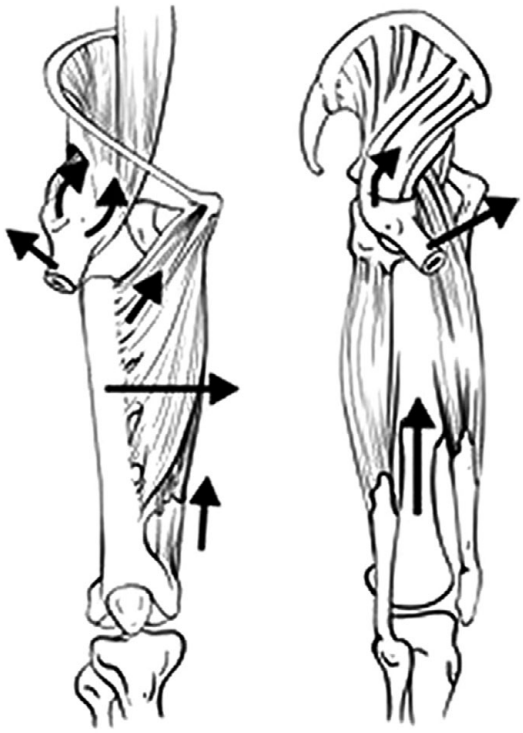


Figure 15.44 Deforming muscle forces on the proximal femur

get an anatomical reduction in these cases. As a result, the most common post-operative deformity is the procurvatum and varus.

46. Answer E. **<0.9**
Patients with an ABPI of <0.9 should be referred to vascular intervention for an urgent consultation and further imaging. In a study of 38 patients, 11 who had an ABPI of <0.9 all had an arterial injury requiring surgical treatment. The remaining 27 patients had an ABPI of 0.90 or higher and none had a vascular injury detectable by serial clinical examination or duplex ultrasonography.

Mills WJ, Barei DP. McNair P. The value of the ankle–brachial index for diagnosing arterial injury after knee dislocation: a prospective study. *J Trauma*. 2004;**56**:1261–1265.

47. Answer D. **Overgrowth**
Overgrowth is the most common complication following femoral shaft fracture in this age group. In children under 10 years old, it is common to have overgrowth of between 1.0 and 2.5cm, which occurs predominantly in the first 2 years after injury, and the parents should be counselled appropriately about this.

Wessel L, Seyfriedt C. Leg length inequality after childhood femoral fractures – permanent or temporary phenomenon? [Article in German] *Unfallchirurg*. 1996;**99**:275–282.

48. Answer A. **ORIF using cerclage wire and locking plate**
The Vancouver classification is useful in allowing an effective treatment algorithm following periprosthetic fracture. The B type is a fracture around the stem. If the implant is not loose (type B1), this can be treated by ORIF using cerclage wires and a locking plate.

If a cemented stem is loose but with good bone stock this can be managed with cerclarge cables and open reduction internal fixation provided the reduction is anatomical. Otherwise a long, porous-coated cementless stem is utilised. Generally patients in this cohort are frail with multiple comorbidities. Fixation over revision surgery is associated with a lower incidence of complications and should be the desired treatment in this patient group. With regards to uncemented stems, revision with a long, porous-coated cementless stem is recommended.

If there is poor bone stock (type B3), the femur is revised to either a long, porous-coated cementless stem with proximal femoral allograft or a proximal femoral replacement. It is sometimes difficult to fully differentiate between a B1and B2 fracture on plain radiographs and so further imaging with a CT scan may be helpful, although implant stability may only truly be appreciated during the time of surgery.

Powell-Bowns MFR et al. Vancouver B periprosthetic fractures involving the Exeter cemented stem. *Bone Joint J*. 2021;**103-B**:309–320.

49. Answer C. **III**
This SBA is good revision for the Advanced Trauma Life Support® (ATLS®) classification of shock (Table 15.1). Class III shock represents blood loss of 1500–2000ml (30–40% blood volume). Respiratory rate is >30 and urine output is 10–20ml/h. Values are represented in Table 15.1. There is no class V.

Table 15.1 ATLS® classification of shock

	Class I	Class II	Class III	Class IV
Blood loss (% volume loss)	<750ml (<15%)	750–1500ml (15–30%)	1500ml–2000ml (30–40%)	2000ml+ (>40%)
Pulse	<100	>100	>120	>140
Blood pressure	No change	Normal systolic BP, raised diastolic BP	Reduced	Reduced/ unrecordable
Pulse pressure	↔	↓	↓	↓
Respiratory rate	<20	>20	>30	>40
Urine output (ml/h)	↔	↔	↓	↓↓
GCS	↔	↔	↓	↓
Base deficit	0 to –2 mEq/L	–2 to –6 mEq/L	–6 to –10 mEq/L	–10 mEq/L or less
Need for blood products	Monitor	Possible	Yes	Massive Transfusion Protocol

50. Answer D. **Kocher-Langenbeck**

A gull sign is present on pelvic radiograph (Figure 15.45). This sign was first described in 1965 by Berkebile et al. (1965). It is used for variations of posterior column fractures where the posterior column displaces and takes the hind portion of acetabular roof; therefore, the posterior segment loses its normal relationship with the segment still attached to anterior column and forms 'an image like a gull in flight'. This sign is pathognomonic of posterior wall fractures of the acetabulum.

To confuse matters, another hip fracture that has been called the 'gull wing sign' is a medially displaced fracture of the acetabular roof where the medially displaced impacted fragment of the acetabulum and the lateral part together also form a seagull outline. This fracture is seen in elderly osteoporotic patients and is associated with a poor prognosis, with debate in the surgical literature discussing whether surgical fixation or total hip replacement is the appropriate choice of management

The posterior Kocher-Langenbeck approach is most suited to posterior-based fractures of the acetabulum. The iliofemoral approach allows visualisation of both columns, whereas the ilioinguinal approach is more suited to anterior wall and column fractures. The modified stoppa allows access to the quadrilateral plate.

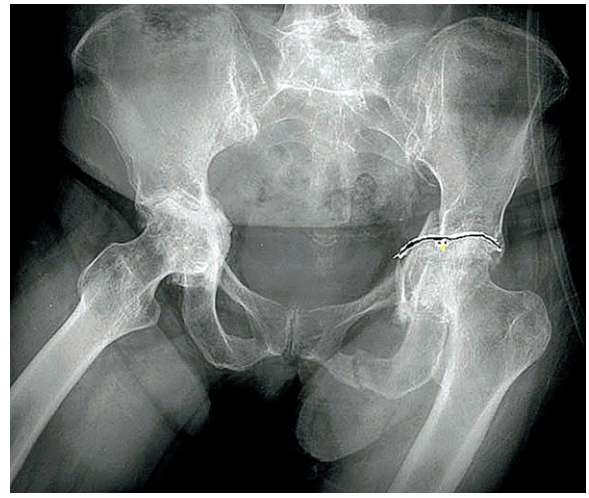


Figure 15.45 Gull sign

Berkebile RD, Fischer D, Albrecht LF. The Gull-wing sign. *Radiology* 1965;**84**:937–939.

Anglen JO, Burd TA, Hendricks KJ, Harrison P. The 'Gull sign': a harbinger of failure for internal fixation of geriatric acetabular fractures. *J Orthop Trauma.* 2003;**17**:625–634.

51. Answer A. **A wound size >10cm**

The BOAST (British Orthopaedic Standards for Trauma) 4 guidelines for management of open fractures state that there are four reasons for emergent operating in the middle of the night:

compartment syndrome, arterial injury requiring repair, gross contamination with marine or agricultural waste and polytrauma. Otherwise, these injuries should be treated in daylight hours by combined senior orthoplastics teams in conjunction.

BOAST 4: British Orthopaedic Association and British Association of Plastic, Reconstructive and Aesthetic Surgeons Audit Standards for Trauma: Open Fractures. https://www.boa.ac.uk/resource/boast-4-pdf.html.

52. Answer D. **Serum lactate**
The serum lactate is the most sensitive indicator of adequate perfusion. A normal value is <2.5mmol/L. According to Vallier et al. (2013), <4 can be used as an indicator of resuscitation.

Vallier HA, Wang X, Moore TA, Wilber JH, Como JJ. Timing of orthopaedic surgery in multiple trauma patients: development of a protocol for early appropriate care. *J Orthop Trauma.* 2013;**27**:543–551.

53. Answer D. **Increase the working length**
Rigidity refers to the resistance of a structure to deformation. There are a number of factors that can be used to increase rigidity, the most important of which is reducing the fracture. Pin factors include increasing the pin diameter and number of pins. Bar factors include cross-linking and reducing the distance between the bars and the skin. Working length refers to the distance between the pins either side of the fracture. Decreasing rather than increasing the working length increases rigidity.

54. Answer B. **Paraesthesia over the dorsum of the foot**
The L5 nerve root crosses the sacral ala. It is at risk if the sacroiliac screw is directed more than 20° laterally and penetrates the anterior cortex. For this reason, bicortical screw fixation is not recommended.

55. Answer D. **Treat PCL and PLC operatively within 2 weeks, ACL within 6 weeks and MCL conservatively in a brace**
Multi-ligament injuries are common after a knee dislocation and it is recommended that the PCL and PLC are operated within 2 weeks and ACL at 6 weeks once the swelling has subsided. The MCL can be treated conservatively in a brace

56. Answer B. **14**
The Injury Severity Score (ISS) is made up of the sum of the squares for the highest Abbreviated Injury Scale (AIS) grades in the three most severely injured regions. The ISS is based on scores of nine anatomical regions:
1. Head.
2. Face.
3. Neck.
4. Thorax.
5. Abdominal and pelvic region.
6. Spine.
7. Upper extremity.
8. Lower extremity.
9. External.

In this case the three highest scores are 3 (severe for lower extremity); 2 (moderate for chest injury); and 1 (mild for face). The squares are $3^2 + 2^2 + 1^2 = 9 + 4 + 1 = 14$

57. Answer C. **Supination adduction type 2**
Lauge-Hansen classification looks at the mechanism of injury and foot position at the time of injury. The radiograph in Figure 15.32 shows a supination adduction type 2 injury and must be treated with a buttress plate.

58. Answer C. **Severe soft tissue injury has the highest impact on a surgeon's decision making**
The Lower Extremity Assessment Project (LEAP) was a multicentre study of severe lower extremity trauma in the US civilian population. Severe soft tissue trauma has the highest impact on a surgeon's decision-making process and absence of plantar sensation has the second highest impact on a surgeon's decision making. Poor outcomes were found for both reconstruction and amputation groups. The most important factor in patient outcome is the ability to return to work.

MacKenzie EJ, Bosse MJ. Factors influencing outcome following limb-threatening lower limb trauma: lessons learned from the Lower Extremity Assessment Project (LEAP). *J Am Acad Orthop Surg.* 2006;**14**:S205S210.

59. Answer D. **The nail diameter should be 60% of the isthmus diameter**
Elastic nailing is used in children up to 50kg. The nails should be 40% the diameter of the isthmus, and the nails should be pre-bent to three times the diameter of the medullary canal. The apex of nail crossover should be at the fracture site, and the entry point of a retrograde femoral nail should be proximal to the physis.

60. Answer E. **Superficial peroneal nerve and tibial nerve**
The posterolateral approach utilises the internervous plane between the peroneal muscles (superficial peroneal nerve) and flexor hallucis longus (tibial nerve). The posterolateral approach can be performed in the lateral or prone position.

61. Answer A. **Primary ankle arthrodesis with hindfoot nail**
The patient is high risk of complications from surgery and is low demand. The operation is salvage surgery and to prevent amputation of her lower leg. The medial malleolus can be removed and her ankle joint prepared for fusion via her open ankle wound which is then closed. The hindfoot nail can be compressed to allow fusion in this instance (Figure 15.46).

Figure 15.46 Anteroposterior (AP) radiograph ankle and distal tibia following nailing

Fadhel WB et al. Outcomes after primary ankle arthrodesis in recent fractures of the distal end of the tibia in the elderly: a systematic review. *International Orthopaedics (SICOT)* 2022;**46**:1405–1412.

Chapter 16

Trauma II Structured SBA

Nayef Aslam-Pervez

TRAUMA II STRUCTURED SBA QUESTIONS

1. A 35-year-old scaffolder carrying a heavy weight steps into a shallow pit and twists his ankle, sustaining a tri-malleolar fracture of his ankle. He has a Weber B fibular, medial malleolus and posterior malleolus fracture. The posterior malleolus involves approximately 40% of the articular surface.

   What is the best management option for him to allow early weight bearing?

   A. CT scan of the ankle followed by open reduction and internal fixation of the posterior malleolus with a buttress plate and fibula plating (posterolateral approach) and medial malleolus fixation with cannulated screws (medial approach) +/– syndesmosis stabilisation
   B. CT scan of the ankle followed by open reduction and internal fixation of the fibula (lateral approach) followed by fixation of the medial malleolus (medial approach)
   C. Open reduction and internal fixation of the fibula (lateral approach) followed by fixation of the medial malleolus (medial approach) +/– syndesmosis stabilisation
   D. Open reduction and internal fixation of the fibula (lateral approach) followed by fixation of the medial malleolus (medial approach) followed by anterior to posterior screws of the posterior malleolus +/– syndesmosis stabilisation
   E. Spanning external fixation of the ankle joint with 5mm pins to his tibia, calcaneum and 4mm to the 1st metatarsal

2. A 45-year-old female fell while wall climbing and landed on her right forearm, sustaining a closed displaced fracture at the junction of proximal one-third to midshaft radius and midshaft ulna fracture.

   What is the best approach for open reduction and fixation of the radius and ulna fracture with plates and screws?

   A. Approach the midshaft of the radius via the brachioradialis/flexor carpi radialis first with the forearm pronated during deep dissection and then work proximally between brachioradialis/pronator teres with the forearm supinated. Then fix the ulna through a separate approach
   B. Approach the midshaft of the radius via the brachioradialis/flexor carpi radialis first with the forearm pronated and then work proximally between brachioradialis/pronator teres with the forearm supinated. Approach the ulna through the incision for the radius and fix the ulna with plates and screws
   C. Approach the midshaft of the radius via the brachioradialis/flexor carpi radialis first with the forearm supinated during deep dissection and then work proximally between brachioradialis/pronator teres with the forearm pronated. Then fix the ulna through a separate approach
   D. Approach the proximal radius first through the brachioradialis/pronator teres interval with forearm supinated and then the midshaft of the radius via the brachioradialis/flexor carpi radialis with the forearm pronated during deep dissection. Then fix the ulna through a separate approach
   E. Approach the ulna first and fix the fracture with plates and screws. Then approach the midshaft of the radius via the brachioradialis/flexor carpi radialis first with the forearm pronated and then work proximally between brachioradialis/pronator teres with the forearm supinated

3. A 9-year-old girl has fallen from monkey bars and landed on her hand. Radiographs demonstrate a lateral condyle distal humerus fracture with 5mm displacement and rotation with extension into the trochlear groove.
   Which management approach will give her the best outcome?
   - **A.** A closed reduction of the fracture with the arm in an above-elbow cast with the forearm in neutral rotation
   - **B.** Exposure via a lateral approach viewing the reduction of the joint anteriorly and insert two divergent Kirschner wires for stabilisation. Removal of the wires in 4–6 weeks' time in clinic and follow up over 2 years
   - **C.** Exposure via a lateral approach viewing the reduction of the joint posteriorly and insert two divergent Kirschner wires for stabilisation. Removal of the wires in 4–6 weeks' time in clinic and follow up over 2 years
   - **D.** Exposure via a lateral approach viewing the reduction of the joint anteriorly and insert two convergent Kirschner wires for stabilisation. Removal of the wires in 4–6 weeks' time in clinic and follow up over 2 years
   - **E.** Exposure via posterior approach to the distal humerus and reducing the fracture with direct visualisation of the joint surface. Once reduced, place two divergent Kirschner wires for fixation. Removal of the wires in 4–6 weeks' time in clinic and follow up over 2 years

4. **Which of these patients can most likely proceed directly for intramedullary nailing?**
   - **A.** A 35-year-old male with a pathological fracture through a lytic area in the subtrochanteric region of the femur
   - **B.** A 69-year-old male with lung cancer treated 10 years ago with a lobectomy who presents with a pathological fracture through a lytic area in the subtrochanteric region of the femur
   - **C.** A 70-year-old male with known renal cell carcinoma who presents with a pathological fracture through a lytic area in the subtrochanteric region of the femur
   - **D.** A 71-year-old female admitted with a pathological fracture through a lytic area in the subtrochanteric region of the femur, who has been complaining of an irregular hard mass in her right breast
   - **E.** A 78-year-old female with known breast cancer with metastasis in her liver and vertebrae undergoing radiotherapy with a pathological fracture through a lytic area in the subtrochanteric region of the femur

5. **Which of the following will most likely benefit from posterior stabilisation of the spine? (Posterior ligament complex – PLC)**
   - **A.** A 12-year-old male has fallen out of a third-floor balcony and found to have isolated compression fracture to his L1 with 60% loss of anterior height of the vertebral body. He has no sensation or movement from L1 below and an MRI shows no injury to his spinal cord or compromise of the PLC
   - **B.** A 25-year-old male is involved in an accident as a front seat passenger. He is found to have a fracture extending from the anterior aspect of the L2 vertebral body passing all the way posteriorly with widening of the interspinous area. He has reduced sensation over his knee, medial malleolus and posterior calf and reduced power with knee extension, ankle dorsiflexion and great toe extension
   - **C.** A 38-year-old male falls from a low bridge and sustains a burst fracture of the L2 vertebrae. He has normal neurology, no posterior midline tenderness and mild canal encroachment on CT. On MRI his PLC is intact
   - **D.** A 45-year-old male falls from the first floor with a compression fracture of the spine involving $<50\%$ of the anterior vertebral body with normal neurology. On MRI his PLC is intact
   - **E.** A 78-year-old female with vertebral compression fractures of the L1 and L2 vertebrae after a fall from standing height. She is found to have some midline tenderness over L1 and L2 and normal neurology

6. A tendon rupture is most commonly encountered with undisplaced fractures of the distal radius.
   Which of the following reconstruction techniques is advised?

A. Transfer of the abductor pollicis longus tendon to restore thumb extension
B. Transfer of the abductor pollicis longus tendon to restore thumb abduction
C. Transfer of the extensor indicis tendon to restore thumb extension
D. Transfer of the flexor digitorum superficialis tendon to the ruptured tendon to restore thumb extension
E. Transfer of the flexor digitorum superficialis tendon to the ruptured tendon to restore thumb flexion

7. A 30-year-old male is unable to flex his DIPJ of the middle finger following pulling on an opponent's shirt. Radiography of the finger does not show any fractures. On attempting to make a grip, his middle finger interphalangeal joints extend. An ultrasound demonstrates the torn end of the tendon over the proximal interphalangeal joint (PIPJ).

What structure limits the movement of the tendon end to this region?

A. A1 pulley
B. A2 pulley
C. Interossei muscles and vinculum longus
D. Joint capsule of the PIPJ
E. Lumbrical muscles and vinculum longus

8. A 33-year-old motorcyclist is admitted following a fracture dislocation of the talus. There is dislocation of the tibiotalar and subtalar joints with comminution of the talus medially. Once it is reduced, the surgeon requires fixation of the talar body medially.

Which approach is best utilised for fixation and to ensure the blood supply of the talus is least compromised?

A. A medial malleolar osteotomy
B. A posteromedial approach protecting the neurovascular structures and dividing the deltoid ligament which is repaired later
C. A posteromedial approach protecting the neurovascular structures and splitting the deltoid ligament in line with its fibres
D. An anterior approach to the ankle joint with intermuscular plane between the extensor hallucis and digitorum longus
E. An anteromedial approach to the medial malleolus protecting the long saphenous vein and nerve with exposure of the talus

9. A 71-year-old fit and well male sustains a fracture of his femur between a hip and knee replacement. The fracture is in the supracondylar area, 3cm above the superior aspect of the knee replacement. The fixation of either hip or knee replacement is not involved. You are planning the fixation and need to decide which modality of treatment will give you best fixation for early weight bearing and decrease future complications.

Which treatment strategy will you choose?

A. Combined retrograde nail from the knee to the tip of the hip replacement with a locking plate to the tip of the hip replacement
B. Combined retrograde nail from the knee to the tip of the hip replacement with a locking plate to the proximal femur with screws around the femoral stem of the hip replacement
C. Locking plate fixation from the distal femur to the proximal femur with screws around the femoral stem of the hip replacement
D. Locking plate fixation from the distal femur to the tip of the hip replacement
E. Retrograde nail from the knee reaching close to the tip of the hip replacement

10. A 25-year-old sustains an isolated knee dislocation. On examination his foot is pale, and pulses are absent. Reduction of the knee is performed and maintained in a back slab, the pulses remain absent and the foot continues to remain pale.

What is the best sequence of management for this patient?

A. External fixation to maintain reduction in theatre, On table angiography, Vascular bypass shunt, Vascular repair/reconstruction +/− fasciotomy, Delayed knee ligament reconstruction following MRI of the knee
B. External fixation to maintain reduction in theatre, Vascular bypass shunt, On table angiography, Vascular repair/reconstruction, +/− fasciotomy, Delayed knee ligament reconstruction following MRI of the knee
C. On table angiography of the limb in theatre, Vascular bypass shunt, External fixator to maintain reduction, Vascular repair/reconstruction, Delayed knee ligament reconstruction following MRI of the knee
D. On table angiography of the limb in theatre, Vascular repair/reconstruction +/− fasciotomy,

Maintain reduction with a back slab, Delayed knee ligament reconstruction following MRI of the knee

E. Vascular bypass shunt in theatre, External fixation to maintain reduction, On table angiography, Vascular repair/reconstruction +/− fasciotomy, Delayed knee ligament reconstruction following MRI of the knee

11. Which of the following manoeuvres is least likely to help with reducing subtrochanteric femoral fractures?

A. Abduction of the distal fragment
B. Adduction of the proximal fragment
C. Extension of the hip joint
D. External rotation of the proximal fragment
E. Traction of the limb in a supine position

12. When performing dual incision fasciotomies of the leg with compartment syndrome, which of the following structures are not encountered with your incisions?

A. Medial incision: extensor hallucis longus; Lateral incision: peroneal artery
B. Medial incision: long saphenous vein; Lateral incision: superficial peroneal nerve
C. Medial incision: posterior tibial artery; Lateral incision: peroneus longus and brevis
D. Medial incision: soleus; Lateral incision: superficial peroneal nerve
E. Medial incision: tibial nerve; Lateral incision: extensor digitorum longus

13. A 14-year-old male with a proximal ulna fracture and anterior radial head dislocation underwent fixation with plates and screws of the proximal ulna and manipulation of the radial head. Post-operative radiographs show excellent reduction of the fracture and radio humeral articulation. He was placed in a cast with 80° of elbow flexion and supination. After one week, a repeat radiograph in clinic shows a recurrent dislocation of the radial head anteriorly with maintained reduction of the ulna. He has been listed on your trauma list.

What would be the best management?

A. Isolated closed reduction of radial head and placed into cast after procedure with 110° elbow flexion and pronation
B. Isolated closed reduction of radial head and placed into cast after procedure with 110° elbow flexion and supination
C. Isolated open reduction of radial head and placed into cast after procedure with 80° elbow flexion and supination
D. Revise proximal ulna fracture fixation and closed reduction of radial head and placed into cast after procedure with 80° elbow flexion and supination
E. Revise proximal ulna fracture fixation and open reduction of radial head and placed into cast after procedure with 80° elbow flexion and supination

14. An 81-year-old man has been admitted with a displaced intracapsular neck of femur fracture. He has been listed for a total hip arthroplasty.

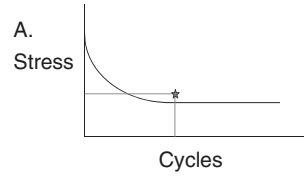
Which one of the following factors confers an advantage towards a hemiarthroplasty rather than a total hip arthroplasty?

A. Dislocation rate (within 4 years of index procedure)
B. Mortality rate
C. Post-operative infection
D. Quality of life and functional scoring with the Harris Hip Score
E. Reoperation rate

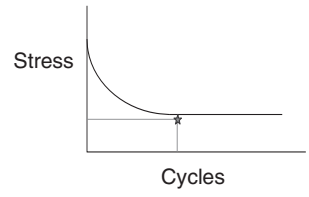
15. A 55-year-old diabetic smoker underwent antegrade nailing for his subtrochanteric femur fracture. His wound healed well, and he continued to make good progress until his leg suddenly gave way after 4 months. Radiographs confirm a non-union with a fractured nail at the site of the fracture.

Which image best depicts the mode of failure?

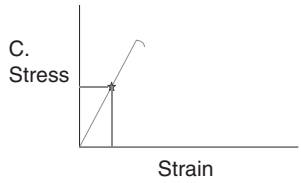
A.



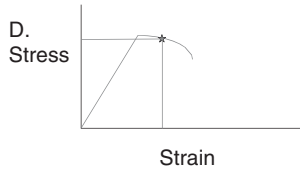
B.



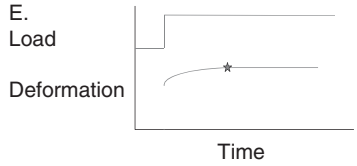
C.



D.



E.



16. A 14-year-old male footballer sustains a valgus twisting injury to his knee. His MRI shows an ACL (anterior cruciate ligament) rupture and a bucket handle medial meniscus tear. His physis is still open. He still has open physis around his knee and his height is 5 feet. His parents are both 6 feet.
What is your management plan?
A. As his physis is still closing, an isolated physiotherapy programme for his ACL-deficient knee
B. Carry out an all epiphyseal femoral tunnel and transphyseal tibial tunnel (hybrid) for his ACL reconstruction using hamstrings and a medial meniscal repair
C. As his physis is still closing, physiotherapy for his ACL-deficient knee and an isolated medial meniscus repair followed by ACL reconstruction once his physis are fully closed
D. Carry out a transphyseal for both femoral and tibial ACL reconstruction using hamstrings and medial meniscus repair
E. Carry out a transphyseal for both femoral and tibial ACL reconstruction using hamstrings and a partial medial meniscectomy

17. A subtrochanteric femoral fracture has been fixed in a varus deformity.
Which of the following factors has been shown to lead to this?
A. Inserting a greater trochanter entry nail through a piriformis fossa insertion point
B. Inserting a lateral entry nail through a piriformis fossa insertion point
C. Inserting a piriformis fossa entry nail through a greater trochanter tip insertion point
D. Inserting the ball-tipped guide wire for the nail laterally in the distal femur
E. Obese patient fixed with a greater trochanter entry nail

18. **Which of the following elbow fractures will be most amenable to treatment with a total elbow replacement?**
A. An 85-year-old female with osteoporosis and a severely comminuted distal humerus fracture
B. A 45-year-old labourer with an intra-articular T type distal humerus fracture
C. A 49-year-old female with non-union of a supracondylar humerus fracture
D. A 65-year-old male with a coronal fracture of the distal humerus
E. An 89-year-old female with osteoporosis and a transolecranon comminuted fracture dislocation of the elbow

19. A 45-year-old motorcyclist has come off his bike, sustaining an open femoral shaft fracture. He underwent a splenectomy for splenic haemorrhage and an extradural haemorrhage requiring invasive intracranial pressure measurement. You have debrided the femoral shaft fracture wound and bone edges.
What is the next most appropriate management plan?
A. Close the wound, place a traction pin in the tibia and carry out skeletal traction
B. Insert antibiotic beads, close the wound and place a traction pin in the tibia and carry out skeletal traction
C. Reamed antegrade intramedullary nailing
D. Stabilise the fracture with an external fixator
E. Unreamed antegrade intramedullary nailing

20. A patient underwent a long spiral comminuted humerus shaft fracture fixation with the posterior triceps muscle splitting approach and presents with a neurological deficit. As the fracture extended quite proximally, the incision extended

from within 3cm of the acromion and distally. The radial nerve was visualised and preserved.

Which of the following deficits is this patient likely to have?

A. Inability of finger abduction and adduction and loss of sensation to the little finger in the hand
B. Inability to abduct the arm and loss of sensation in lateral aspect of the shoulder
C. Inability to extend the wrist and loss of sensation to the first web space of the hand dorsally
D. Loss of contraction of pectoralis major and minor muscles
E. Weakness in flexing the elbow and loss of sensation to the lateral aspect of the forearm

21. A 23-year-old presented to the clinic with a humeral shaft fracture. He is unable to extend his wrist and fingers and has altered sensation over the radial aspect of the dorsum of his hand. You have decided to treat this conservatively.

Which of the following motor functions is expected to recover last?

A. Elbow extension
B. Finger abduction and adduction
C. Index finger hyperextension at the MCPJ
D. Ring finger extension at the MCPJ
E. Wrist extension

22. **Which of the following open tibial fractures is more likely to require an open reduction internal fixation and free flap soft tissue reconstruction?**

A. A Gustilo IIIA midshaft spiral tibia fracture
B. A Gustilo IIIB intra-articular displaced bicondylar fracture of the proximal tibia
C. A Gustilo IIIB intra-articular distal tibia fracture
D. A Gustilo IIIB proximal tibia lateral condyle depression and long split fracture to midshaft tibia
E. A Gustilo IIIB transverse tibia fracture

23. **Which of the following ways can be utilised to overcome distal femur anterior breach in antegrade nailing for the femur?**

A. A more posterior entry point for the nail proximally
B. A lateral proximal entry point
C. Ensuring the radius of curvature of the nail matches closely to the femur
D. Ensuring the radius of curvature of the nail is less than that of the femur
E. Lateral patient positioning

24. A 30-year-old base jumper presented with a mangled extremity and underwent an above-knee amputation. He presents to clinic complaining of his amputated leg pointing away from his contralateral normal leg while sitting or walking. His gait assessment reveals a side lurch, and he gets exhausted quickly with mobilisation.

What important step during the amputation was not done?

A. Bevelling of the distal femur after amputation
B. Dividing the sciatic nerve while on stretch to allow it to retract into the posterior thigh muscles
C. Loose closure of skin to cover the distal stump
D. Myodesis of the adductor tendon
E. Prominence of the bone due to inadequate muscle coverage of the distal femur

25. An obese 35-year-old fell from a ladder, landing on his left foot and sustaining an isolated Schatzker II tibial plateau fracture.

Which of the following injuries is most frequently associated with this fracture?

A. Anterior cruciate ligament rupture
B. Lateral collateral ligament rupture
C. Lateral meniscal tear
D. Medial collateral ligament rupture
E. Medial meniscal tear

26. A patient attends the emergency department sustaining a supination adduction type of ankle fracture.

When planning to internally fix his medial malleolus, what form of plating will be required?

A. Bridge plating
B. Buttress/anti-glide plating
C. Compression plating
D. Neutralisation plating
E. Tension-band plating

27. A 48-year-old patient has sustained a Schatzker II proximal tibia fracture.

Which substance used to fill the void after elevation of joint line has the highest compressive strength?

A. BMP-impregnated collagen sponge
B. Calcium phosphate cement
C. Cancellous autograft
D. Cancellous autograft freeze-dried
E. Tricalcium phosphate

28. A patient is brought to clinic to check on the healing of a conservatively treated anterior column pelvic fracture.
Which view will help best assess this area?

A. Anteroposterior radiograph of the pelvis
B. Inlet view
C. Judet – iliac oblique view
D. Judet – obturator oblique view
E. Outlet view

29. A 40-year-old man is admitted to the ED following a fall. He presents with haematuria. Radiograph is shown in Figure 16.1.

Figure 16.1 Anteroposterior (AP) pelvis

His injury is likely to be where?

A. Bladder
B. Bulbous urethra
C. Membranous urethra
D. Prostatic urethra
E. Ureter

30. A 24-year-old polytrauma patient came off a motorcycle. He sustained axial loading on a fully abducted arm and extended elbow (Figure 16.2).
What is his most likely injury?

Figure 16.2 Clinical picture on admission to ED

A. Brachial plexus injury
B. Dislocated shoulder
C. Proximal humeral fracture
D. Scapula fracture
E. Vascular injury

31. **How would you reduce this fracture (Figure 16.3)?**

Figure 16.3 Anteroposterior (AP) radiograph ankle

A. Pronation of the foot and abduction
B. Pronation of the foot and external rotation
C. Pronation of the foot and internal rotation

D. Supination of the foot and adduction
E. Supination of the foot and internal rotation

32. A 70-year-old patient underwent a femoral nail following an RTA. The next day she was found to be confused, short of breath and had a petechial rash.
Which of the following parameters is this patient most likely to also have?
A. PaO_2 70mmHg
B. Hypothermia
C. pH 7.5
D. Raised platelet count.
E. Sudden fall in haematocrit

33. A 50-year-old motorcyclist is admitted with an intra-articular fracture of the right acetabulum involving the anterior column only.
Which structures are more at risk during the open approach to fix this fracture?
A. Bladder, Corona mortis, External iliac vessels, Obturator neurovascular bundle
B. Bladder, Obturator neurovascular bundle, External iliac vessels, rectum, Urethra
C. Sciatic nerve, Bladder, Inferior gluteal neurovascular bundle, Superior gluteal neurovascular bundle
D. Sciatic nerve, femoral nerve, Inferior gluteal neurovascular bundle, Superior gluteal neurovascular bundle
E. Sciatic nerve, Inferior gluteal neurovascular bundle, Superior gluteal neurovascular bundle

34. **Which of these options is the correct limitation for approaches for tibial plateau fracture fixation?**
A. Hockey stick anterolateral approach limited distally approximately 30cm from joint line due to danger to superficial peroneal nerve
B. Posterolateral approach (Frosch) limited 5cm distally from joint due to trifurcation of vessels at interosseous membrane
C. Posteromedial approach (Lobenhoffer) limited distally due to arch of soleus and posterior neurovascular bundle
D. Posteromedial approach (Lobenhoffer) limited distally due to trifurcation of vessels at interosseous membrane
E. Posteromedial approach (Lobenhoffer) limited proximally by medial head of gastrocnemius

35. A 25-year-old sustains an open book pelvic fracture with disruption of the right sacroiliac joint and a right anterior column fracture. Numerous radiographic techniques have been described to assist in fixation.
Which one of these combinations is NOT correct?
A. Iliac (External) oblique view to view posterior column and anterior wall
B. Lateral sacral view for insertion of sacroiliac screw in midpoint of the sacral alae
C. Obturator (Internal) oblique view to view anterior column and posterior wall
D. Outlet view helps with superior – inferior sacroiliac screw placement in the S1 body
E. Outlet view of the pelvis will help in anterior – posterior sacroiliac screw placement in the S1 body

36. **After fixation of a subtrochanteric femur fracture with an antegrade nail which muscles most likely lead to the most common deformity after fixation?**
A. Abductors of the hip and iliopsoas
B. Abductors of the hip and quadriceps
C. External rotators of the hip and hamstrings
D. External rotators of the hip and quadriceps
E. Hamstrings and iliopsoas

TRAUMA II STRUCTURED SBA ANSWERS

1. Answer A. **CT scan of the ankle followed by open reduction and internal fixation of the posterior malleolus with a buttress plate and fibula plating (posterolateral approach) and medial malleolus fixation with cannulated screws (medial approach) +/– syndesmosis stabilisation**

   A recent review of practice by Solan and Sakellariou (2017) has made best practice recommendations for fixation of ankle fractures with a posterior malleolus component. CT scans are recommended in the context of complex fractures with a posterior malleolar element to help identify fracture configuration to plan fixation. It is recommended to start with provisionally reducing the posterior malleolus to ensure the fibula comes to length. AP screws are not recommended, as they may push the fragment away. Posterolateral approach provides a good view of the posterior malleolar reduction and allows access to the fibula from a separate window. Option A allows this 35-year-old to weight bear early once the soft tissues have healed.

   PMID 29092978

   Solan MC, Sakellariou A. Posterior malleolus fractures: worth fixing. *Bone Joint J.* 2017;**99**:1413–1419.

2. Answer A. **Approach the midshaft of the radius via the brachioradialis/flexor carpi radialis first with the forearm pronated during deep dissection and then work proximally between brachioradialis/pronator teres with the forearm supinated. Then fix the ulna through a separate approach**

   Generally, it is best to fix the radius first to restore the radial bow using a modified Henry's approach. The ulna often comes to good alignment to allow for fixation. It is preferred to develop the incision over the midshaft of the radius first and then follow this proximally to allow better identification of anatomical structures and muscular planes. While dissection is being carried out to expose the proximal radius, the forearm is kept supinated to avoid damage to the PIN. For the midshaft of the radius, deep dissection is done with the forearm in pronation for similar reasons. To avoid radioulnar synostosis, it is advised to have separate incisions for the ulna and radius.

3. Answer B. **Exposure via a lateral approach viewing the reduction of the joint anteriorly and insert two divergent Kirshner wires for stabilisation. Removal of the wires in 4–6 weeks' time in clinic and follow up over 2 years**

   Paediatric lateral condyle fractures are fixed when displaced to allow for accurate reduction and normal growth. Accurate reduction may be facilitated with open reduction. Care should be taken to avoid soft tissue stripping posteriorly, as it will disrupt the blood supply. Divergent K-wire fixation maintains reduction. In contrast, convergent wires are inferior in maintaining reduction. Wires can be left buried or outside the skin. A recent study did not show reduced infection rates with burying K-wires. Removal is done at 4–6 weeks, and follow up is required to ensure normal growth. Inadequate reduction may lead to abnormal growth with valgus and consequently a tardy ulnar nerve palsy.

   PMID 29263760

   Wormald JC, Park CY, Eastwood DM. A systematic review and meta-analysis of adverse outcomes following non-buried versus buried Kirschner wires for paediatric lateral condyle elbow fractures. *J Child Orthop.* 2017;**11**:465–471.

4. Answer E. **A 78-year-old female with known breast cancer with metastasis in her liver and vertebrae undergoing radiotherapy with a pathological fracture through a lytic area in the subtrochanteric region of the femur**

   It is important that patients with a pathological fracture are worked up prior to surgical management with intramedullary nailing. In option C, the patient has a RCC and therefore will be at risk of catastrophic bleeding intraoperatively. A consideration for preoperative embolisation of the lesion is needed to reduce the bleeding risk. In option A, the patient may have a primary bone tumour at risk of seeding further distally with nailing. They will need discussing with the local bone tumour unit for definitive management. In option D, the likelihood is that the patient has breast cancer metastasis leading to the pathological fracture. Despite the likelihood, a definitive diagnosis is needed, with appropriate

investigations prior to nailing. This is the same for option A. In option E, we know the patient has breast cancer with metastasis in her organs and bone and therefore directly proceeding to nailing will be beneficial.

5. Answer B. **A 25-year-old male is involved in an accident as a front seat passenger. He is found to have a fracture extending from the anterior aspect of the L2 vertebral body passing all the way posteriorly with widening of the interspinous area. He has reduced sensation over his knee, medial malleolus and posterior calf and reduced power with knee extension, ankle dorsiflexion and great toe extension**
The TLICS scoring system was devised to guide surgical treatment for patients with spinal fractures (Table 16.1). It has excellent validity and is widely used. However, it should be noted that almost all the papers that mention the safety and reliability of TLICS belong to the authors that have developed the system.

In option A, the patient has sustained a SCIWORA (spinal cord injury without radiological abnormality). Closely observing these patients is recommended to assess for return on neurology.

In option C, the TLICS is 2 and therefore not likely to require surgical intervention. Follow up will assess kyphotic deformity and healing. Burst fractures need assessment on a case by case basis and therefore just relying on the TLICS may not be wise.

In option D, the patient' s TLICS is 1 and therefore will be treated conservatively.

In option E, the patient has osteoporotic fractures. She will require screening for myeloma.

In option B, the patient has a TLICS of 9 or 10 and therefore most likely to benefit from surgical fixation.

PMID: 27943230

Yuksel MO, Gurbuz MS, Is M, Somay H. Is the Thoracolumbar Injury Classification and Severity Score (TLICS) superior to the AO Thoracolumbar Injury Classification System for guiding the surgical management of unstable thoracolumbar burst fractures without neurological deficit? *Turk Neurosurg.* 2018;**28**:94–98.

6. Answer C. **Transfer of the extensor indicis tendon to restore thumb extension**
The tendon most commonly ruptured with undisplaced distal radius fractures is the extensor pollicis longus (EPL). This results in a loss of thumb extension. Therefore, it is imperative this tendon is examined on routine follow ups and the patient is made aware of the risk so they may seek treatment early. Reconstruction of the EPL

Table 16.1 Thoracolumbar Injury Classification and Severity (TLICS) Score

TLICS Three independent predictors			
1 **Morphology** Immediate stability	Compression Burst Translation/rotation Distraction	1 2 3 4	Radiographs CT
2 **Integrity of PLC** Long-term stability	Intact Suspected Injured	0 2 3	MRI
3 **Neurological status**	Intact Nerve root Complete cord Incomplete cord Cauda equina	0 2 2 3 3	Physical examination
Predicts	Need for surgery	0–3 4 >4	Non-surgical Surgeon's choice Surgical

can be done using EI, APL or the FDS. EI is most suitable as it most complies with tendon transfer principles with similar excursion, least sacrifice of movement and same line of pull.

7. Answer E. **Lumbrical muscles and vinculum longus**
The tendon torn is the FDP. This injury is also referred to as the 'Jersey finger'. The lumbricals originate on the FDP tendon and therefore are overactive when the torn FDP is actively flexed. This leads to the paradoxical extension of the IP joints on attempted grip. This is referred to as the lumbrical plus finger. Restriction of the FDP retraction is due to attachments of the vinculum longus and lumbricals. The other structures do not attach to the FDP and therefore do not restrict its retraction.

8. Answer A. **A medial malleolar osteotomy**
The main blood supply of the talus enters via the deltoid ligament from branches of the posterior tibial artery. Therefore, it is imperative the deltoid ligament is protected. A posteromedial approach will destroy this blood supply and therefore is not recommended. A medial malleolar osteotomy will preserve the deltoid and provide adequate access to the medial talar body for fixation. An anterior or anteromedial approach will not provide sufficient exposure to fix the talar body.

9. Answer B. **Combined retrograde nail from the knee to the tip of the hip replacement with a locking plate to the proximal femur with screws around the femoral stem of the hip replacement**
Stress risers are a common pitfall after fixation of these fractures. This is mainly related to around the proximal tip of retrograde nails and when the locking plate construct ends distal to the femoral stem. A locking plate in isolation that spans from the distal to proximal femur may be suitable, but new evidence is coming to light that early weight bearing can be permitted with a combination of nail and plate construct.
PMID: 34836629
Garala K, Ramoutar D, Li J, Syed F, Arastu M, Ward J, Patil S. Distal femoral fractures: A comparison between single lateral plate fixation and a combined femoral nail and plate fixation. *Injury*. 2022 Feb;53(2):634–639.

10. Answer E. **Vascular bypass shunt in theatre, External fixation to maintain reduction, On table angiography, Vascular repair/reconstruction +/- fasciotomy, Delayed knee ligament reconstruction following MRI of the knee**
This patient presents with an acutely ischaemic limb. It is best to call the vascular surgeons for immediate assessment and a plan made together. A vascular bypass shunt initially will reperfuse the limb and reduce ischaemia time. An external fixator is then applied, taking into account the need for posterior access to the knee by the vascular surgeons. The external fixator will allow for stability for the vascular surgeons. This is best followed by an on table angiogram to identify the vascular lesion and proceed to vascular reconstruction. A fasciotomy may be required at the end, depending how long the limb was exposed to ischaemia. The external fixator can be removed in 4–6 weeks and a manipulation under anaesthesia performed under general anaesthetic. Reconstruction of the ligaments can be delayed. Reconstruction strategy will be informed by findings from MRI and clinical evaluation.
PMID: 32296548.
Ng JWG, Myint Y, Ali FM. Management of multiligament knee injuries. *EFORT Open Rev*. 2020 Mar 2;5(3):145–155.

11. Answer D. **External rotation of the proximal fragment**
The proximal fragment will have unopposed external rotation due to the short external rotators. Internal rotation of the proximal fragment can be facilitated with a joystick guidewire for better reduction. There is a deforming adduction force on the distal fragment that can be countered by abduction enough to ensure adequate proximal entry for wire entry and the nail. Traction of the limb allows countering the shortening effects of the quadriceps. Extension of the hip may help counter the flexion force of the proximal fragment, although, due to discontinuity, distal fragment extension may not alter the proximal fragment position.

12. Answer A. **Medial Incision: extensor hallucis longus; Lateral incision: peroneal artery**

Please refer to this BAPRAS document for a revision of fasciotomy anatomy: www.bapras.org.uk/docs/default-source/commissioning-and-policy/standards-for-lower-limb.pdf?sfvrsn=0.

13. Answer B. **Isolated closed reduction of radial head and placed into cast after procedure with 110° elbow flexion and supination**
This patient has sustained a Monteggia fracture dislocation. This is Bado type I due to the anterior radial head dislocation. Operative treatment went well with good post-operative reduction of the fracture and dislocation; however, flexion was only 80° at the elbow. Most of the time, this may suffice but, in this patient, has resulted in a recurrent radial head dislocation. As the fracture of the ulna continues to be well reduced in the repeat radiographs, manipulation under anaesthesia and casting in 110° of flexion at the elbow with the forearm in supination will suffice. Pronation will not help with reduction, and revision of the ulna fixation will not make any difference as the ulna is not the problem here. Open reduction of the radial head is rarely required if there is soft tissue interposition – this would have transpired had the radial head not reduced with the primary operation.

14. Answer A. **Dislocation rate (within 4 years of index procedure)**
A recent review article found increased dislocation rates with THA within 4 years of the index procedure compared with hemiarthroplasty. There were no differences in mortality rates and post-operative infection. THA had lower reoperation rates and better quality of life and functional scores.

PMID 31060915.

Lewis DP, Wæver D, Thorninger R, Donnelly WJ. Hemiarthroplasty vs total hip arthroplasty for the management of displaced neck of femur fractures: a systematic review and meta-analysis. *J Arthroplasty* 2019;**34**:1837–1843.

15. Answer A.
Due to the non-union, the implant has been working above its endurance limit and therefore ultimately fails. In B the implant is under its endurance limit and therefore cannot fail. In D and C, the implant has not reached breaking point. Figure E represents creep, which is a viscoelastic property and not related to implant failure.

16. Answer B. **Carry out an all epiphyseal femoral tunnel and transphyseal tibial tunnel (hybrid) for his ACL reconstruction using hamstrings and a medial meniscal repair**
Adolescents at age 14 sustaining an ACL tear benefit from ACL reconstruction with hamstrings. It has shown to reduce chondral and meniscal damage as it avoids continuing instability. In the setting of an associated meniscal tear, the case for an ACL reconstruction is even more strong.

With regards to the type of tunnel, an all epiphyseal femoral tunnel avoids traversing the posterolateral aspect of the femoral physis with a transphyseal femoral tunnel and therefore avoids future deformity.

A transphyseal tibial tunnel kept below 9mm has shown to have minimal effect on future growth. Using a more vertical tunnel and avoiding hardware/bone plugs across the physis make it less likely for growth-related complications to develop.

Therefore, a delay in ACL reconstruction until the physis fuses is not necessary. The repair of the meniscus will benefit from ACL reconstruction in the same sitting to ensure integrity and superior healing rates. A partial medial meniscectomy in the context of the injuries sustained is not good for the patient's knee in the long term.

17. Answer C. **Inserting a piriformis fossa entry nail through a greater trochanter tip insertion point**
Inserting a piriformis entry nail through a greater trochanter (GT) tip insertion point will lead to a varus fixation of the subtrochanteric fracture. The GT is lateral to the axis of the femur. As the straight piriformis nail is inserted into the GT, the GT axis and femoral axis become co-linear, leading to varus.

Insertion of the ball-tipped guide wire laterally in the distal femur will not lead to a varus deformity. In obese patients, it is preferred to fix the fracture with a GT entry nail with maximal leg adduction.

PMID: 29326763.

Sadagatullah AN, Nazeeb MN, Ibrahim S. Incidence of varus malalignment post interlocking nail in proximal femur shaft fractures comparing two types of entry points. *Malays Orthop J.* 2017;**11**:31.

18. Answer A. **An 85-year-old female with osteoporosis and a severely comminuted distal humerus fracture**

Although the optimal treatment of distal humerus fractures has yet to be determined, there is a well-described indication of total elbow replacement (TER) for comminuted distal humerus fractures in the elderly. Studies have shown poor results with open reduction and internal fixation (ORIF) of distal humerus fractures in the elderly. There was a 25% conversion to TER following failure of ORIF. Elderly patients who underwent TER primarily had excellent outcomes. Non-unions in younger patients are better dealt with ORIF +/– bone grafting. Dislocated elbows with transolecranon fractures are more amenable to fixation +/– elbow stabilisation with ligament reconstruction. Young labourers will not fare well with TER.

PMID: 25035841.

Sørensen BW, Brorson S, Olsen BS. Primary total elbow arthroplasty in complex fractures of the distal humerus. *World J Orthop.* 2014;**5**:368.

19. Answer D. **Stabilise the fracture with an external fixator**
This patient has sustained a severe head injury and therefore requires a damage-control approach, which will rule out nailing as a treatment option currently. The aim is to avoid a second hit, which may further deteriorate the patient. With external fixation option available, traction provides an inferior technique for stabilisation of the femur.

20. Answer B. **Inability to abduct the arm and loss of sensation in lateral aspect of the shoulder**
Axillary nerve is at risk when the posterior approach to the humerus is proximally extended to within 8cm of the posterolateral tip of the acromion. This leads to the deficits described in option B. Option C relates to the radial nerve, which was found to be preserved. Option E, musculocutaneous nerve, option A, ulnar nerve, and option D, medial and lateral pectoral nerves are not in danger with the approach described.

21. Answer C. **Index finger hyperextension at the MCPJ**
This patient presents with a radial nerve palsy. This can be treated conservatively, and the function of the nerve reviewed regularly in clinic. The last motor supply of the radial nerve is to the extensor indicis proprius; therefore, this will recover last.

22. Answer C. **A Gustilo IIIB intra-articular distal tibia fracture**
Open intra-articular fractures of the distal tibia often require free flap soft tissue reconstruction due to the lack of local rotational flaps that can be constructed. In the proximal tibia, a gastrocnemius rotational flap can be utilised and mid-shaft tibia fractures can be covered with a soleus rotation flap. Distal tibia fractures can be covered with a local fasciocutaneous flap or a distally based sural artery flap, but the incidence of requiring a free flap is higher as compared with other regions of the tibia.

PMID:22912523

Kamath JB, Shetty MS, Joshua TV, Kumar A. Soft tissue coverage in open fractures of tibia. *Indian J Orthop.* 2012;**46**:462.

23. Answer C. **Ensuring the radius of curvature of the nail matches closely to the femur**
Several studies have shown that mismatch of the radius of curvature of the nail with the femur is a known factor causing anterior cortex perforations in the distal femur. A more anterior entry starting point proximally can be utilised to avoid this complication. Lateral entry point and lateral patient positioning do not have an effect.

PMID: 25104888.

Kanawati AJ, Jang B, McGee R, Sungaran J. The influence of entry point and radius of curvature on femoral intramedullary nail position in the distal femur. *J Orthop.* 2014;**11**:68–71.

24. Answer D. **Myodesis of the adductor tendon**
This patient's abductors are overpowering and not neutralised; therefore, his limb is abducted, which leads to a side lurch and extra energy expenditure. A myodesis of the adductor tendon allows neutralisation of the abductor forces on the femur and therefore required intraoperatively.

25. Answer C. **Lateral meniscal tear**
Lateral meniscal tears frequently accompany lateral tibial plateau split/depression fractures. The higher the injury is, the more likely soft tissue injuries are to result. LCL and PCL ligament ruptures are also known to occur, but lateral meniscal

tears are more frequent and require repair at the time of surgical fixation of the fracture.

26. Answer B. **Buttress/anti-glide plating**
Supination adduction ankle fractures lead to a vertical medial malleolus fracture. This is best fixed with buttress or anti-glide plating.

27. Answer B. **Calcium phosphate cement**
The compressive strength of calcium phosphate cement superseded the other options when studied on cadavers.

PMID: 16314717.

Trenholm A et al. Comparative fixation of tibial plateau fractures using α-BSM™, a calcium phosphate cement, versus cancellous bone graft. *J Orthop Trauma* 2005;**19**:698–702.

28. Answer D. **Judet – obturator oblique view**
Judet views help to assess the pelvic columns and walls. An iliac oblique view is appropriate to assess the posterior column and anterior wall. The obturator oblique view best visualises the anterior column and posterior wall. The other options are useful but not best for visualising the anterior column.

29. Answer C. **Membranous urethra**
The radiograph demonstrates widening of the pubic symphysis and the suggestion of a full bladder. Figure 16.4 is not a cystogram or urethrogram as no white contrast is seen.

Urethral injuries can be classified into 2 broad categories based on the anatomical site of the trauma. Posterior urethral injuries are located in the membranous and prostatic urethra. These injuries are most commonly related to major blunt trauma such as motor vehicle collisions and major falls, and most of such cases are accompanied by pelvic fractures. Injuries to the anterior urethra are located distal to the membranous urethra. Most anterior urethral injuries are caused by blunt trauma to the perineum (straddle injuries), and many have delayed manifestation, appearing years later as a urethral stricture.

30. Answer B. **Dislocated shoulder**
The clinical picture on admission to the ED shows a right hyperabducted shoulder with bulging of the axillary skin due to inferior displacement of the humeral head.

Most inferior dislocations of the shoulder are the result of one of two mechanisms. A direct axial load on an abducted arm can force the humeral head inferiorly with respect to the glenoid. Forceful hyperabduction on an already partially abducted arm can lever the humeral neck against the acromion and force the head inferiorly. Both mechanisms usually occur during a

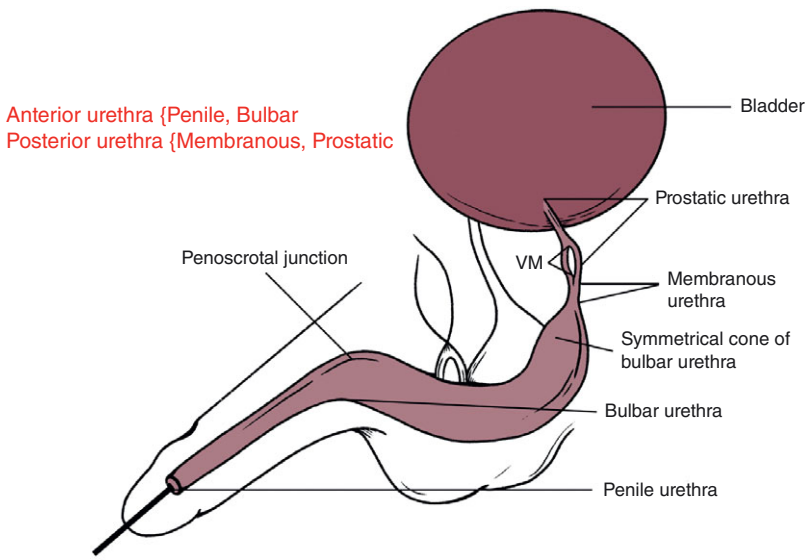


Figure 16.4 Diagram demonstrating urethra anatomy in male patient. VM, verumontanum

fall as a patient attempts to catch himself/herself with an outstretched arm. Although motor vehicle accidents or falls from a height are the most associated mechanism, inferior dislocation associated with sports have been reported.

The affected arm is locked in a hyperabducted position above the head, usually with the elbow flexed. The humeral head may be palpable or visible in the axillary fossa. The arm was abducted in a 'hands-up' position, any movement from this position is painful.

The clinical presentation is distinct when the affected arm is held above and behind the head and patient is unable to adduct arm.

This is often associated with nerve injury, rotator cuff injury, tears in the internal capsule, and the highest incidence of axillary nerve all shoulder injuries. Arterial injury is reported in 3.3% of cases and more common in patients over 50 years of age mainly due to an overlying atherosclerosis.

Sogut O, Yigit M, Karayel E, Demir N. Luxatio erecta humeri: hands-up dislocation. *J Emerg Med.* 2015;**49**:e53–55.

Yamamoto T, Yoshiya S, Kurosaka M, Nagira K, Nabeshima Y. Luxatio erecta (inferior dislocation of the shoulder): a report of 5 cases and a review of the literature. *Am J Orthoped.* 2003;**32**:601–603. PMID: 14713067.

Figure 16.5 Right upper extremity at admission. Shown is a hyperabducted shoulder with bulging axillary skin due to inferior displacement of the humeral head

31. Answer C. **Pronation of the foot and internal rotation**
Candidates have to use the principles of the Lauge–Hansen classification. Candidates need to understand how to reduce an ankle with a spiral fracture of the distal fibula through the syndesmosis and a transverse medial malleolar fracture.

Table 16.2 Lauge–Hansen Classification

Subtype	Fractures	Weber Analogy
Supination-adduction	• Fibular avulsion • Vertical shear fracture of the medial malleolus	Weber A
Supination external rotation	• Oblique/spiral fracture of distal fibula +/− medial malleolar avulsion	Weber B
Pronation-abduction	• Transverse fibular fracture at syndesmosis +/− medial malleolar fracture +/− butterfly fragment	Weber B
Pronation external rotation	• Suprasyndesmotic fibular fracture +/− medial malleolar avulsion	Weber C

32. Answer E. **Sudden fall in haematocrit**
- Fat Embolism Syndrome is an acute respiratory disorder caused by an inflammatory response to embolised fat globules that may enter the bloodstream as a result of acute long bone fractures or intramedullary instrumentation. Patients present with hypoxia, changes in mental status and petechial rash. A decrease in haematocrit occurs within 24–48 h and is attributed to intra-alveolar haemorrhage.
- Diagnosis is made clinically with presence of hypoxemia ($PaO_2 < 60$), CNS depression, petechial rash and pulmonary oedema.

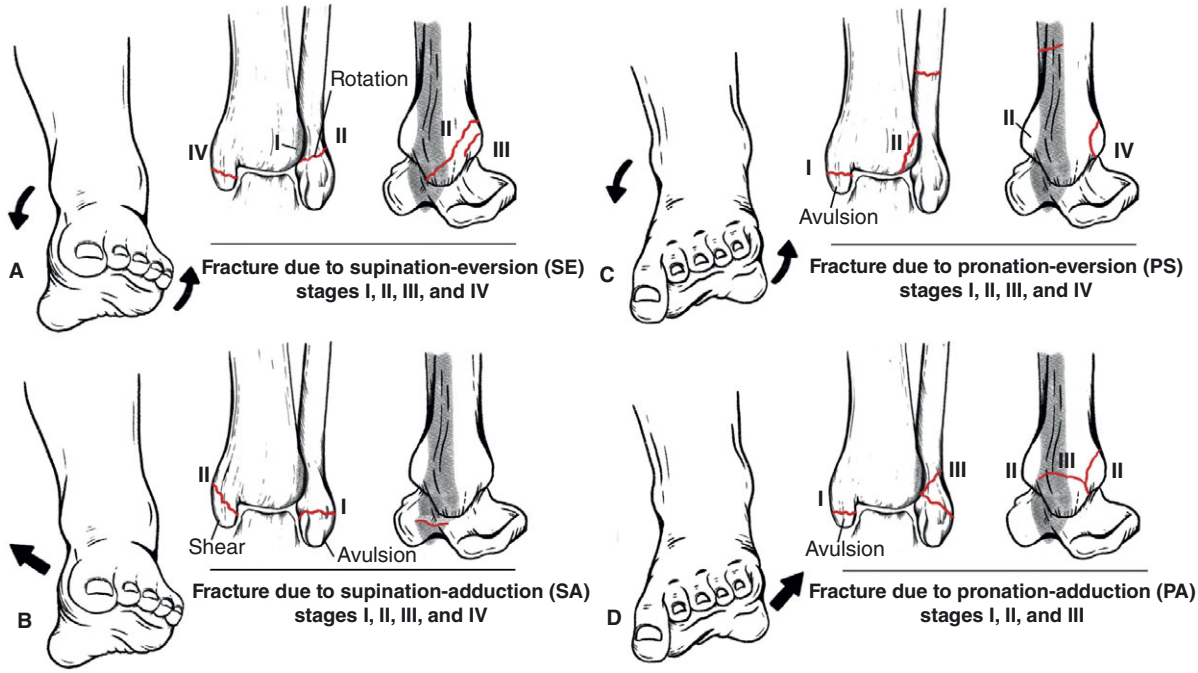


Figure 16.6 Lauge–Hansen Classification of ankle fractures

- Treatment is focused on prevention with early stabilisation of long bone fractures. Mechanical ventilation with high levels of PEEP is the recommended treatment for acute presentation.
- Major (1)
  - Hypoxaemia ($PaO_2 < 60$). (N = 75–100)
  - CNS depression (changes in mental status)
  - Petechial rash
  - Pulmonary oedema
- Minor (4)
  - Tachycardia
  - Pyrexia
  - Retinal emboli
  - Fat in urine or sputum
  - Thrombocytopenia
  - Decreased HCT
- Additional
  - $PCO_2 > 55$
  - pH <7.3
  - RR >35
  - Dyspnoea
  - Anxiety

Two theories are postulated for the occurrence of FES.

- First, there is the mechanical theory by Gassling and Pellegrini (1982) which states that large fat droplets are released into the venous system; these droplets are deposited in the pulmonary capillary beds and travel through arteriovenous shunts to the brain. Microvascular lodging of the droplets produces local ischaemia and inflammation, with concomitant release of inflammatory mediators and vasoactive amines and platelet aggregation.
- The biochemical theory states that hormonal changes caused by trauma and/or sepsis induce systemic release of free fatty acids as chylomicrons. Acute-phase reactants, such as C-reactive proteins, cause the chylomicrons to coalesce and create the physiological reactions described above.

Gossling HR, Pellegrini VD Jr. Fat embolism syndrome: a review of the pathophysiology and physiological basis of treatment. *Clin Orthop Relat Res.* 1982;**165**:68–82. PMID: 7042168.

33. Answer A. **Bladder, Corona mortis, External iliac vessels, Obturator neurovascular bundle**

This question requires the candidate to think about the various approaches to the pelvis. With anterior column and acetabular involvement, the recommended approaches are the ilio-inguinal and Stoppa's approach. Stoppa's approach is more popular amongst pelvic surgeons due to better reduction, operative time and complications. This approach provides clear acetabular access, including access to the pubic body, superior ramus and pubic root, the ilium above and below the pectineal line, the quadrilateral plate, and the medial aspect of the posterior column, sciatic buttress and anterior sacroiliac joint.

The structures in option A refer to the dangers of the Stoppa's approach. The corona mortis is a leash of vessels forming the anastomosis between the external iliac and obturator vessels.

34. Answer B. **Posterolateral approach (Frosch) limited 5cm distally from joint due to trifurcation of vessels at interosseous membrane**

This SBA is testing knowledge of the posterolateral approach to the tibia to fix a posterolateral tibial plateau fracture. These fractures require anatomic articular reduction and buttress plate fixation on the posterior aspect. This is difficult to achieve through a lateral or anterolateral approach. A modified posterolateral approach can be used.

Option A: The Hockey stick incision can be continued distally and is not limited by the superficial peroneal nerve. The extension will be similar to the lateral incision for a fasciotomy.

Option B: The Frosch approach is limited distally due to the trifurcation. It allows visualisation through two windows, anterolateral and posterolateral. Further advantages include the avoidance of a fibular osteotomy as described by the posterolateral Lobenhoffer approach.

Option C: The arch of soleus can be lifted and the posterior neurovascular bundle is usually protected in distal extension. If further distal extension is required, the medial fasciotomy incision can be followed.

Option D: The trifurcation is encountered with distal extension of the Frosch approach and not the posteromedial Lobenhoffer.

Option E: The posteromedial Lobenhoffer approach is limited by the medial head of gastrocnemius, but the head can be incised and repaired later to overcome the limitation and achieve better visualisation more laterally.

A limitation of the posterolateral approach (Frosch) is that it cannot be extended distally because of the trifurcation vessels that traverse the interosseous membrane approximately 5 cm below the joint line. However, because the lateral tibial metaphysis has a posterior inclination angle of approximately 45°and the posterolateral split fracture segment is usually less than 4 cm in cortical length, this limitation does not seem to be a problem in practice. Iatrogenic injuries to vascular structures do not tend to occur in practice.

Frosch KH, Balcarek P, Walde T, Stürmer KM. A new posterolateral approach without fibula osteotomy for the treatment of tibial plateau fractures. *J Orthop Trauma.* 2010;**24**:515–520. PMID: **20657262**

Raschke MJ, Kittl C, Domnick C. Partial proximal tibia fractures. *EFORT Open Rev.* 2017;**2**:241–249.

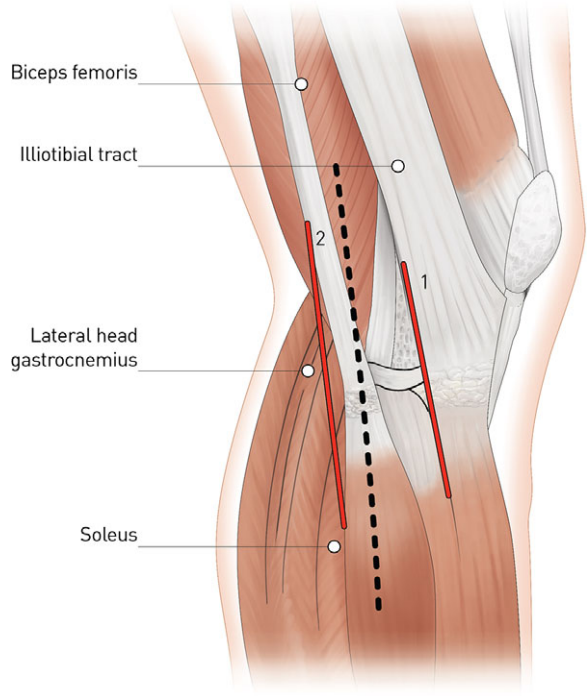


Figure 16.7 An anatomic drawing of the lateral and posterolateral region of the knee. Dashed black line: skin incision; 1: lateral standard arthrotomy; and 2: blunt dissection of the popliteal fossa between M. soleus and M. gastrocnemius (lateral head).

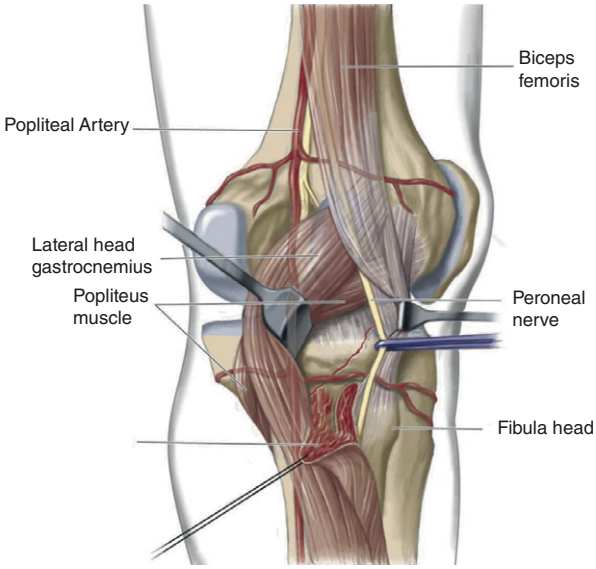


Figure 16.8 In the distal direction, the soleus and the peroneal nerve border the situs. In the medial direction, the operation site is bordered by the popliteal artery and nerve. Superiorly the operation site is bordered by the popliteus and in the lateral direction by the fibular head, the lateral collateral ligament, the biceps femoris, and the peroneal nerve. The dissected area at the tibial is approximately 3 cm wide superiorly, L-shaped, and approximately 4 to 5 cm length from a cranial to caudal direction. Figure reused with permission by Wolters Kluwer Health

35. Answer E. **Outlet view of the pelvis will help in anterior – posterior sacroiliac screw placement in the S1 body**

The way to remember the Outlet view is to think of the various 'O's that can be seen, the bilateral Obturator foramen 'O's as well as the sacral foramen 'O's for the exiting nerve roots. This view allows for the Superior-Inferior placement of the sacroiliac screw insertion.

The correct description is Option D. The answer (Option E) is the correct combination utilising the Inlet view and not the Outlet view.

The optimal angulation for an inlet view is 25° caudal tilt, and 60° cranial tilt for the outlet view.

Inlet view: This is a cranial tilt (X-ray tube angle toward head and photons beamed in a caudal direction). The beam is perpendicular to the S1 end plate.

Outlet view: This is a caudal tilt (X-ray tube angled toward feet and beamed in cranial direction). Demonstrates cranial-caudal displacement of the pelvic ring and sacral morphology.

Do not mix up inlet and outlet views with Judet views.

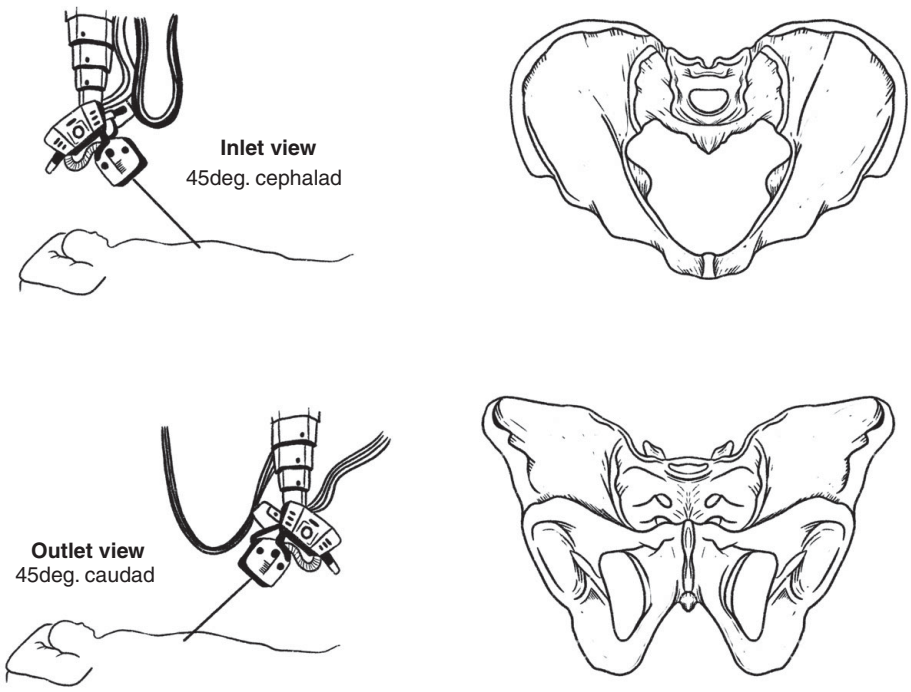


Figure 16.9 Inlet and outlet views. The optimal angulation for an inlet view is 25° caudal tilt, and 60° cranial tilt for the outlet view

36. Answer A. **Abductors of the hip and iliopsoas**
The most common deformity after antegrade nailing for a sub-trochanteric femoral fracture is varus and procurvatum. This is due to the action of the abductors and iliopsoas on the proximal fragment and the adductors on the distal fragment. The article referenced below talks about an interesting method to help reduce this deformity with intramedullary nailing. The concepts discussed allow an in-depth understanding of the different generations of nails and how important the technique for the entry portal on the femur is, in avoiding subsequent deformity.

Russell TA, Mir HR, Stoneback J, Cohen J, Downs B. Avoidance of malreduction of proximal femoral shaft fractures with the use of a minimally invasive nail insertion technique (MINIT). *J Orthop Trauma* 2008;**22**:391–398.
PMID: **18594303**.

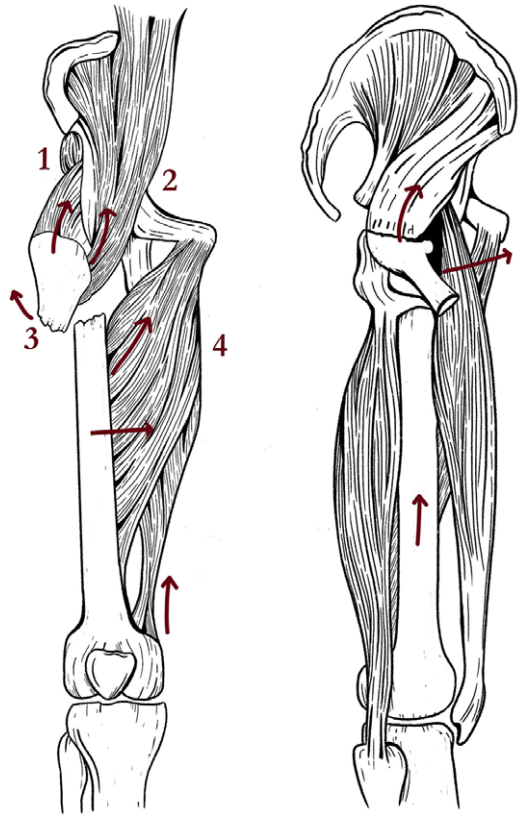


Figure 16.10 The muscular deforming forces around the proximal femur

Chapter 17

Trauma III Structured SBA

Yusuf Omran Hasan

TRAUMA III STRUCTURED SBA QUESTIONS

1. A 23-year-old male had a twisting injury to his left ankle while playing in a local Sunday football league. His radiographs are shown in Figure 17.1.

Figure 17.1 Anteroposterior (AP) and lateral radiographs ankle

Which of the following signs or tests is the best predictor of the stability of the fracture?

A. Gravity stress views
B. Intraoperative stress views
C. Medial side bruises
D. Medial side tenderness
E. Weight bearing radiographs

2. A 9-month-old child was brought to the ED by his mother after falling onto his leg. The on-call ST3 registrar applies a hip spica. The patient is neurovascularly intact and his pain is controlled. The radiographs are shown in Figure 17.2.

What is the next step in the management of this patient?

Figure 17.2 Anteroposterior (AP) and lateral radiographs right femur

A. Admit the patient
B. Follow up in 2 weeks with radiographs on arrival
C. Gallows traction
D. Pavlik harness
E. Reapply the cast as the reduction is not acceptable

3. During the daily trauma meeting, it was agreed that the injury represents a Haraguchi Type 1 fracture and requires fixation with a buttress plate.

Which of the following is the correct internervous plane of the commonly used approach to fix this fracture?

A. Deep peroneal nerve and superficial peroneal nerve
B. Tibial nerve and deep peroneal nerve
C. Tibial nerve and femoral nerve

D. Tibial nerve and superficial peroneal nerve
E. There is no true internervous plane

4. A 34-year-old man is brought to the ED after a road traffic accident. He has a clinically swollen left shoulder. The radiographs are shown in Figure 17.3.

Figure 17.3 Anteroposterior (AP) view middle third clavicle

Which of the following is true regarding the treatment of this fracture?
A. Patient-reported scores are similar with operative and non-operative treatment at 6 weeks
B. The union rate at 3 months does not correlate with the functional status of the patients
C. The union rate in smokers is significantly different between the operatively and non-operatively treated patients
D. The union rate is around 90% at 3 months with operative treatment
E. The union rate is higher with operative treatment at 3 months

5. A 68-year-old woman sustained a displaced intracapsular fracture to the neck of the femur whilst shopping after a minor fall. She had breast cancer in the past and suffers from diabetes and chronic renal disease.
Which of the following risk factors is associated with the highest mortality risk?
A. Age more than 66
B. AMTS less than 7 and living in a care home
C. Haemoglobin on the admission of less than 80 g/l
D. History of malignancy
E. Multiple comorbidities

6. A 41-year-old man is involved in a road traffic accident and sustains multiple rib fractures and chest injury, minor splenic laceration, anterior acetabular wall fracture and femoral shaft fracture. He was intubated with a Glasgow Coma Scale of 8 and admitted to the intensive care unit.
When should the spinal precautions be removed?
A. After an initial thin slice c-spine CT scan report indicating no fracture, instability or haematoma
B. At 24 hours if there is no suspicion of spinal cord injury
C. Only after an MRI scan of the c-spine
D. When the patient is extubated
E. All of the above

7. A young man sustained an isolated injury to the right ankle while playing football. A CT scan done in the accident and emergency department confirms that this is a Hawkins type I fracture.
What of the following is true regarding this injury?
A. Hawkins classified fractures of the talar body based on the degree of displacement
B. Post-traumatic arthritis is the most common complication following this injury
C. Subchondral lucency seen at 8 weeks is a bad prognostic sign
D. The AVN rate is between 20–30%
E. This injury is associated with a subtalar dislocation

8. A 41-year-old undergoes fixation of a femoral head fracture using safe surgical dislocation through the Kocher–Langenbeck approach.
Which of the following is true?
A. Capsular incision starts anteriorly on the femoral shaft and runs along the femoral neck axis
B. Pipkin type II fractures do not involve the weight-bearing area and can be managed conservatively
C. Similar to the posterior approach to the hip, dislocation is achieved by applying traction and internal rotation of the leg
D. The main arterial supply to the femoral head can be identified on the lower edge of the quadratus femoris and should be protected
E. Worst prognosis is seen in femoral head fractures associated with acetabular fractures

9. A 25-year-old medical intern is complaining of left hand pain after a recent intense cross-fit

session at the gym. Clinical photographs of her left hand are shown in Figure 17.4.

Figure 17.4 Clinical photograph hand

Which of the following is NOT true regarding the anatomy of the damaged structure?

A. It is the primary stabiliser of the extensor tendon at the level of the metacarpophalangeal joint
B. It originates from the volar plate at the metacarpal neck
C. Sectioning of the ulnar part is less commonly seen and associated with less instability
D. The collateral ligaments are located deep to this structure
E. The fibres of this ribbon-like structure run sagittal to the axis of the digit

10. During operative fixation of a posterior column acetabular fracture, a nerve exiting the greater sciatic foramen directly above the piriformis muscle was identified.

Which of the following muscles is innervated by this nerve?

A. Gluteus maximus
B. Gluteus medius
C. Iliopsoas
D. Quadratus femoris
E. Obturator internus

11. An open reduction and internal fixation of humeral shaft fracture was done for a 51-year-old fit and healthy plumber. The surgery was performed through the extended deltopectoral approach. The post-operative radiograph is shown in Figure 17.5.

Figure 17.5 Anteroposterior (AP) radiograph right humerus

Which of the following is true?

A. The brachialis is the only muscle with dual innervation encountered in this approach
B. The brachialis muscle can be dissected or retracted medially
C. The lateral cutaneous nerve of the arm is at risk and can be identified between the biceps and mobile wad
D. The radial nerve enters the anterior compartment in the distal third of the humerus by perforating the medial intermuscular septum
E. This approach can be used to access any humeral shaft fracture

12. A 43-year-old construction worker had a fall on his right elbow and sustained the injury shown in Figure 17.6.

Which of the following represents the correct type of the injury and the position of elbow in the cast after treatment?

A. Bado I – Flexion and pronation
B. Bado I – Flexion and supination
C. Bado II – Flexion and pronation
D. Bado III – Flexion and pronation
E. Bado III – Flexion and supination

13. A 29-year-old professional batsman was seen in the hand clinic for long-standing paraesthesia and pain in his right ring and little finger.

Figure 17.6 Anteroposterior (AP) radiograph right forearm

Which of the following is true regarding his condition?

A. It is unlikely that this patient will present with sensory symptoms only
B. Jeanne's sign is always negative
C. Simple radiographs have no diagnostic values
D. The cause is usually vascular in origin
E. The wrist joint is the most common site of compression of this nerve

14. A 67-year-old male was brought to the hospital after a motor vehicle accident. He was taken to the operating room for management of Type 1 open tibial fracture. He was managed by irrigation, debridement and tibial nailing. On day 3 post-operatively the patient was complaining of localised ankle pain and foot weakness. A dynamic ultrasound showed an injury to one of the structures around the right lower leg. Post-operative radiographs are shown in Figure 17.7.

What is the most likely damaged structure?

A. Extensor hallucis longus tendon
B. Flexor hallucis longus tendon
C. Posterior tibial nerve
D. Tibialis anterior tendon
E. Tibialis posterior tendon

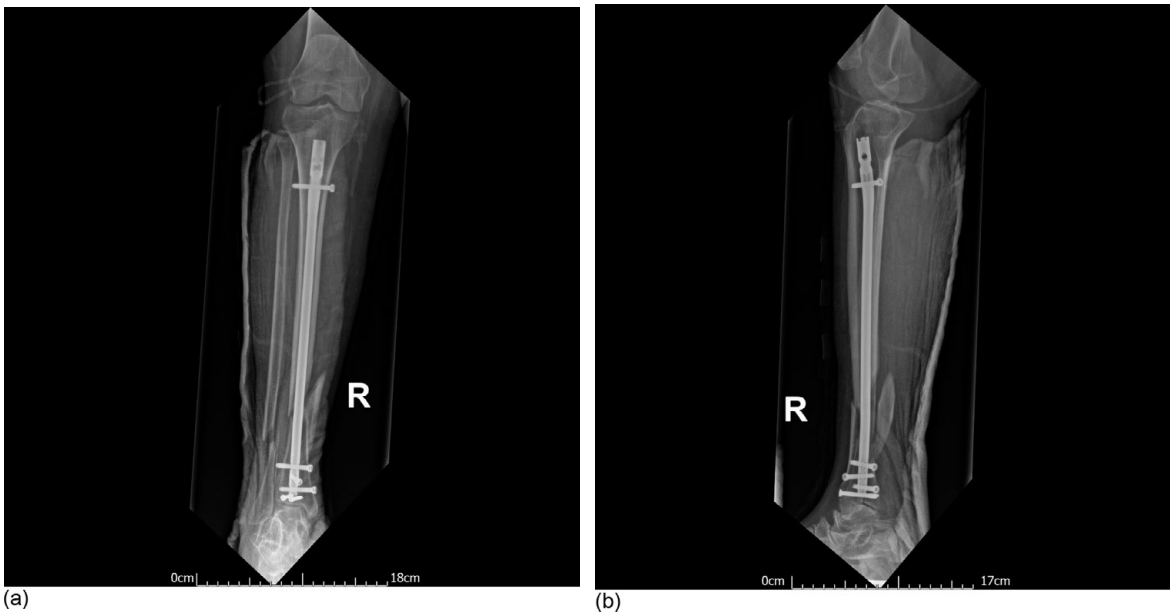


Figure 17.7 (a) Anteroposterior (AP) and (b) lateral radiographs tibia

15. A fit 20-year-old woman was playing softball when she fell onto the floor with both hands outstretched. She is right-hand dominant and a non-smoker. She sustained the injury shown in Figure 17.8.

Figure 17.8 Anteroposterior (AP) radiograph hand

Which of the following is true regarding the management of this injury?

A. Bi-cortical fracture with 2mm displacement should be treated with surgical fixation
B. Cast immobilisation treatment is associated with more serious complications
C. Patient-Reported Wrist Evaluation (PRWE) score is higher with surgical treatment compared with cast immobilisation at 52 weeks
D. Screw joint penetration is nearly 50% with surgical fixation
E. Suspected non-union at 10 weeks with cast treatment should be treated with further immobilisation for 4–6 weeks

16. A 16-year-old pedestrian was hit by a car. He was brought to the resus zone at the accident and emergency and ATLS protocol was started. His physical examination was remarkable for gross haematuria and ecchymosis around the perineal area. A urogenital injury was suspected.

Which one of the following statements is false?

A. Bladder injury in the paediatric population is rare and more complex than in adults
B. Extraperitoneal rupture of the bladder may be treated by catheter drainage only
C. Primary re-alignment of the urethra during fracture surgery is recommended
D. The finding of blood-stained urine mandates a retrograde cystogram
E. The membranous part of the urethra is prone to injury from pelvic fracture

17. A 72-year-old female had a minor fall and sustained a proximal femoral fracture. During surgery and while inserting the femoral stem, the anaesthetist noticed a slight drop in the systolic pressure and a decrease in oxygen saturation.

Which of the following measures would help in preventing this complication?

A. Aim to maintain the systolic pressure within 20% of pre-induction values
B. Avoiding the use of a pressurised lavage system
C. Identification of patients at high risk including increasing age and female gender
D. The use of a fourth generation cementing technique with proper pressurisation
E. The use of high-viscosity cement

18. A 14-month-old infant sustained a fracture to the shaft of the right femur after a non-accidental injury. The safeguarding protocols were initiated and the patient was admitted for a Bryant traction.

Which of the following is true regarding this treatment method?

A. Non-accidental injury is a contraindication to the application of this treatment method
B. Skeletal traction is often necessary to obtain satisfactory limb alignment
C. This is best used for small children older than 12 months
D. Traction is usually applied to the injured limb only
E. Volkmann's ischaemic contracture usually occurs on the normal side

19. A 62-year-old female sustained a left femoral shaft fracture after long-standing thigh pain. Her past medical history includes osteoporosis and breast cancer. Radiographs are shown in Figure 17.9.

Figure 17.9 (a) Anteroposterior (AP) radiographs proximal and (b) distal femur

Which of the following is true regarding her injury?

A. Anatomical reduction and absolute instability are usually indicated
B. Bilateral injuries are uncommon
C. Fracture comminution is unusual
D. Incomplete fractures involve the medial cortex only
E. It usually involves the metaphyseal part of the bone

20. After a skiing accident, a 22-year-old female was evaluated in the accident and emergency department. CT scan of the chest, abdomen and pelvis was obtained. It showed an isolated injury to the thoracolumbar spine. The on-call spinal team decides to treat this injury with a plaster jacket. One day later the patient complains of ongoing nausea and severe vomiting.

What is the most likely cause of the patient's symptoms?

A. Associated pancreatic injury
B. Compression of the third part of the duodenum by a branch of the aorta
C. Compression of the jejunum by the superior mesenteric artery
D. Increased intracompartmental abdominal pressure
E. Side effect to use of opioid analgesics

21. A 34-year-old man presented with acute low back pain after jumping from a 3-meter height. On examination, he had severe tenderness on his back, his score was ASIA D and the rest of his examination was unremarkable. The CT scan is shown in Figure 17.10.

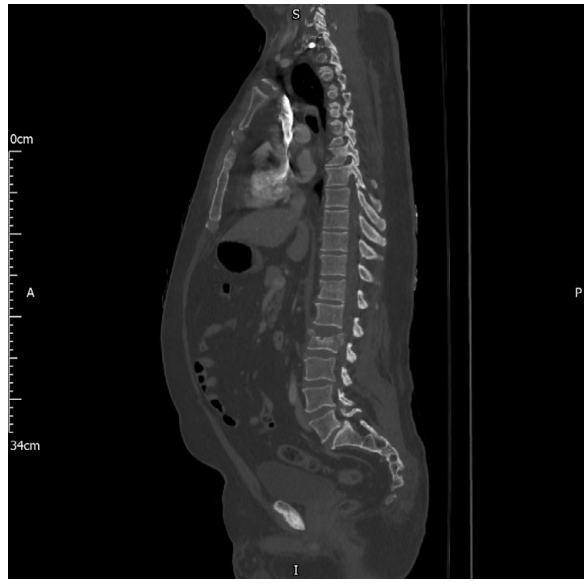


Figure 17.10 Sagittal image whole spine CT scan

Which of the following is an indicator of an unstable injury?

A. 30% canal retropulsion
B. 30% loss of height
C. Associated osteoporosis
D. Loss of the height of the anterior cortex of the vertebral body
E. Widening of the interpedicular distance

22. A 72-year-old lady was seen in the fracture clinic with long-standing low back pain and recurrent falls. She had an X-ray and then a CT scan which showed a 'Honda' fracture of the sacrum.

Which of the following is true regarding her fracture?

A. It is part of the Denis classification

B. It is the most common type of sacral fracture associated with neurological injuries
C. It represents an abnormal repetitive stress fracture to the sacrum
D. Low bone elasticity is the main contributing factor
E. Surgical treatment is usually indicated

23. A 38-year-old left-hand dominant young accountant who was involved in a jet ski accident and sustained an isolated injury. His radiographs are shown in Figure 17.11. After careful examination, the patient chooses to be treated conservatively in a Sarmiento brace. With gentle manipulation and application of the brace, a sudden wrist drop was noted.

What is the best next course of action?

A. Continue brace treatment and nerve conduction studies in 3 months
B. Referral to the peripheral nerve injury unit within 2 weeks
C. Remove the brace and re-manipulate the fracture
D. Take to theatre overnight for urgent exploration
E. None of the above

24. A 69-year-old female with a history of primary total hip arthroplasty 10 years ago presents with a ground-level fall while gardening. She was unable to bear weight. The acetabular component was deemed to be unremarkable, however, a fracture line was noticed just below the Exeter stem tip involving the cement mantle only. It appears that the stem is well-fixed.

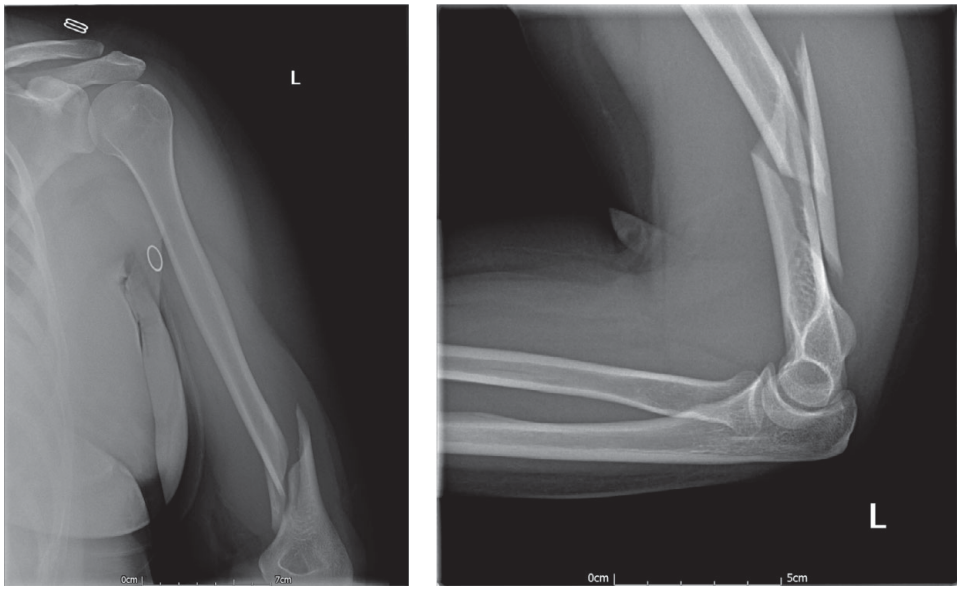
Which of the following is the correct Vancouver Classification for this patient?

A. Vancouver A
B. Vancouver B1
C. Vancouver B2
D. Vancouver B3
E. Vancouver C

25. A healthy young male was brought to the hospital by ambulance after falling from the second floor. He sustained multiple long bones fracture, mild abdominal injury and blunt chest trauma. The decision was to fix his fractures within 36 hours.

Which of the following parameters is indicative of a good response to resuscitation?

A. Base excess <5.5mmol/l.
B. IL-6 value >500pg/dl.



(a) (b)

Figure 17.11 (a) Anteroposterior (AP) and (b) lateral radiographs left humerus

C. ISS>40.
D. Lactate level <4.
E. pH level <7.25.

26. A 30-year-old male was admitted to the trauma bay after sustaining a right foot crush injury with multiple tarsal and metatarsal fractures. His pain was still uncontrolled with a maximum dose of opiates. It was decided that he should immediately undergo fasciotomies of all the foot compartments.
Which of the following muscles is located in the superficial compartment of the foot?
A. Abductor digiti minimi
B. Abductor hallucis
C. Flexor digiti minimi brevis
D. Flexor digitorum brevis
E. Flexor hallucis brevis

27. A 7-year-old boy sustained an injury to his left elbow. Radiograph demonstrated a type-II Milch lateral condyle fracture. The patient undergoes open reduction and screw fixation. On 12 months follow up, he complains of hard swelling above his elbow which has not decreased in size.
Which of the following is true regarding this complication?
A. It is caused by the fracture malunion, especially with type-II Milch injuries
B. Posterior dissection at the time of open reduction increases the risk of this complication
C. Resection of the physeal bar in young children should be considered to avoid further deformity
D. The presence of this swelling does not influence the final range of motion
E. Ulnar nerve neuropraxia is commonly associated

28. A 61-year-old man fell suddenly while going downstairs. He was complaining of sharp pain in his right knee despite not sustaining any direct trauma. He was able to partially extend his knee but was unable to straight leg raise. His pulse was intact.
What is the most likely diagnosis?
A. Acute ACL tear
B. Femoral stress fracture
C. Patellar avulsion fracture
D. Quadriceps tendon rupture
E. Ruptured Baker's cyst

29. While reaming the tibia for intramedullary nail fixation for fracture of the midshaft of the tibia, you notice that the intraoperatively placed pressure monitors show an increase of the anterior and posterior compartments pressure to 33 and 37, respectively.
What is the best next action?
A. Continue reaming and don't perform fasciotomy
B. Continue reaming and perform 2 compartments fasciotomy
C. Continue reaming and perform 4 compartments fasciotomy
D. Stop reaming and use small diameter nail
E. Stop reaming, perform fasciotomy and apply external fixator

30. A 70-year-old woman sustained an intracapsular fracture of the neck of the femur. She suffers from Parkinson's disease and lives alone.
Which of the following is false regarding the management of her hip fracture?
A. Anterolateral approach should be in favour of posterior approach when inserting a hemiarthroplasty
B. If hip fracture is suspected despite negative X-rays, consider CT scan if MRI is not available within 24 hours
C. Offer total hip replacement if the patient is able to walk out of doors with one stick
D. Offer total hip replacement if the patient is expected to be able to carry out activities of daily living independently beyond 2 years
E. Trauma units should aim to have different options of femoral components for hemiarthroplasties

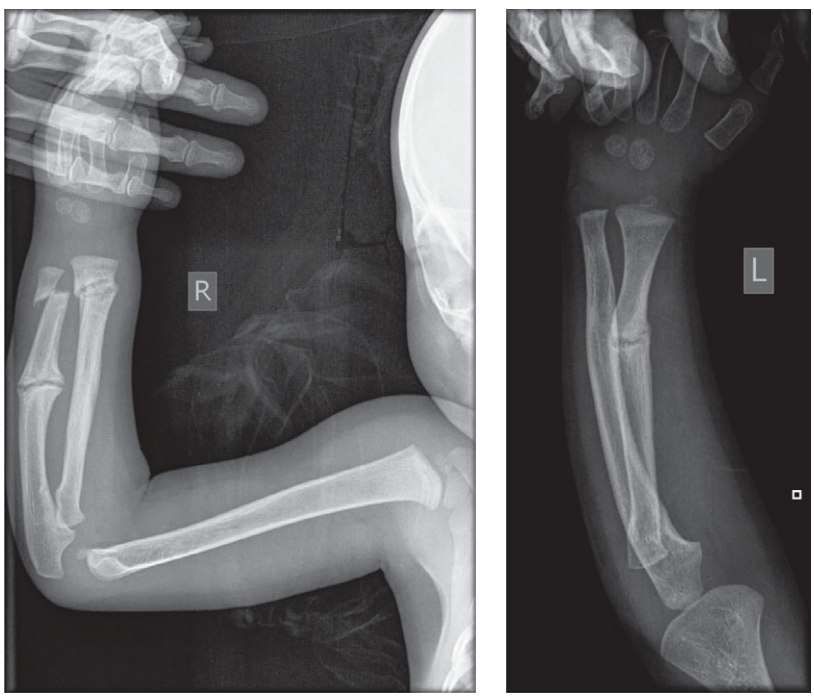
TRAUMA III STRUCTURED SBA ANSWERS

1. Answer E. **Weight bearing radiographs**
   The treatment of the isolated lateral malleolus fracture, in particular supination-external rotation injuries, remains controversial. The majority can be treated non-operatively. Several studies showed that medial side tenderness or bruises do not predict deltoid ligament incompetence. Stress radiographs are often associated with overestimation of the instability. Weight bearing radiographs performed within 10 days of the injury can identify the potentially unstable 10% fracture. However, only a small proportion of unstable fractures require operative fixation.

   Gougoulias N, Sakellariou A. When is a simple fracture of the lateral malleolus not so simple? How to assess stability, which ones to fix and the role of the deltoid ligament. *Bone Joint J.* 2017;**99-B**:851–855.

2. Answer A. **Admit the patient**
   Femoral shaft fractures in non-ambulatory children are highly suspicious for non-accidental injuries. These victims should be carefully evaluated and recognised by the medical healthcare providers including surgeons. The local children safeguarding protocols must be followed. These patients should be referred to the local safeguarding team or the on-call paediatrician. Photographs should be taken and the body map completed. Immediate blood tests are required. A skeletal survey and ophthalmology review must be completed within 24 hours. Admission is usually needed. Further radiographs (Figure 17.12) of this patient show multiple fractures in different stages of healing.
   Femoral fractures in this age group heal rapidly and a 2-week period of immobilisation is sufficient for the majority. Non-invasive treatment is the recommended treatment for this age group, and gallows traction is suitable for patients weighing <10–15kg. This can be used as definitive management or with elective substitution for a hip spica. A Pavlik harness is also commonly used in this age group, particularly in the neonate with a birth fracture.

   National Institute for Health and Care Excellence. NICE Guideline NG76. Child abuse and neglect: recognising, assessing and responding to abuse and neglect of children and young people.



(a) (b)

Figure 17.12 (a) Anteroposterior (AP) radiograph of the right arm and (b) lateral radiographs left forearm

3. Answer D. **Tibial nerve and superficial peroneal nerve**
Haraguchi was the first to classify posterior malleolus fractures based on the fragment size using transverse CT scans. He described three types: type I is the posterolateral-oblique fracture, type II is the medical-extension fracture and type III represents the small-shell fracture. The posterolateral approach to the ankle provides optimal visualisation to the posterior malleolus utilising the interval between the flexor hallucis longus medially and the peroneal tendons laterally, supplied by the tibial and the superficial peroneal nerve, respectively.

Boer Pde, Buckley R, Hoppenfeld S. The foot and ankle. In *Surgical Exposures in Orthopaedics: The Anatomic Approach.* Philadelphia, PA: Wolters Kluwer; 2022.

Haraguchi N, Haruyama H, Toga H, Kato F. Pathoanatomy of posterior malleolar fractures of the ankle. *J Bone Joint Surg Am.* 2006;**88**:1085–1092.

4. Answer B. **The union rate at 3 months does not correlate with the functional status of the patients**
The clavicle trial is a UK multicentre RCT to compare the clinical effectiveness and safety between operative and non-operative management for displaced midshaft clavicle. The results showed that the union rate at 3 months was 70% regardless of the treatment type. However, the radiographic non-union rates at 9 months were significantly lower in the surgical treatment group (<1% vs 11%). The subgroup analysis did not show higher rates of non-union in smokers. The Constant-Murley Score and DASH (Disabilities of the Arm, Shoulder and Hand) score were all significantly better in the fixation group at 6 weeks and 3 months.

Ahrens PM, Garlick NI, Barber J, Tims EM. The Clavicle Trial: a multicenter randomized controlled trial comparing operative with nonoperative treatment of displaced midshaft clavicle fractures. *J Bone Joint Surg Am.* 2017;**99**:1345–1354.

5. Answer A. **Age more than 66**
The Nottingham Hip Fracture Score (NHFS) was developed in 2008 as a tool to predict 30-day mortality for patients with hip fractures. Seven variables were found to be independent predictors of 30-day mortality. Age was found to be the greatest predictor (Table 17.1).

Maxwell MJ, Moran CG, Moppett IK. Development and validation of a preoperative scoring system to predict 30 day mortality in patients undergoing hip fracture surgery. *Br J Anaesth.* 2008;**101**:511–517.

Table 17.1 The Nottingham Hip Score

Nottingham Hip Fracture Score		
Variable	**Value**	**Points**
Age	66–85 years	3
	≥86 years	4
Sex	Male	1
Admission Hb	≤10 g/dl	1
Admission MMTS	≤6 out of 10	1
Living in an institution	Yes	1
Number of comorbidities	≥2	1
Malignancy	Yes	1

6. Answer A. **After an initial thin slice c-spine CT scan report indicating no fracture, instability or hematoma**
The British Orthopaedics Association has issued guidance on cervical spine clearance in trauma patients. A serious spinal injury can be excluded in an awake patient with normal clinical examination, or after completing the spinal imaging protocols in the unconscious patient. It is not recommended to keep the spinal precautions for more than 48 hours due to the risks of pressure sores. MRI of the cervical spine or waiting until the patient is extubated is not necessary before removal of the spinal precautions.

British Orthopaedic Association *BOAST 2: Cervical Spinal Clearance in the Trauma Patient*; 2021. https://www.boa.ac.uk/resource/boast-cervical-spine-clearance-in-the-trauma-patient.html.

7. Answer B. **Post-traumatic arthritis is the most common complication following this injury**
Hawkins classified talar neck injuries (not the talar body) based on the degree of displacement and the congruency of the subtalar and ankle joints. He also described the injury patterns and the AVN rates. Type I fractures are non-displaced fractures with AVN incidence rate between 0–15%.

Hawkins' sign seen at 6– 8 weeks is usually indicating that osteonecrosis is unlikely. Post-traumatic arthritis is widely thought to be more common than AVN after talar neck injuries.

Hawkins LG. Fractures of the neck of the talus. *J Bone Joint Surg Am.* 1970;**52**:991–1002.

8. Answer A. **Capsular incision starts anteriorly on the femoral shaft and runs along the femoral neck axis**
Pipkin classified femoral head fractures as one of four types (Table 17.2). Pipkin's Type III fracture is a high-energy injury associated with a poor prognosis. The deep branch of the medial circumflex femoral artery (MCFA) can be identified in the interval between the upper margin of the quadratus femoris muscle and the inferior border of the gemellus inferior muscle. When performing surgical hip dislocation with trochanteric osteotomy, the femoral head can be dislocated posteriorly by applying external rotation of the hip.

Romeo NM, Firoozabadi R. Classifications in brief: The Pipkin classification of femoral head fractures. *Clin Orthop Relat Res.* 2018;**476**:1114–1119.

Table 17.2 The Pipkin classification of femoral head fractures

Type	Description
1	Dislocation associated with a fracture of the femoral head caudad to the fovea capitis femoris
2	Dislocation with an associated fracture of the femoral head cephalad to the fovea capitis femoris
3	Type I or II injuries associated with a fracture of the femoral neck
4	Type I or II injuries associated with a fracture of the acetabular rim

9. Answer E. **The fibres of this ribbon-like structure run sagittal to the axis of the digit**
The sagittal band originates from the volar plates and surrounds each metacarpophalangeal joint ulnarly and radially to insert on the extensor hood. It runs perpendicular to the plane of the extensor tendons. The ulnar sagittal band is considered to be stronger and denser than the radial sagittal band. Instability due to the rupture of the ulnar sagittal is less commonly seen or reported.

Young CM, Rayan GM. The sagittal band: anatomic and biomechanical study. *J Hand Surg Am.* 2000;**25**:1107–1113.

10. Answer B. **Gluteus medius**
The superior gluteal nerve and vessels are the only structures that exit the pelvis through the greater sciatic foramen superior to the piriformis muscle. The superior gluteal nerve innervates the gluteus medius, gluteus minimus and tensor fasciae latae muscles.

The iliopsoas muscle is supplied by the lumbar spinal nerves and branches of the femoral nerve.

The nerve to quadratus femoris, the nerve to obturator internus and the inferior gluteal nerve (innervates gluteus maximus) exit the pelvis through the greater sciatic notch below the piriformis.

Jacobs LG, Buxton RA. The course of the superior gluteal nerve in the lateral approach to the hip. *J Bone Joint Surg Am.* 1989;**71**:1239–1243.

11. Answer B. **The brachialis muscle can be dissected or retracted medially**
The extended deltopectoral approach is used to access fractures involving the proximal 4/5 of the humeral shaft. The anterior fibres of the deltoid can be partially released and retracted laterally. The pectoralis major receives dual motor innervation by the medial pectoral nerve and the lateral pectoral nerve and is retracted medially. The lateral cutaneous nerve of the forearm is at risk when extending the incision of the superficial fascia of the upper arm. The radial nerve enters the anterior compartment through the lateral intermuscular septum. The brachialis is supplied by the radial and the musculocutaneous nerves. It is usually dissected within the neurovascular plane. Alternatively, it can be retracted medially.

Ruedi TP, Buckley RE, Moran CG. 6.2.2 Humerus, shaft. In *AO Principles of Fracture Management*. Davos: AO Publishing; 2007.

12. Answer B. **Bado I – Flexion and supination**
Bado classified Monteggia injuries according to the level and angulation of ulna shaft fracture and the direction of dislocation of the radial head. Type I is a fracture of the proximal ulna and radial head dislocation directed anteriorly.

This is the most common type in children. Type II is a fracture of the ulna with posterior dislocation of the radial head. This is the most common type in adults. Type III is lateral dislocation of the radial head. Type IV is a fracture of the radial and ulnar shafts with dislocation of the radial head. Bado types I and III are most stable when immobilised in >90° of flexion and full supination.

Rehim SA, Maynard MA, Sebastin SJ, Chung KC. Monteggia fracture dislocations: a historical review. *J Hand Surg Am.* 2014;**39**:1384–1394.

13. Answer A. **It is unlikely that this patient will present with sensory symptoms only**
The elbow is the most common site for entrapment of the ulnar nerve. It occurs less commonly at Guyon's canal in the wrist. In the wrist, Zone I compression at the proximal Guyon's canal results in a mixed motor and sensory deficit and is most likely caused by the hook of hamate fractures or ganglion. Zone II compression is purely motor. Zone III compression occurs secondary to compression of the superficial sensory branch and is usually vascular in origin. Golf, cricket and racquet sports have been associated with hook of the hamate fractures. Carpal tunnel views can aid in the diagnosis. Jeanne's sign is a sign of loss of adductor pollicis muscle power which is innervated by the deep motor branch of the ulnar nerve which runs between the pisiform and hamate.

Parker RD, Berkowitz MS, Brahms MA, Bohl WR. Hook of the hamate fractures in athletes. *Am J Sports Med.* 1986;**14**:517–523.

14. Answer E. **Tibialis posterior tendon**
The tibialis posterior tendon is the closest structure to the medial malleolus behind the distal tibia. It can be injured during the incision, dissection or drilling for the distal locking of tibial nails. A prominent posteriorly placed screw can cause further irritation. The structures behind the medial malleolus in order (closest first) are: posterior tibial tendon, flexor digitorum longus, posterior tibial artery, posterior tibial vein, tibial nerve and flexor hallucis longus.

Kavuri VC, Earasi K, Varacallo M, Harding SP. Diagnosing posterior tibial tendon tear with dynamic ultrasound following tibial intramedullary nailing. *J Clin Orthop Trauma.* 2019;**10**:666–668.

15. Answer D. **Screw joint penetration is 50% with surgical fixation**
The SWIFFT is a multi-centre trial which compared cast treatment versus surgical fixation of undisplaced fractures of the scaphoid waist in adults. The report showed that there were no differences in pain, function or in the patient-rated wrist evaluation (PRWE) score at 52 weeks. The surgery group experienced more potentially serious complications and had a penetration of the screw into the adjacent joints in 42.9% of the patients. The results of SWIFFT support treating all undisplaced and minimally displaced waist of scaphoid fractures in a cast, to investigate for non-union between 6-12 weeks and fix all the confirmed cases immediately.

Dias JJ et al. Surgery versus cast immobilisation for adults with a bicortical fracture of the scaphoid waist (SWIFFT): a pragmatic, multicentre, open-label, randomised superiority trial. *Lancet* 2020;**396**:390–401.

16. Answer C. **Primary re-alignment of the urethra during fracture surgery is recommended**
According to the BOAST 14 guideline, primary re-alignment of the urethra during fracture surgery is not recommended due to the risk of further damage in the hands of an inexperienced surgeon. These injuries are difficult to manage and are associated with a high long-term incidence of urinary and sexual dysfunction. This should be referred to and managed early by a named urologist or/and andrologist.

British Orthopaedic Association *BOAST 14: The Management of Urological Trauma Associated with Pelvic Fractures*; 2016. https://www.boa.ac.uk/static/86c72eff-26aa-4cec-98d1e85cda3dac6c/bcdaeccf-0cff-4da8-bca1b9519b3a542d/the%20management%20of%20urological%20trauma%20associated%20with%20pelvic%20fractures.pdf.

17. Answer A. **Aim to maintain the systolic pressure within 20% of pre-induction values**
Bone cement implantation syndrome (BCIS) is defined as hypoxia, hypotension, cardiac dysrhythmia or increased pulmonary vascular

resistance during surgery using methyl methacrylate. The pathophysiology of this potentially fatal condition is not fully understood. The Association of Anaesthetists of Great Britain and Ireland, The British Orthopaedic Association and The British Geriatric Society published a concise guideline and recommendation to reduce the incidence of BCIS in patients undergoing cemented hemiarthroplasty for hip fracture. The three-stage process includes: the identification of high-risk patients: increasing age, cardiopulmonary disease, diuretics and male sex.

Preparation of team and identification of roles in case of a severe reaction and specific intraoperative roles such as thoroughly washing the femoral canal, avoiding pressurisation and preparing vasopressors in case of cardiovascular collapse.

Griffiths R et al. Safety guideline: reducing the risk from cemented hemiarthroplasty for hip fracture. Association of Anaesthetists of Great Britain and Ireland British Orthopaedic Association British Geriatric Society. *Anaesthesi*a 2015;**70**:623–626.

18. Answer E. **Volkmann's ischaemic contracture usually occurs on the normal side**

Bryant's or gallows traction is used to manage femoral shaft fractures in children weighing less than 18kg and typically less than 18 months old.

Adhesive skin strapping is placed on both legs and suspended vertically with the hips flexed at 90° and the knees extended. Gallows traction has been associated with severe compartment syndrome and Volkmann's ischaemic contracture. Usually, vascular compromise occurs on the normal side. The neurovascular status of both feet should be monitored daily.

Hunter JB. Femoral shaft fractures in children. *Injury* 2005;**36**(Suppl. 1):A86–A93.

19. Answer C. **Fracture comminution is unusual**

Atypical femoral fractures are related to long-term osteoporosis treatment with bisphosphonates.

However, the overall risk for femoral fracture (typical or atypical) is lower in patients who take bisphosphonate. Atypical fractures typically located below the lesser trochanter, start as thickening in the lateral cortex and then progress to a transverse or oblique fracture line medially. It can be associated with medical spike, and they can be bilateral.

Larsen MS, Schmal H. The enigma of atypical femoral fractures: a summary of current knowledge. *EFORT Open Rev.* 2018;**3**:494–500.

20. Answer B. **Compression of the third part of the duodenum by a branch of the aorta**

Superior mesenteric syndrome or cast syndrome is a rare syndrome caused by obstruction of the third portion of the duodenum. It is caused by the narrowing of the angle between the aorta and the superior mesenteric artery. Although rare, it has been associated with plaster jacket and spica application, usually due to accentuation of the lumbar lordosis.

Van Horne N, Jackson JP. *Superior Mesenteric Artery Syndrome*. Treasure Island, FL: StatPearls Publishing; 2022.

21. Answer E. **Widening of the interpedicular distance**

Loss of height of the anterior wall of the vertebral body is seen in compression and burst fractures. Burst fractures involve injury to the middle column.

An increase in the interpedicular distance seen on AP views is suggestive of instability. The other radiographic signs of unstable injuries are: widening of interspinous or interlaminar distance, articular process fracture, >50% loss of height. >20° of kyphosis, >50% of canal compromise and associated posterior element disruption.

McAfee PC, Yuan HA, Lasda NA. The unstable burst fracture. *Spine (Phila Pa 1976)* 1982;**7**:365–373.

22. Answer D. **Low bone elasticity is the main contributing factor**

Sacral insufficiency fractures have a characteristic appearance on bone scans. The pattern of uptake resembles a 'Honda logo' or 'H sign'. These fractures are the results of normal repetitive stress on the abnormal (osteoporotic) bone, which has a lower elastic modulus and increased strain to failure compared with the normal bone. Denis describes three zones of injury to the

sacrum. Zone III injuries that extend into the spinal canal are associated with the highest rate of neurological deficit.

Denis F, Davis S, Comfort T. Sacral fractures: an important problem. Retrospective analysis of 236 cases. *Clin Orthop Relat Res.* 1988;**227**:67–81.

Ries T. Detection of osteoporotic sacral fractures with radionuclides. *Radiology* 1983;**146**:783–785.

23. Answer E. **None of the above**
Based on the BOAST peripheral nerve injury guideline, formal advice from the peripheral nerve injury unit should be sought within 24 hours if operative management of the fracture is not indicated, with laceration and penetrating injuries. If the nerve is damaged intraoperatively, an immediate referral is recommended. Removal of the brace and re-manipulating the fracture risks further damage to the nerve and it is not advised. In unstable fractures, fixation should be carried out. Surgical exploration or nerve repair should be carried out by a specialist peripheral nerve injuries surgeon.

British Orthopaedic Association *BOAST 5: Peripheral Nerve Injury*; 2021. https://www.boa.ac.uk/resource/boast-peripheral-nerve-injury.html.

24. Answer B. **Vancouver B1**
The Vancouver classification was based on the location of the fracture relative to the stem, the stability of the implant and the quality of the bone stock. Type A fractures occur proximal to the stem, Type B around the stem or just below it and Type C are located well distal to the tip of the prosthesis. Type B fractures are further subdivided into: B1 fractures with a stable implant that can be treated by internal fixation, B2 fractures are associated with a loose implant that requires revision to another stem, and B3 fractures that are unstable implants with a bone loss which requires allograft during revision surgery, or conversion to megaprosthesis.

Duncan CP, Masri BA. Fractures of the femur after hip replacement. *Instr Course Lect.* 1995;**44**:293–304.

25. Answer D. **Lactate level <4**
Early appropriate care was popularized by Vallier and colleagues. The concept is based on the early stabilisation of pelvic, acetabular, femoral and spinal fractures after appropriate resuscitation. They recommended definitive management of mechanically unstable fractures within 36 hours of injury as long as the patient has demonstrated response to resuscitation based on the improvement of acidosis with a lactate of <4 mmol/l, a base excess ≥ -5.5 mmol/l or pH >7.25.

Vallier HA, Wang X, Moore TA, Wilber JH, Como JJ. Timing of orthopaedic surgery in multiple trauma patients: development of a protocol for early appropriate care. *J Orthop Trauma* 2013;**27**:543–551.

26. Answer D. **Flexor digitorum brevis**
There is controversy about the amount of existing myofascial compartments of the foot. Early books described four myofascial compartments of the foot. However, recent research suggests the presence of nine myofascial compartments in the foot (Table 17.3).

Lugo-Pico JG, Aiyer A, Kaplan J, Kadakia AR. Foot compartment syndrome controversy. In Mauffrey C, Hak DJ, Martin III MP, ed. *Compartment Syndrome: A Guide to Diagnosis and Management*. Cham: Springer; 2019.

Table 17.3 Compartment contents

Compartment	Contents
Medial	Abductor hallucis, flexor hallucis brevis
Superficial (superficial central)	Flexor digitorum longus Flexor digitorum brevis
Lateral	Abductor digiti minimi Flexor digiti minimi brevis
Adductor	Oblique head of the adductor hallucis
Interossei (four compartments)	Each compartment includes the dorsal and plantar interosseous muscle of its location
Calcaneal (deep central)	Quadratus plantae

27. Answer D. **The presence of this swelling does not influence the final range of motion**

Lateral condyle spur formation is almost universal following lateral condylar fractures. It occurs in more than 70% of the cases regardless of the treatment method. It is a result of displacement of the periosteum followed by new bone formation. It is important to counsel the parents about this complication before starting treatment. However, lateral spurring is not of functional significance.

It can be a cosmetic problem leading to cubitus pseudovarus.

Pribaz JR, Bernthal NM, Wong TC, Silva M. Lateral spurring (overgrowth) after pediatric lateral condyle fractures. *J Pediatr Orthop*. 2012;**32**:456–460.

28. Answer D. **Quadriceps tendon rupture**
Quadriceps tendon rupture is more prevalent in males over 40 years old. Those under age 40 usually have an associated metabolic disorder. It is usually due to eccentric loading of the extensor mechanism. Patients with complete tears have an impaired ability to perform a straight leg raise. With partial tears, some patients will be able to walk, and there is impaired knee extension. Quadriceps tendon rupture is more common than patellar tendon rupture. It is usually unilateral but there are several case reports of bilateral rupture in the literature.

Pope JD, El Bitar Y, Mabrouk A, Plexousakis MP. Quadriceps tendon rupture. Treasure Island, FL: StatPearls Publishing; 2023.

29. Answer A. **Continue reaming and don't perform fasciotomy**
A randomised prospective study showed that the peak average pressures during reaming or nail insertion in unreamed nailing can reach above 30 mmHg. The average pressures quickly returned to less than 30mmHg and remained there for 24 hours post-operatively. The ΔP values were greater than 30mmHg at all times after nail insertion in both the reamed and unreamed nailing. Therefore, these values are not indicators of compartment syndrome, and should not preclude reaming or nail insertion.

Nassif JM, Gorczyca JT, Cole JK, Pugh KJ, Pienkowski D. Effect of acute reamed versus unreamed intramedullary nailing on compartment pressure when treating closed tibial shaft fractures: a randomized prospective study. *J Orthop Trauma* 2000;**14**:554–558.

30. Answer E. **Trauma units should aim to have different options of femoral components for hemiarthroplasties**
The new (updated in 2023) National Institute for Health and Care Excellence (NICE) guideline for the management of hip recommends considering total hip replacement rather than hemiarthroplasty for patients who were able to walk independently out of doors with no more than the use of a stick and do not have a condition or comorbidity that makes the procedure unsuitable for them and are expected to be able to carry out activities of daily living independently beyond 2 years. In addition, the new guideline encourages hospitals to aim to use a single type of cemented femoral component for hemiarthroplasties as standard treatment for displaced intracapsular hip fracture management. The committee believes that medical teams familiar with implanting one single type of component as standard is associated with a decrease in cost of training and potentially the cost of adverse outcomes related to using a new implant.

National Institute for Health and Care Excellence. NICE guideline CG124. Hip fracture: management. www.nice.org.uk/guidance/cg124.

Chapter 18

Hand I Structured SBA

Emma Reay

HAND I STRUCTURED SBA QUESTIONS

1. A 75-year-old man with dementia is admitted after being found on the floor by his carer, who last saw him 12 hours ago. He has a swollen left upper limb and hand. His hand looks tense and is tender to palpation over his thenar and hypothenar eminences. On examination, he winces when his fingers are passively flexed. Pulses are present but you are unable to assess sensation due to cognitive impairment. He has had high-dose opioid analgesia in the ED.

   What is the most appropriate next step in the management?

   A. Admit for observation and reassessment of clinical signs after 4 hours
   B. Elevate arm and prescribe further opioid analgesia
   C. Perform urgent fasciotomies of the hand
   D. Request creatine kinase levels
   E. Request urgent hand compartment pressure monitoring

2. A 53-year-old right-handed patient sustained a small puncture wound to the palmar surface of her right index finger 10 days ago. Yesterday, she began to develop pain and swelling of the digit, which is worsening despite oral antibiotics from her GP.

   Which clinical signs would suggest she requires emergency surgical treatment?

   A. Erythema, extended finger position, flexor surface tenderness, pain on passive extension
   B. Erythema, flexed finger position, tenderness of palm at base of digit, pain on passive extension
   C. Fusiform swelling, flexor surface tenderness, fixed proximal interphalangeal joint on passive flexion and extension
   D. Fusiform swelling, flexor surface tenderness, pain on passive extension and semi flexed position
   E. Swelling into the palm, loss of normal palmar concavity, tenderness over proximal palmar crease

3. A 48-year-old right-handed patient underwent a washout for flexor sheath infection this afternoon. She does not have any known medication allergies.

   While waiting for microbiological analysis of the intraoperative samples, what is the most appropriate antibiotic management for this patient?

   A. Benzylpenicillin and flucloxacillin
   B. Cefuroxime
   C. Co-amoxiclav
   D. Flucloxacillin
   E. Flucloxacillin and metronidazole

4. A 26-year-old male patient has fallen from his motorbike at 50 mph and is transferred to the ED in your hospital. He is conscious and complaining only of pain in his left hand and wrist. His X-rays show a trans-scaphoid perilunate dislocation. He is also complaining of altered sensation of his thumb and index finger.

   What is the most appropriate initial management plan for this patient?

   A. MUA and carpal tunnel decompression on next available list
   B. MUA and fixation of scaphoid on next available operating list
   C. MUA, fixation of scaphoid and carpal tunnel decompression on next available operating list
   D. MUA in the ED
   E. MUA on next available operating list

5. A 35-year-old joiner presents with increasing pain and swelling of his right dominant hand after sustaining a puncture wound over the palmar aspect of his thumb MCPJ crease. On examination, he has restricted range of movement of his index and little fingers and has exquisite tenderness over the distal wrist crease where the hypothenar and thenar eminences meet.
Between which anatomical structures is the most likely pathology in this case?
   A. Flexor digitorum profundus tendons and pronator quadratus
   B. Flexor digitorum superficialis tendons and pronator quadratus
   C. Flexor pollicis longus and flexor digiti minimi
   D. Pronator quadratus and wrist capsule
   E. Transverse carpal ligament and median nerve

6. A 60-year-old patient presents with intermittent radial-sided altered sensation in their dominant hand occurring predominantly at night and when driving. Phalen's test is grossly positive, and there is no evidence of motor weakness or wasting.
Which would be the most likely findings on nerve conduction testing?
   A. Decreased median nerve conduction velocity compared with the ipsilateral ulnar nerve
   B. Fibrillation potentials and positive sharp waves on needle EMG
   C. Normal study
   D. Peak latency delay of median nerve sensory nerve action potential (SNAP)
   E. Unrecordable SNAP

7. Parents of a child who has a deformity of her right forearm present to your outpatient clinic wanting an explanation for her upper limb abnormality. On examination, you find an absent thumb and a flexed small index finger on the right hand with a radially deviated wrist and prominent ulnar head.
Which is the most likely explanation from the options below?
   A. It is caused by an abnormality of the apical ectodermal ridge
   B. It is caused by an abnormal Hox gene
   C. The condition occurs sporadically with no known cause
   D. This is an autosomal-dominant condition
   E. This is an X-linked genetic condition

8. A patient returns from an ice-climbing trip with acute pain in the right forearm and wrist. He describes the forearm as feeling tired and heavy. On examination, you find an inability to pinch items between the thumb and index finger.
Which of the following is most likely?
   A. Nerve conduction studies will show sensory nerve conduction slowing
   B. The patient will need a routine cervical MRI scan and referral to a neurosurgeon
   C. The symptoms are due to nerve compression by the tendinous edge of pronator teres
   D. The symptoms have an inflammatory cause analogous to Parsonage–Turner syndrome
   E. Urgent ultrasound and MRI of the forearm should be requested

9. You are about to perform revision surgery on the little finger of a patient with a benign fibroproliferative disorder of the palmar fascia.
Which of the following tests gives the most useful preoperative information?
   A. Allen's test
   B. Phalen's test
   C. Pincer grip test
   D. Tinel's test
   E. Watson's test

10. A 53-year-old right-handed patient sustained a small puncture wound to the palmar surface of her right index finger 10 days ago. Yesterday, she began to develop pain and swelling of the digit, which is worsening despite oral antibiotics from her GP. On examining her finger, you find she has fusiform swelling, flexor surface tenderness, pain on passive extension and slight flexed position of the digit.
What is the most appropriate management?
   A. Elevation, intravenous antibiotics and reassessment
   B. Open flexor sheath washout
   C. Closed flexor sheath washout
   D. Urgent ultrasound scan of the flexor sheath
   E. X-ray to rule out foreign body

11. A 27-year-old male patient presents to the hand clinic complaining of pain over the dorsoradial aspect of his left wrist. The pain is worse on loading his wrist in extension, and he complains of restricted range of extension of the wrist. He remembers falling onto his wrist 6 months ago while playing football. He had an X-ray and was informed he had no bony injury. On examination, he has point tenderness over the dorsum of his wrist between the second and third extensor compartments.

What is the most appropriate management plan for this patient?

A. CT scan
B. MRI scan
C. X-ray and CT scan
D. X-ray and gadolinium-enhanced MRI scan
E. X-ray and MRI arthrogram

12. A 46-year-old rock climber presents to the hand clinic 3 months after injuring her right dominant ring finger while climbing. She describes a pop and pain while taking her whole weight through that digit. She developed immediate swelling. She is now left with a strange appearance of her finger when she bends the PIPJ – she says the tendon 'seems to be pulling away from the finger'.

Which structures are most likely to have been damaged?

A. A3 and A5 pulleys
B. A1 and A2 pulleys
C. Volar plate of PIPJ
D. Collateral ligaments of PIPJ
E. A2 and A3 pulleys

13. A 55-year-old mechanic presents to the outpatient department complaining of a tender lump in his palm at the base of his ring finger without functional impairment. On examination, you observe a nodule and a thickened longitudinal band of tissue extending from the ring finger proximal compartment to the proximal palmar crease, causing a 15° flexion contracture at the MCPJ. Tabletop test is negative and there is no PIPJ contracture.

What would you advise?

A. Collagenase injection
B. Nodule excision
C. Percutaneous fasciotomy
D. Segmental fasciectomy
E. Watchful waiting

14. A 72-year-old woman has a displaced and comminuted distal radius fracture, which you have been asked to manage with a volar locking plate. You choose to approach the distal radius through the bed of flexor carpi radialis tendon.

Which anatomical structure is most commonly damaged during this procedure?

A. Extensor pollicis longus
B. Palmar cutaneous branch of the median nerve
C. Radial artery
D. Median nerve
E. Superficial branch of the radial nerve

15. A 56-year-old woman presents with a 6-month history of difficulty extending her ring and middle fingers of both hands after flexing into her palms. She needs to use her opposite hand to straighten the digits, and this is associated with pain in her palm at the base of the digits.

Which one of the following medical conditions is commonly associated with this pathology?

A. Carpal tunnel syndrome
B. Diabetes
C. Hypothyroidism
D. Psoriasis
E. Scleroderma

16. A 22-year-old semi-professional football player falls heavily onto his outstretched right hand during a tackle. He complains of a pop in his wrist, followed by pain and swelling of his wrist. He attends the ED, and a wrist X-ray is performed. At X-ray, the distance between the lunate and scaphoid appears increased.

Which of the following statements best describes the anatomical structure damaged following this injury?

A. Forty per cent of distal radial fractures will have an associated scapholunate ligament injury
B. Of the three parts of the scapholunate ligament, the anterior section is biomechanically strongest
C. The blood supply enters the scapholunate ligament through the arcuate ligament

D. The normal scapholunate angle is between 80° and 110°
E. The scapholunate ligament is less biomechanically important than the lunotriquetral ligament

17. A 15-year-old girl complains of an inability to actively flex the tip of her right middle finger after grabbing an opponent's collar during a judo bout yesterday. She is taken to theatre and found to have a type I injury of her flexor tendon.
What is most likely to be damaged?
A. A5 pulley
B. Both vinculae to flexor digitorum profundus
C. Flexor digitorum superficialis tendon
D. Vinculum brevis to flexor digitorum profundus
E. Vinculum longus to flexor digitorum profundus

18. You take a telephone referral from an urgent care centre about a patient who has injured themselves with a knife while removing the stone from an avocado. They have a laceration in their palm at the level of the distal palmar crease and are unable to actively flex their index and middle fingers.
How would you describe this injury?
A. Zone I flexor tendon injury
B. Zone II flexor tendon injury
C. Zone III flexor tendon injury
D. Zone IV flexor tendon injury
E. Zone V flexor tendon injury

19. A patient is assessed in the hand clinic following an injury where they fell onto their outstretched hand 3 months ago while skiing. X-rays show a scapholunate angle of 80°.
Which anatomical structure is most likely to be damaged?
A. Lunotriquetral ligament
B. Scapholunate ligament
C. Dorsal wrist capsule
D. Radioscapholunate ligament
E. Ligament of Testut

20. A window cleaner falls from the top of his ladder onto an outstretched left wrist. He attends the ED with a deformed and grossly swollen wrist. X-rays show no evidence of a distal radial fracture, but Gilula's lines within the carpus are broken and there is an associated scaphoid fracture.
Which of the following most accurately classifies this injury pattern?
A. Carpal instability complex
B. Carpal instability dissociative
C. Carpal instability non-dissociative
D. DISI deformity
E. VISI deformity

21. A patient presents with a laceration over the ulnar border of her forearm and complains of paraesthesia running from the level of the laceration down the ulnar border of her forearm into her little and ring fingers. At exploration, the ulnar nerve is found to be lacerated completely.
How would you classify this injury using the Sunderland Classification system for nerve injury?
A. First degree
B. Second degree
C. Third degree
D. Fourth degree
E. Fifth degree

22. An elderly patient caught the tip of his right middle finger in a circular saw as he was cutting wood. He presents to the ED with a 1cm defect in the skin of the tip of his pulp with no bone exposed. His X-rays show no associated bony injury.
What is the most appropriate management for this patient?
A. Atasoy flap
B. Primary closure
C. Terminalisation to the distal interphalangeal joint level
D. Toilet, dressings and wound review 1 week
E. Venkataswami flap

23. A medical student observes you suturing an incised skin wound and asks you what is involved in the stages of wound healing.
Which of the following most accurately describes the cellular sequence of healing of the wound?
A. Coagulation, fibronectin, collagen, granulocytes

B. Fibroblasts, coagulation, macrophages, cross-linked collagen
C. Granulocytes, macrophages, fibroblasts, collagen, cross-linked extracellular matrix
D. Macrophages, granulocytes, collagen, fibroblasts
E. Neutrophils, extracellular matrix cross-linking, granulocytes, macrophages

24. A 76-year-old female patient sustained a closed distal radius fracture, which was treated conservatively in a cast for 4 weeks. She presents to her GP complaining of an inability to use her thumb properly and with a reduced range of movement of her thumb. Her GP refers her back to the fracture clinic for review.

Which of the following thumb movements is most likely to be impaired in this patient?

A. Abduction
B. Adduction
C. Flexion
D. Opposition
E. Retropulsion

25. A 26-year-old falls and injures her right hand. There is no bony injury identified on X-ray, but she is noted to have a lytic lesion at the base of her middle finger proximal phalanx. The lesion demonstrates geographic bone destruction, bony expansion and cortical thinning. The lesion is asymptomatic.

What is the most appropriate management plan for this patient?

A. CT scan
B. MRI scan and review
C. Reassurance and discharge
D. Reassurance and observation with serial radiographs
E. Screening blood tests and chest X-ray

26. You have just repaired a zone II flexor tendon injury involving both flexor digitorum superficialis and flexor digitorum profundus. You are now filling in the hand therapy request form after applying a dorsal splint.

Which of the following post-operative rehabilitation regimens is most appropriate?

A. Early combined passive and active motion at days 3–5
B. Early full range active flexion
C. Early passive motion at days 3–5
D. Place and hold at 1 week
E. Splint 7 days, then combined passive and active motion

27. A patient sustained a proximal humeral fracture that was treated with plating while she was on holiday in Egypt. Six months later, she now presents with an inability to extend her wrist, fingers or thumb. Nerve conduction tests have already been organised by her GP and show no evidence of function of the affected nerve. She has read on the Internet about tendon transfers.

Which of the following tendon transfers would be most appropriate in this patient?

A. Brachioradialis to flexor pollicis longus
B. Flexor digitorum superficialis to adductor pollicis
C. Latissimus dorsi to triceps
D. Pronator teres to extensor carpi radialis brevis
E. Pronator teres to extensor carpi radialis longus

28. A 36-year-old rugby player sustained a forced abduction injury to his right dominant thumb during a match. He attends hand trauma clinic 24 hours later with a bruised and swollen right thumb, he is tender over the ulnar border of the MCPJ with a palpable lump over the ulnar side of the joint. On examining the joint, there is no firm end point to radial deviation in either full extension or 20° of flexion.

Which of the following most accurately describes the most likely anatomical injury?

A. Avulsion of ulnar collateral ligament from distal insertion
B. Midsubstance ulnar collateral ligament injury
C. Stener lesion
D. Ulnar collateral ligament and volar plate injury
E. Volar plate injury

29. You are asked to assess a motorcyclist who was involved in a serious RTA 2 weeks ago. He has open fractures to both lower limbs which have been nailed. He complains of weakness in his left upper limb. When you examine him, he has

weakness of flexion and extension of his wrist and fingers including his thumb. He is also unable to actively pull his arm into his side against resistance. He cannot cross his fingers when asked.

Which is the most likely level of brachial plexus injury based on the above clinical examination?

A. C5, C6
B. C5, C6, C7
C. C7
D. C7, C8, T1
E. C8, T1

30. A patient presents with a pattern of upper limb injury suggestive of brachial plexus damage. You notice that he is unable to fully open his eye on the ipsilateral side.

At what level within the brachial plexus is this lesion?

A. Root level
B. Trunk level
C. Division level
D. Cord level
E. Nerve level

31. You are asked to assess a pedal cyclist who fell off his bicycle 2 weeks ago. At that time, he was diagnosed with a lower brachial plexus injury resulting in weakness of his left upper limb. He has now returned to clinic with pain on active and passive movement of his shoulder.

What is the most appropriate next step for this patient?

A. Angiogram left arm
B. CT myelogram
C. MRI cervical spine
D. Nerve conduction testing
E. Shoulder and chest X-rays

32. A 55-year-old male patient presents to your outpatient clinic complaining of pain, swelling and restricted range of movement of his right dominant wrist. The pain occasionally occurs at night and it is affecting his ability to do his job. He remembers an injury to his wrist as a young man. X-rays show osteoarthritic change in the radioscaphoid articulation and the capitoscaphoid articulations.

What is the most appropriate next course of management?

A. CT scan
B. Four corner fusion
C. Proximal row carpectomy
D. Steroid injection and CT scan
E. Total wrist fusion

33. A 27-year-old cleaner presents to the hand clinic with an inability to actively extend the distal interphalangeal joint (DIPJ) of her right middle finger after changing a bed. On examination, she has mild swelling and bruising over the dorsum of the DIPJ and an extensor lag of 30°. X-rays show no bony injury.

What is the most appropriate management plan in this patient?

A. DIPJ splinting for 4 weeks in extension
B. DIPJ splinting for 6 weeks in extension, followed by plain radiographs
C. Surgical repair
D. Percutaneous K-wire fixation
E. DIPJ splinting for 6 weeks in extension, then 2 weeks at night only

34. A 30-year-old builder presents with fractures to the shafts of his 3rd, 4th and 5th metacarpals, which are closed injuries. There is no rotational deformity, although it is difficult to examine him because of pain on flexion of his digits. The fractures are oblique midshaft comminuted fractures.

What is the most appropriate management plan for this patient?

A. Buddy taping and mobilisation
B. Cast immobilisation
C. Moulded thermoplastic splinting
D. MUA and cast immobilisation
E. Operative fixation

35. After sustaining an axial load type injury to their right ring finger, a 22-year-old factory worker attends the hand trauma clinic with a painful proximal interphalangeal joint (PIPJ), and X-rays show a comminuted intra-articular fracture to the base of their middle phalanx and confirm a dorsal triangle sign.

What is the most appropriate management for this patient?

A. Dynamic external fixation
B. Open reduction and internal fixation

C. Non-operative management with buddy taping
D. Splinting in flexion
E. Static external fixation

36. A 76-year-old female patient complains of pain over the radial side of her hand and around her thumb with an inability to open her hand fully and decreased grip strength because of pain. She is unable to knit for more than 10 minutes. X-rays show grade IV changes at both the thumb CMC joint and the STT joint.

Which other anatomical structure should be examined during the consultation?

A. IPJ of the thumb
B. Median nerve
C. Radial artery
D. Superficial radial nerve
E. Ulnar nerve

37. A patient returns to clinic 6 months after carpal tunnel decompression complaining that they have not felt any improvement in their symptoms post-operatively. They are 89 years old and had preoperative nerve conduction testing, which showed severe compression of the median nerve. They also have evidence of abductor pollicis brevis wasting.

Which is the most important prognostic indicator following carpal tunnel decompression?

A. Age
B. Comorbidities
C. Duration of symptoms
D. Presence of muscle wasting
E. Severity of compression on NCT

38. A 43-year-old sustained a twisting injury to her wrist when picking up a heavy suitcase while on holiday 2 weeks ago. She attends the hand trauma clinic with a painful wrist, and on examination she has tenderness over the fovea of her ulnar head and her distal radioulnar joint appears lax.

Which anatomical structure provides most stability to the distal radioulnar joint?

A. Bony anatomy
B. Deep head of pronator quadratus
C. Extensor carpi ulnaris
D. Intraosseous membrane of forearm
E. Triangular fibrocartilage complex

39. A patient presents with functional problems in her hand after repair of a flexor digitorum profundus avulsion injury of her left middle finger. She describes being unable to fully flex her index and ring fingers when she flexes her repaired middle finger into her palm.

What is the anatomical basis for this problem?

A. Adhesions within flexor sheath of repaired middle finger
B. Damage to nerve supply to flexor digitorum profundus
C. Rupture of flexor digitorum profundus tendons to index and ring fingers
D. Shared muscle belly of all four flexor digitorum profundus tendons
E. Tethering of flexor digitorum profundus tendons in forearm

40. A 45-year-old factory worker presents with a long-standing history of a painful wrist that she localises to the dorsum, worse on extension. X-rays show sclerosis of the lunate, and an MRI organised by the musculoskeletal service shows proximal lunate collapse.

What is the most appropriate management option to discuss with the patient?

A. Immobilisation and rehabilitation
B. Lunate replacement
C. Proximal row carpectomy
D. Radial shortening
E. Vascularised bone graft to lunate

41. A 52-year-old manual worker presents to the ED after amputating part of his little finger with a circular saw. On examination, he has a jagged, dirty wound at the level of the PIPJ. He hands you the amputated digit, which he recovered from the scene. The amputated digit has no evidence of vessels or nerves on inspection. X-rays show severe comminution of the middle and distal phalanges of the amputate.

What advice are you going to give him when he asks what can be done for his finger?

A. Amputation at the level of the MCPJ
B. Ray amputation
C. Replantation
D. Terminalisation
E. Wound debridement and closure in the ED

42. A 52-year-old manual worker presents to the ED after amputating part of his dominant thumb with a circular saw. On examination, he has a jagged, dirty wound at the level of the MCPJ. He hands you the amputated digit which he recovered from the scene. The amputated digit has no obvious vessels or nerves on examination. X-rays show severe comminution of the proximal and distal phalanges of the amputated thumb.
What is the most appropriate management of this patient?
A. Amputation at the level of the MCPJ
B. Ray amputation
C. Replantation
D. Terminalisation
E. Wound debridement and closure in the ED

43. A 45-year-old female patient presents with a recent history of pain at the tip of her right middle finger. She also complains of hypersensitivity to cold stimulus at the tip of the finger. On examination, a small mass lesion is palpated in the tip and there is slight discolouration of the nailbed.
What is the most likely diagnosis?
A. Glomus tumour
B. Malignant melanoma of the nailbed
C. Mucous cyst
D. Osteoid osteoma
E. Pulp abscess

44. A patient who is studying biology at university is about to undergo carpal tunnel decompression. They ask you to describe to them the anatomical structures that can be encountered during the operation.
Which of the following structures is most at risk during a carpal tunnel decompression?
A. Deep palmar arch
B. Extra-ligamentous recurrent motor branch of the median nerve
C. Flexor digitorum superficialis tendons
D. Palmar cutaneous branch of the median nerve
E. Superficial recurrent motor branch of the median nerve

45. A 76-year-old male patient presents with weakness in his left hand and altered sensation in the little and ring fingers. He has guttering of the small muscles of the hand and a mild flexible claw deformity of his little and ring fingers.
Where is the most likely nerve pathology in his case?
A. Arcade of Struthers
B. Cubital tunnel
C. Exit from flexor carpi ulnaris
D. Guyon's canal
E. Midforearm

46. An elderly patient undergoes treatment for her pantrapezial osteoarthritis with a trapeziectomy through a dorsal approach.
Which anatomical structure is not at risk through this approach?
A. ECRB tendon
B. EPB tendon
C. Flexor carpi radialis tendon
D. Radial artery
E. Superficial radial nerve branches

47. A patient presents to hand trauma clinic with pain in his palm after using his palm to knock down some tent pegs during a recent camping trip. He has tenderness over his hypothenar eminence and weakness of abductor digiti minimi and first dorsal interosseous muscle but no sensory loss.
What imaging would be most appropriate?
A. Angiography
B. MRI wrist
C. Nerve conduction testing
D. Ultrasound scan
E. X-ray

48. You have been asked to perform a diagnostic wrist arthroscopy and are being quizzed about the best port sites to use.
Which of the following portal sites is the best for accessing the wrist?
A. 3–4
B. 4–5
C. 6R
D. 6U
E. Radial midcarpal

49. A chef has sustained a laceration to the dorsum of her right index finger at the MCPJ level.

Which zone of extensor tendon injury is this?

A. Zone I
B. Zone III
C. Zone V
D. Zone VI
E. Zone VIII

50. A 55-year-old patient with severe rheumatoid deformities in her hands, wrists and elbows has asked for your advice regarding her surgical options to improve her function. She has severe pain in her right elbow and wrist and her right hand MCP joints.

Which procedure should be performed first in the sequence of management for her joint pathology?

A. Elbow replacement
B. Finger MCP joint replacements
C. PIPJ fusions
D. Thumb MCP joint fusion
E. Wrist fusion

51. You are asked to describe the anatomy of the forearm.

Which of the following descriptions most accurately describes the forearm musculature?

A. Flexor pollicis longus muscle takes its origin from the mid ulnar shaft
B. Flexor digitorum profundus muscle is supplied in part by the radial nerve
C. Flexor digitorum superficialis muscle has two heads
D. Flexor digitorum superficialis tendons to the index and middle finger are deep to the ring and little finger tendons
E. Pronator quadratus is supplied by the posterior interosseous nerve

52. A patient presents with painful swollen deformed distal interphalangeal joints (DIP joint) of both of his hands with shortened digits. He has pitting and onycholysis of his nails.

What finding would you not expect to see at X-ray?

A. Chondrocalcinosis
B. Interphalangeal ankylosis
C. Joint subluxation
D. 'Pencil in cup' appearance of joints
E. Resorption of bone

53. A patient presents to the ED after being bitten by her cat 3 days ago. She has erythema and swelling over the palmar surface of her hand and over the thumb. She has multiple small, healing puncture wounds. You take her to the operating theatre and wash the wounds out. Intraoperative microbiology swabs are taken.

What is the most likely organism cultured from the swabs?

A. *Corynebacterium*
B. *Neisseria*
C. *Pasteurella*
D.
E. *Streptococcus*

54. A 45-year-old patient presents with altered sensation and tingling in the radial three digits of her right dominant hand, which she says intermittently also affects the ulnar two digits particularly when she is driving. She is Phalen's positive at the wrist and provocation testing for cubital tunnel syndrome is grossly negative.

What is the most likely explanation for her symptoms?

A. Diabetes
B. Hypothyroidism
C. Martin–Gruber anastomosis
D. Peripheral neuropathy
E. Ulnar nerve entrapment at elbow

55. A 3-year-old patient comes into clinic after having a set of scaphoid X-rays performed. Their mother asks why there aren't as many bones on the 3-year-old's X-rays as there were on her own scaphoid X-ray.

Which is the last carpal bone to ossify?

A. Capitate
B. Hamate
C. Lunate
D. Pisiform
E. Trapezium

56. A 53-year-old female patient with a history of diabetes presents with pain over the radial border of her right dominant wrist. On examination, she has tender nodularity over her radial styloid and pain on ulnar deviation of her wrist with her thumb flexed.

What is the most likely diagnosis?

A. Base of thumb arthritis
B. De Quervain's tenosynovitis
C. Flexor carpi radialis tendonitis
D. Intersection syndrome
E. Superficial radial nerve neuroma

57. A 3-year-old child is brought to the hand clinic after her parents noticed she was unable to fully extend the IPJ of her left thumb. There has been no history of injury and she is functioning normally. On examination, the IPJ of her left thumb is fixed in 30° of flexion and you palpate a nodule in her palm at the base of the digit. What management should you propose?
A. Observation
B. Observation and splinting
C. Thumb A1 pulley release
D. Ultrasound scan of flexor sheath
E. X-ray of thumb

58. A 21-year-old football player has been diagnosed with an undisplaced scaphoid waist fracture. He wants to get back to training as soon as possible and asks for your advice regarding management.
What management option would you suggest?
A. Cast for 6 weeks and CT scan to assess union
B. Cast for 6 weeks and X-ray again
C. Open reduction and internal fixation with headless compression screw
D. Percutaneous fixation with headless compression screw
E. Scaphoid plate

59. A 65-year-old patient presents to the fracture clinic 12 weeks after her cast was removed following conservative treatment of her right distal radius fracture. Check radiographs show a healing fracture that is well aligned. She is complaining of a constant burning pain in her wrist. She describes the skin over her wrist being very sensitive and swollen. On examination, her wrist is swollen and red and her skin appears thin and shiny.
What is the most likely incidence of the above condition, following distal radius fracture?
A. 1%
B. 5%
C. 10%
D. 20%
E. 40%

60. A 56-year-old female patient presents to the hand clinic with a painful, swollen right ring finger proximal interphalangeal joint (PIP joint). The pain occurs at rest and at night, requiring regular analgesia. On examination, she has an arc of movement of 10–80°at the PIP joint, and her radial collateral ligament is lax. She expresses a wish to maintain as much movement at the joint as possible to allow her to continue her hobbies. Radiographs show complete loss of joint space at the PIPJ level.
What is the most appropriate management option for this patient?
A. PIP joint fusion
B. PIP joint injection
C. PIP joint pyrocarbon replacement
D. PIP joint silastic replacement
E. Watchful waiting

61. A family is referred to your hand clinic by the paediatric team. Their baby was born yesterday with the upper limb difference illustrated in Figure 18.1. This is their first child and they are planning to have more children.

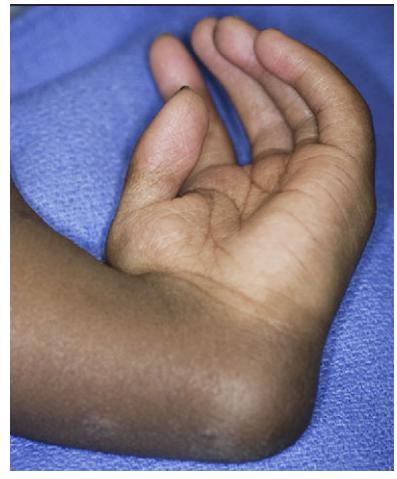


Figure 18.1 Clinical picture hand (Photograph courtesy of Shriners Hospital for Children, Philadelphia, PA)

Choose the most appropriate initial management plan from the options below.
A. Consent for surgical correction
B. Genetic testing
C. Renal ultrasound, echocardiogram and full blood count
D. Serial splintage and stretching
E. Skeletal survey

62. A 2-year-old child is brought to the trauma clinic having trapped their middle finger in a door. Their mother is concerned about the fact they are unable to fully straighten the finger. X-ray findings are shown in Figure 18.2.

Figure 18.2 Lateral radiograph middle finger

Involvement of which anatomical structure must be assumed with this X-ray appearance?

A. Epiphysis of distal phalanx
B. Nail bed
C. Nail plate
D. Terminal extensor tendon
E. Triangular ligament

63. A window cleaner falls from their ladder onto an outstretched left wrist sustaining the following injury (Figure 18.3).

Which surgical approach will give you the best exposure to repair the damaged structures?

A. 2nd and 3rd extensor compartment splitting approach
B. 3rd and 4th extensor compartment splitting approach
C. Radial approach
D. Ulnar approach
E. Volar approach through carpal tunnel

64. A 65-year-old recently retired lecturer presents to your clinic with pain at the thumb base and reduced grip strength. They have squaring of the thumb base and an adducted thumb metacarpal with tender thumb carpo-metacarpal joint and scaphotrapeziotrapezoidal joint (STTJ). You choose to perform the gold-standard surgery for this pathology.

Figure 18.3 Anteroposterior (AP) radiograph wrist

To prevent the most common cause of persistent post-operative pain, which of these manoeuvres should be performed intraoperatively?

A. Excise the scaphotrapezoidal joint
B. Perform a metacarpal suspension-plasty
C. Perform a tendon interposition
D. Stabilise the thumb metacarpophalangeal joint
E. Use a volar approach

65. A patient presents with a long-standing history of the lesion pictured (Figure 18.4). Pressure to the area elicits exquisite pain.

Which of the following statements is correct?

A. Marginal excision is curative
B. Mean age at presentation is 60 years
C. The patient is likely to have presented with heat intolerance
D. The recurrence rate following surgical excision is 50%
E. Tourniquet inflation increases pain

66. A 47-year-old scaffolder presents with an 8-month history of wrist pain which is not relieved with painkillers and is now keeping them awake

Figure 18.4 Photograph of left index finger

at night. On examination there is swelling over the dorsum of the wrist with restricted extension but preserved flexion. Radiographs are shown in Figure 18.5.

What is the most appropriate surgical treatment option?

A. Proximal row carpectomy
B. Radial shortening
C. Radiocarpal fusion
D. Ulnar lengthening
E. Vascularised bone grafting

67. A 69-year-old alcoholic patient presents with problems related to their right hand. On examination, there is a thickening and pitting of the skin, and the little finger is held in an adducted position.

The structure most likely to be involved is:

A. Commissural band
B. Grayson ligament
C. Lateral digital sheet
D. Natatory band
E. Pretendinous band

Figure 18.5 (a) AP radiograph and (b) lateral radiograph wrist

68. **A patient with anterior interosseous nerve (AIN) palsy due to entrapment at the tendinous edge of the deep head of pronator teres will have all the following except:**
    A. Intact sensation at base of thenar eminence
    B. Normal pronation strength with the elbows fully flexed
    C. Weakness of flexion to the index finger DIPJ
    D. Weakness of flexion of the DIPJ of the middle/long finger
    E. Weakness of flexion of the IPJ of the thumb

69. A 72-year-old patient caught the tip of the right middle finger in a circular saw sustaining loss of the tip of the volar surface of the finger with a 1cm skin defect without exposed bone.
    Which of the following treatments is most appropriate?
    A. Advancement flap
    B. Pedicled flap
    C. Primary closure
    D. Split skin grafting
    E. Toilet and dressing

70. A farmer presents to hand trauma clinic with a painful blister on the right index finger. There is no history of injury but they have been very busy with lambing season. The clinical picture of the finger is illustrated in Figure 18.6.

Figure 18.6 Photograph of right index finger

Which of the following management plans is most appropriate for this condition?
A. Acyclovir
B. Biopsy
C. Flucloxacillin
D. Surgical excision
E. Watchful waiting

71. An otherwise healthy 50-year-old left hand-dominant man has a fixed deformity as is shown in Figure 18.7. Examination reveals a thickened cord.

Figure 18.7 Clinical picture hand

Which of the following would be the procedure of choice with regards to treatment?
A. Dermofasciectomy and skin graft
B. Fusion of the PIP joint
C. Needle fasciotomy
D. No treatment is necessary
E. Partial fasciectomy

HAND I STRUCTURED SBA ANSWERS

1. Answer C. **Perform urgent fasciotomies of the hand**
   Compartment syndrome of the hand is a rare but functionally devastating condition and is often more difficult to diagnose in the hand because of the number of differential diagnoses that can cause similar symptoms. The history suggests a prolonged period of compression on the left upper limb combined with the clinical findings of pain not controlled with adequate analgesia and pain on passive stretch of the tendons passing through the hand. Emergent treatment in the form of formal hand fasciotomies is required to preserve muscle tissue.

2. Answer D. **Fusiform swelling, flexor surface tenderness, pain on passive extension and semi flexed position**
   The clinical picture points to a diagnosis of flexor sheath infection (pyogenic flexor tenosynovitis); the four signs described in the correct answer are collectively known as Kanavel's signs and indicate the need for emergency treatment. The findings described in answer E suggest a potential deep space infection rather than pyogenic flexor tenosynovitis.

3. Answer D. **Flucloxacillin**
   The most common organism isolated in flexor sheath infection is *Staphylococcus aureus*, which will respond well to flucloxacillin.

4. Answer A. **MUA and carpal tunnel decompression on next available list**
   A perilunate dislocation must be reduced emergently in the presence of carpal tunnel symptoms. The ideal situation would be an MUA in theatre to reduce the perilunate dislocation and to allow for carpal tunnel decompression. Scaphoid fixation can be performed on a less emergent basis if the skill set of the admitting general trauma team allows. The Tavernier closed technique for reducing a perilunate dislocation involves hyper-extending the wrist to accentuate the deformity while applying traction to the hand. Place the thumb on the lunate to stabilise it and then bring the hand into flexion. This will allow the capitate head to seat itself back into the lunate. Closed reduction of a perilunate dislocation often fails, as the lunate has breached the volar wrist capsular structures and is unreducible without opening the carpal tunnel.

5. Answer A. **Flexor digitorum profundus tendons and pronator quadratus**
   A flexor sheath infection within the flexor pollicis longus bursa can communicate proximally into the potential space of Parona. The potential space of Parona occurs in the palm between the FDP sheath and pronator quadratus muscle.

6. Answer D. **Peak latency delay of median nerve sensory nerve action potential (SNAP)**
   Nerve conduction testing in mild carpal tunnel syndrome, as described by the clinical scenario in the question, is controversial. When reviewing nerve conduction results for mild to moderate compression, often the only finding is a slight delay in the peak latency of the sensory nerve action potential. The motor parameters are not usually affected in mild to moderate compression, and needle EMG is rarely performed. If needle EMG is performed, fibrillation potentials and positive sharp waves are late signs. In 25% of those presenting with mild carpal tunnel symptoms and signs, the study is normal.

7. Answer C. **The condition occurs sporadically with no known cause**
   This is an example of a severe radial longitudinal deficiency, which can be associated with a number of other syndromes such as TAR, VACTERL or VATER. As yet, we do not know the cause, and in the majority of cases there is no genetic predisposition. It is believed to be an abnormality of the sonic hedgehog protein or an abnormality within the zone of polarising activity (ZPA) which causes the underdevelopment of the radial side of the hand and forearm. In some rare cases, it has been passed genetically in autosomal recessive or autosomal dominant forms.

8. Answer C. **The symptoms are due to nerve compression by the tendinous edge of pronator teres**

Anterior interosseous nerve (AIN) syndrome is most commonly caused by compression at the edge of pronator teres muscle. Parsonage–Turner syndrome, although rarer, can mimic AIN palsy and should be considered, and a thorough history of viral illness should be sought. The history does not suggest a cervical spinal pathology in this case, and although an X-ray should be performed to rule out rare bony pathology causing the palsy, an urgent ultrasound or MRI is not indicated. The AIN does not have a sensory component; therefore, nerve conduction test results would be unlikely to show sensory slowing.

9. Answer A. **Allen's test**
Revision Dupuytren's surgery has a higher incidence of neurovascular damage, and it is vital to assess both the sensation and vascular supply of each digit to be revised prior to surgery. Allen's test assesses the blood supply of the hand or digit by exsanguinating the digit, then releasing each neurovascular bundle in turn to see if the digit revascularises, i.e. turns pink. An accurate assessment of the blood and nerve supply to the digit will allow pre-operative planning and to accurately counsel the patient regarding the risks of surgery, including amputation.

10. Answer C. **Closed flexor sheath washout**
The clinical examination signs described above are known collectively as Kanavel's signs. They indicate flexor sheath infection (pyogenic flexor tenosynovitis) and the need for emergent treatment. Optimal management would be a closed flexor sheath washout using two incisions and a small catheter – usually a paediatric feeding tube. The tube is inserted proximal to the A1 pulley through a small palmar incision, and a second incision at the DIPJ crease allows the irrigation fluid to wash out of the flexor sheath. The flexor sheath is irrigated after microbiological samples are taken.

11. Answer D. **X-ray and gadolinium-enhanced MRI scan**
The patient describes a proximal pole scaphoid fracture. His young age and the high-energy injury, along with the location of the symptoms, indicate a diagnosis of proximal pole scaphoid fracture until proven otherwise.

Proximal pole scaphoid fractures are often missed on the first X-ray, so history and examination must be combined with a high index of suspicion. The X-ray confirms the diagnosis, and the MRI with gadolinium is to assess the vascularity of the proximal pole to plan further management.

12. Answer E. **A2 and A3 pulleys**
The most commonly injured pulley in rock climbers is the A2, but rupture of this pulley would not cause significant bowstringing of the tendons as described by the patient. Both the A2 and the next most distal annular pulley, the A3 pulley, would need to be ruptured to allow the tendons to bowstring. In some cases, the A2, A3 and A4 pulleys are all ruptured, causing significant functional impairment.

13. Answer E. **Watchful waiting**
This gentleman is presenting with early Dupuytren's disease. He has both a Dupuytren's nodule and an abnormal pretendinous cord. The inflammatory stage of the condition can cause the nodules to become painful, and this may be exacerbated by his job as a mechanic. The tabletop test is performed by asking the patient to place their hand palm down on the table. If they are unable to get the palm flat on the table, then this is a positive test and suggests significant MCPJ contracture. Until functional impairment occurs, conservative management is advocated in most cases.

14. Answer B. **Palmar cutaneous branch of the median nerve**
Published literature suggests all of the answer choices can be damaged, but the most likely injury is to the palmar cutaneous branch of the median nerve. It arises 5cm proximal to wrist crease from the radial aspect of the nerve, but ulnar to the flexor carpi radialis.

15. Answer B. **Diabetes**
Trigger finger, particularly in multiple digits, is often associated with diabetes, and new patients presenting with triggering should be questioned

about diabetes as well as gout and rheumatoid arthritis history.

16. Answer A. **Forty per cent of distal radial fractures will have an associated scapholunate ligament injury**
The scapholunate ligament is divided into three sections – the anterior, intermediate and posterior. The posterior section is the strongest, being able to withstand 260N of force vs the anterior section at 118N. It is the most important of the interosseous ligaments in the carpus and is frequently damaged following a distal radial fracture. The injury can be partial or complete, and the normal scapholunate angle is between 30° and 60°. The blood supply of the scapholunate ligament enters through the radioscapholunate ligament via the radial artery.

17. Answer B. **Both vinculae to flexor digitorum profundus**
The Leddy and Packer classification describes closed flexor digitorum profundus injuries:
Type I – avulsion into the palm with complete avulsion of the vinculae system. Type II – avulsion of FDP through the A4 but not the A2 pulley, therefore the possibility of maintaining the long vinculum Type III – avulsion of FDP but with the stump not retracted through the A4 pulley.

18. Answer C. **Zone III flexor tendon injury**
The zones of injury of the flexor tendons (or Verdan's zones) are as follows:
Zone I: FDP only from its insertion onto the distal phalanx to the insertion of FDS on the middle phalanx.
Zone II: From the insertion of FDS onto the middle phalanx to the proximal edge of the A1 pulley.
Zone III: Proximal edge of A1 pulley to the entry of the carpal tunnel – transverse carpal ligament distal border.
Zone IV: Carpal tunnel.
Zone V: Proximal to carpal tunnel in forearm.

19. Answer B. **Scapholunate ligament**
The natural tendency of the scaphoid is to flex, and the natural tendency of the triquetrum is to extend. The intraosseous ligaments between these bones keep these two competing forces balanced. When the scapholunate ligament (SLL) is ruptured, the scaphoid will naturally adopt a flexed position, increasing the SLL angle and creating a dorsal intercalated segment instability (DISI) deformity. When the lunotriquetral ligament is damaged, the triquetrum will extend, allowing the lunate to flex under the control of the scaphoid and the intact SLL, creating a volar intercalated segment instability (VISI) deformity.

20. Answer A. **Carpal instability complex**
The carpal instability patterns are divided into three main groups:
Injuries occurring between the carpal bones – carpal instability dissociative (CID).
Injuries occurring between the carpal rows or distal radius – carpal instability non- dissociative (CIND).
Complex injuries that are a mixture of the two – carpal instability complex (CIC).
Perilunate injuries are a combined injury and therefore fall into the CIC group.

21. Answer E. **Fifth degree**
This is an example of neurotmesis, which means the nerve is completely severed including the endoneurial tube.
First degree – segmental demyelination that occurs in crush or minor traction injuries
Second degree – axon disruption but intact endoneurium, perineurium and epineurium
Third degree – a severed axon and endoneurium, but perineurium and epineurium are intact
Fourth degree – a severed axon, endoneurium and perineurium, but intact epineurium
Fifth degree – complete division of all elements

22. Answer D. **Toilet, dressings and wound review 1 week**
A volar fingertip injury without exposed bone with a surface area of less than 1cm will heal very well with conservative management with wound toilet and regular dressings. The other options could be performed for this injury, but the best cosmetic and functional outcomes are observed following conservative management. It will take

around 6 weeks for the pulp to heal, and the patient will regain his normal fingerprints and sensation, and most of the bulk of the tip, without any surgical scarring.

23. Answer C. **Granulocytes, macrophages, fibroblasts, collagen, cross-linked extracellular matrix**
The healing of skin after an incised wound follows a defined pattern with inflammatory, late-inflammatory, proliferative and maturation phases. Each phase is associated with a particular cell type. First, there are inflammatory cells, such as neutrophils and granulocytes; then, during the late inflammatory phase, the macrophages arrive and stimulate angiogenesis and epithelialisation. Fibroblasts are activated during the late inflammatory phase and deposit collagen. During the proliferative phase, granulation tissue starts to form as a loose network of collagen, fibronectin and hyaluronic acid. During the maturation phase, more collagen is laid down and the extra-cellular matrix becomes cross-linked, strengthening the scar tissue.

24. Answer E. **Retropulsion**
The patient has a closed extensor pollicis longus (EPL) rupture with the classic loss of retropulsion. Ask the patient to place their hand flat on the table palm down. Now ask them to lift the thumb off the table. An EPL rupture prevents this movement.

25. Answer D. **Reassurance and observation with serial radiographs**
This is a classic presentation of an enchondroma. These lesions represent 10–25% of all benign bone tumours and commonly present in the hands and feet. An MRI would show chondroid calcification, or a 'popcorn' appearance, to the lesion. Histologically, these lesions show low cellularity, regular distribution, abundant chondroid matrix and encasement. The cells have small hyperchromatic nuclei without mitoses. The most appropriate management is observation.

26. Answer A. **Early combined passive and active motion at days 3–5**
Flexor tendon rehabilitation is as important as the surgical repair in gaining a good outcome. Following flexor tendon injury, research suggests rehabilitation should start no later than day 7, which is the point at which the gliding resistance is lower. The work of flexion is related to force and oedema, and it has been shown that force and work increase progressively for the first 4 days, then remain constant from days 4–7, making it the best time to start rehabilitation. The Manchester Group has shown that a combination of passive and controlled active motion gives the best results. Passive movement maintains glide, but it needs to be augmented by active movement, which has been shown to reduce adhesions and inflammation and to increase tensile strength. Early full active flexion is not advocated because of the increased resistance to digital flexion that occurs in the final range of motion – increasing the potential for rupture of the repair.

27. Answer D. **Pronator teres to extensor carpi radialis brevis**
This patient has a radial nerve palsy likely at the midhumeral level. The most appropriate tendon transfer would be the median nerve innervated pronator teres transfer to extensor carpi radialis brevis to allow wrist extension. The ability to extend the wrist is one of the most important aspects of improving function in radial nerve palsy, as wrist flexion further de-functions the hand long flexors and is cosmetically undesirable for patients. There is no mention of elbow weakness, so the triceps transfer is not required. Brachioradialis to flexor pollicis longus is for a high median nerve palsy, and flexor digitorum superficialis to adductor pollicis is for ulnar nerve dysfunction.

28. Answer C. **Stener lesion**
This injury pattern and the examination findings suggest a Stener lesion until proven otherwise. For there to be no end point in either partial flexion (tests ulnar collateral ligament) or extension (tests volar plate), both of these structures must have been damaged. The lump over the ulnar collateral ligament territory has been described as highly suggestive of a Stener lesion, and when the clinical picture includes joint laxity with no firm end point, this requires surgical exploration. A Stener lesion occurs when the

torn end of the ulnar collateral ligament flips over the edge of the adductor aponeurosis and becomes superficial, thus preventing the ligament from healing without surgical intervention.

29. Answer D. **C7, C8, T1**
The most common pattern of brachial plexus injury in motorcyclists is at the C8/T1 level with or without some contribution from C7. The intrinsic muscles of the hand and long flexors of the digits are supplied by C8. Weakness of these suggests a C8 lesion. If extensor digitorum and extensor pollicis longus are also involved, it suggests a radial nerve lesion, which is a C7 innervated nerve. Weakness of the latissimus dorsi muscle suggests a thoracodorsal nerve palsy which is exclusively supplied by C7.

30. Answer A. **Root level**
Horner's syndrome occurs due to damage to the sympathetic ganglion as it lies close to the T1 nerve root. Developing a Horner's syndrome (miosis, ptosis and anhidrosis) suggests a root-level avulsion and therefore a supraclavicular injury, which is the most common type of plexus injury in motorcyclists following an RTA as described by the commonly quoted Narakas rule of 'seven seventies':

70% of brachial plexus injuries are due to RTAs.

Of those RTAs, 70% are motorcycle/pedal bicycle riders.

Of those riders, 70% have multiple injuries. Of those 70% have supraclavicular injuries. Of the supraclavicular injuries, 70% have at least one root avulsed.

Of the avulsed roots, 70% are of the lower plexus: C7, C8, T1.

Of those with avulsed roots, 70% are left with chronic pain.

31. Answer E. **Shoulder and chest X-rays**
There are a number of injuries associated with brachial plexus injuries and many of the investigations in the answer choices are appropriate during the course of the patient's management. The most immediate priority should be ensuring there is no cervical spine, chest or shoulder girdle injury. This is usually achieved first with plain imaging and then with further tests. Nerve conduction testing is more useful after 6 weeks post-injury, and a CT myelogram looking for root avulsions is most sensitive 3–4 weeks post-injury.

32. Answer D. **Steroid injection and CT scan**
This patient is presenting with a stage II or III scaphoid non-union advanced collapse. Recent studies have suggested that radiographs alone are not reliable in identifying the extent of the arthritic change, so a CT scan is indicated in anyone who is considered for operative management. Immediate symptomatic treatment in a patient with night pain is a local anaesthetic and steroid injection. If the CT scan shows that the lunocapitate articulation is also involved, this changes the decision-making process; an arthritic head of the capitate articulating with the lunate fossa after proximal row carpectomy will still cause pain.

33. Answer E. **DIPJ splinting for 6 weeks in extension, then 2 weeks at night only**
This is a mallet injury of the terminal extensor tendon. Without bony injury, the majority of these injuries are treated with 6 weeks in an extension splint (either custom made or the classic Stack splint), followed by 2 weeks of night splinting. Patients may never regain full extension even if they are fully compliant with treatment.

34. Answer E. **Operative fixation**
The management of metacarpal fractures is controversial, although there are a number of factors that, when present, should indicate a surgical management plan. Multiple unstable metacarpal fractures are one indication; open fractures, rotational deformity, gross angulation and excessive displacement are some of the others. Some surgeons would still manage these scenarios conservatively, but the outcome has been shown to be worse. The surgical technique employed is down to the choice and expertise of the surgeon, and no single technique has been shown to be best. The principle should always be to get the hand moving as quickly as possible. Plating, intramedullary wiring and percutaneous transverse wiring have all been described.

35. Answer A. **Dynamic external fixation**
This is a pilon fracture of the PIPJ. These fractures are difficult to treat, and the outcome is often poor. Operative management is indicated if the joint is subluxed, which is identified by the dorsal triangle sign on X-ray. In this case, the main aim of management is to maintain joint congruity. This can be achieved in a number of ways, but many surgeons prefer dynamic external fixation, as this method theoretically maintains some joint movement.

36. Answer B. **Median nerve**
Carpal tunnel syndrome can occur in association with base of thumb arthritis in up to 43% of patients. It is essential that a median nerve examination is performed and documented. It is also necessary to examine the MCPJ for evidence of a compensatory hyperextension of the joint caused by the relative stiffness of the arthritic CMCJ. The ulnar nerve is not usually affected in base of thumb arthritis but can form part of the routine hand examination. The superficial radial nerve can be damaged during the approach to the trapezium, as can the radial artery.

37. Answer A. **Age**
All of the answer choices are prognostic indicators for the outcome following carpal tunnel decompression, but age is the most significant. Counselling the patient well preoperatively and documenting that discussion is imperative. There is unlikely to be any improvement in the symptoms in the patient described in the scenario and, in some cases, as the nerve begins to reinnervate, patients also describe shooting pains in the nerve distribution.

38. Answer E. **Triangular fibrocartilage complex**
All of the other components lend stability to the joint, but the primary stabiliser is the triangular fibrocartilage complex (TFCC). The deep head of pronator quadratus is a dynamic stabiliser, and it is the distal oblique bundle of the intraosseous membrane that lends most support to the joint. In a study that sectioned these components individually, it was found that the TFCC alone could support the joint, but that without the TFCC and with the other components intact, the joint would still maintain stability.

39. Answer D. **Shared muscle belly of all four flexor digitorum profundus tendons**
This patient is describing the quadriga effect. This is a condition in which the flexor tendon excursion is reduced in an unaffected finger when the excursion of the flexor digitorum profundus (FDP) tendon of the adjacent finger is altered by stiffness, injury or adhesion. This has occurred in the scenario after repair of the FDP. The tendon has been overly shortened during repair; because all of the other FDP tendons arise from the same muscle belly in the forearm, the index and middle fingers are unable to flex fully. There is evidence that inter-tendinous connections are as important in contributing to this phenomenon, although they are rarely mentioned in the textbooks.

40. Answer C. **Proximal row carpectomy**
This patient has Kienböck's disease, and the staging of this condition is now based on a combination of plain imaging, MRI findings and arthroscopic examination. The classification and management options have recently been modified by Lichtman. The broad categories of management depend upon whether the lunate is intact, compromised or unreconstructable and whether the wrist is compromised or unreconstructable. In the scenario, the patient has evidence of lunate compromise.

41. Answer D. **Terminalisation**
In this case, the amputated digit is not reconstructable due to the severe damage to the soft tissues and bones. Without obvious neurovascular structures to repair to, the amputated digit would be insensate and avascular. To get this patient back to work and full function as soon as possible, a terminalisation of the remaining digit down to good-quality soft tissue and bone is the best option. Eventually, he may require further surgery in the form of a more proximal amputation, but this is best assessed after the patient has tried functioning with the digit.

42. Answer C. **Replantation**
The thumb contributes 40–50% of the function of the hand. In a fit and well manual worker, dominant thumb replantation should be

attempted if possible. It may be that the function of the thumb is poor, but creating a stable, static post is still a better functional outcome than losing the thumb entirely.

43. Answer A. **Glomus tumour**
A glomus tumour is a tumour of the glomus body, which is a thermoregulatory organ found in large numbers in the digits. It is classically moderately painful, associated with temperature hypersensitivity and point tenderness. It occurs most commonly between the ages of 30 and 50 but is still a rare tumour. Malignant melanoma of the nailbed can present as a discolouration of the nail. A mucous cyst is a dorsal swelling around the DIPJ crease secondary to OA. Osteoid osteomas are painful mainly at night, are rare in the hand and show the classic nidus on CT scan. A pulp abscess could present in a similar way, but the onset would be more acute and may be associated with an injury.

44. Answer E. **Superficial recurrent motor branch of the median nerve**
All of the structures presented are potentially at risk during carpal tunnel decompression. Recognition of the normal anatomy of the approach makes damage to the common structures less likely. However, anatomical variations make damage to those structures more likely. The recurrent motor branch of the median nerve has five recognised patterns of anatomical variation. The normal pattern, which is extraligamentous and recurrent, is less likely to be damaged, as most surgeons will be aware of its course. The superficial branch, which occurs in around 10% of the population, sits superficial to the transverse carpal ligament and can be inadvertently damaged. The superficial palmar arch can be damaged by an incision made too distally, and damage to the palmar cutaneous branch of the median nerve is possible if the incision is made too radially.

45. Answer B. **Cubital tunnel**
This clinical picture fits with a high ulnar nerve palsy, and the most common cause is compression in the cubital tunnel. A high ulnar nerve palsy occurs when the damage to the ulnar nerve is proximal to the branches of the nerve that supply the flexor carpi ulnaris and flexor digitorum profundus. All of the other sites are potential areas for ulnar nerve compression but are less common.

46. Answer A. **ECRB tendon**
All of the other anatomical structures must be identified and protected throughout the procedure. The approach centres over the middle of the thumb metacarpal and the radial styloid with the CMCJ at the midpoint. The superficial branches of the radial nerve and cephalic vein are mobilised and gently retracted, followed by the extensor tendons of the anatomical snuffbox. The radial artery is then identified over the STTJ and mobilised and protected. The FCR tendon is found in the base of the wound after removal of the trapezium and should be identified and protected.

47. Answer E. **X-ray**
Initial management is to rule out a hook of hamate fracture, which can be performed with a carpal tunnel view plain radiograph. The patient's symptoms indicate that a hook of hamate fracture is more likely, as this fracture occurs in zone I or II of Guyon's canal where the ulnar nerve is either mixed or purely motor. One of the differential diagnoses in this case is 'hypothenar hammer syndrome', in which an aneurysm forms on the ulnar artery after repetitive injury to the palm. This occurs in zone III, which is purely sensory.

48. Answer A. **3–4**
The most commonly used of the wrist arthroscopy portals is the 3–4 portal. It is in the interval between the third and fourth extensor compartments just distal to the distal lip of the distal radius. You can visualise the scaphoid and lunate fossae as well at the TFCC and scapholunate ligament from this port site. It also allows direct vision for the creation of the 6R portal.

49. Answer C. **Zone V**
The zones of injury of the extensor tendons are useful for describing the injury and also for categorising the management and subsequent rehabilitation options. Numbers are allocated to different zones of the hand, wrist and forearm.

Odd numbers are allocated to joints (I = DIPJ; III = PIPJ; V = MCPJ; VII = Wrist) and even numbers represent the remaining structures (II = middle phalanx; IV = proximal phalanx; VI = dorsum of hand; VIII = forearm).

50. Answer A. **Elbow replacement**
With rheumatoid arthritis, the surgical sequence in most cases is to start with the most proximal joint that is affected and work distally. If the patient is unable to place her hand in space because she has a painful, stiff elbow, replacing her finger MCPJs will not improve her overall function, although it will help with pain. Replacing or fusing her wrist joint will correct the wrist deformity, which will in turn enable later finger MCPJ replacements to have the maximum functional benefit.

51. Answer C. **Flexor digitorum superficialis muscle has two heads**
The flexor pollicis longus takes its origin from the midradial shaft, not the ulnar shaft; the flexor digitorum profundus is supplied by the anterior interosseous nerve and the ulnar nerve. The flexor digitorum superficialis splits into four tendons with the index and little finger tendons running deep to the middle and ring finger tendons. The pronator quadratus is supplied by the anterior interosseous nerve.

52. Answer A. **Chondrocalcinosis**
This patient has psoriatic arthritis, which occurs in 10–30% of patients who suffer from psoriasis. The majority of these patients will have arthritis affecting their hands and a minority will develop arthritis mutilans (around 5%). Arthritis mutilans is a severe form of arthritis that affects both patients with rheumatoid arthritis and those with psoriatic arthritis. Severe forms cause bone loss and telescoping of the digits, with a classic 'pencil in cup' appearance of the joints.

Chondrocalcinosis is not usually associated with arthritis mutilans.

53. Answer C. ***Pasteurella***
Pasteurella spp. are the most common pathogen found in both cat and dog bite wounds. All of the other bacteria are also found in cat bites but less frequently than *Pasteurella*.

54. Answer C. **Martin–Gruber anastomosis**
A Martin–Gruber anastomosis is an anatomical variant that connects the ulnar and median nerves in the forearm. All of the other conditions listed can cause neurological symptoms. The examination findings in this case suggest a lesion at the elbow is unlikely, Phalen's test is positive, suggesting definite median nerve compression at the wrist, ruling out a peripheral neuropathy. Diabetes is associated with carpal tunnel syndrome, as is hypothyroidism, but specific ulnar nerve symptoms present only in the hand point to a Martin–Gruber anastomosis as the most likely scenario.

55. Answer D. **Pisiform**
The carpus ossifies in a reliable sequence starting with the capitate and ending with the pisiform. The sequence is as follows:

Capitate, hamate, distal radius, triquetrum, lunate, scaphoid, trapezium, trapezoid, pisiform, distal ulna.

The carpal radiographs can be used to assess the difference between chronological age and physiological age in children with developmental delay.

56. Answer B. **De Quervain's tenosynovitis**
De Quervain's tenosynovitis is a tendon entrapment syndrome affecting the first dorsal extensor compartment. It presents as pain and tenderness over the radial aspect of the wrist joint proximal to the anatomical snuffbox. Intersection syndrome occurs over the second compartment tendons and the pain is usually more proximal.

57. Answer A. **Observation**
The clinical picture is one of trigger thumb. The nodule in the palm is a Notta's nodule, which is a thickening of the flexor tendon. The management is controversial. In young children under the age of 5, there is some evidence that there may still be spontaneous resolution of the trigger thumb even after years of observation. The literature supports either non-operative or operative management.

58. Answer D. **Percutaneous fixation with headless compression screw**
There is no conclusive evidence that fixation gives a better long-term outcome or a quicker

return to work. However, in this case the patient needs to get back to sporting activities as soon as possible. Following successful percutaneous fixation, a cast may not be required, and mobilisation can begin almost immediately. The patient needs to be counselled as to the risks of surgery vs cast and advised that healing may still take the same length of time.

59. Answer A. **1%**
Chronic regional pain syndrome presents as a spectrum of symptoms and signs, but the most defining feature is debilitating pain. There are two types of the disorder: Type 1 has no associated nerve injury and type 2 is associated with nerve injury. The most commonly used diagnostic criteria are the Budapest criteria. In a large population study from the Netherlands in 2004, the overall general population incidence was defined at 26.2 per 100,000 with the highest incidence occurring in women (3:1 ratio) between the ages of 60 and 70 years and post fracture. A study looking specifically at conservatively managed distal radial fractures described an incidence of 1%.

60. Answer D. **PIP joint silastic replacement**
In this case, the patient wants to maintain range of movement. The symptoms and signs are such that an injection is only a very short-term solution. The time for watchful waiting has passed and operative intervention is now the best option to improve pain. Joint replacement is the only option that will allow preservation of range of movement. The laxity of the radial collateral ligament is important in planning which type of prosthesis you will choose. The silastic implant is a hinged implant that will compensate for the loss of the radial collateral ligament. The pyrocarbon implant does not lend any stability to the joint and would be likely to fail in this scenario.

61. Answer C. **Renal ultrasound, echocardiogram and full blood count**
The clinical photograph above shows a patient with a radial longitudinal deficiency which is one of a spectrum of limb differences which occur when the radial forearm and hand anatomy fails to develop normally. This patient has a thumb but has a deficient radius which produces the radial deformity and the prominence of the ulnar at the wrist. The condition is associated with several potentially life-threatening conditions including Holt Oram syndrome and Fanconi anaemia as well as cardiac and gastrointestinal abnormalities hence the urgent need for renal ultrasound, echocardiogram and full blood count. It is also important to start treatment for the forearm deformity with initiation of splintage and stretching exercises but these start after the child has had other more life-threatening conditions ruled out. Genetic testing is not likely to be helpful as the aetiology of radial longitudinal deficiency remains unknown. Surgical correction may be warranted in older children with the aim of realigning the carpus onto the radial shaft but in newborns, splintage is the preferred initial management. A full skeletal survey will not be necessary but it will be useful to perform plain radiography of the affected limb to plan further management of the deformity.

Maschke SD, Seitz W, Lawton J. Radial longitudinal deficiency. *J Am Acad Orthop Surg.* 2007;**15**:41–52.

62. Answer B. **Nail Bed**
The clinical radiograph of the above skeletally immature patient shows a deformity of the physis of the distal phalanx of the right middle finger which represents a Salter Harris 2 fracture. This is a classic presentation of a Seymour fracture which is a variation of a mallet injury and occurs in children. With the history of a crush injury and the above radiographic appearance an associated nail bed injury must be assumed until proven otherwise. The nail bed becomes approximated within the physis preventing either normal bony healing or nail regrowth or both. The nail plate is not involved in the fracture neither is the terminal extensor tendon (true mallet injury) or the triangular ligament which is part of the extensor hood found just proximal to the terminal extensor tendon.

63. Answer B. **3rd and 4th extensor compartment splitting approach**
The clinical radiograph above shows a perilunate dislocation of the wrist. The 'workhorse' approach to the wrist for carpal trauma is a dorsal approach through the interval between

the 3rd and 4th extensor tendons. This approach allows for direct visualisation of the scapholunate ligament and the lunotriquetral ligament both of which will be damaged following the above injury. A volar approach through the carpal tunnel may be needed in the acute setting if the lunate is irreducible but will not allow adequate visualisation of the dorsal structures allowing repair. Neither a radial or an ulnar approach would allow enough access to repair the scapholunate and lunotriquetral ligaments or adequately hold the lunate reduced. An approach through the 2nd and 3rd compartments would also only provide limited exposure to the lunate.

64. Answer A. **Excise the scaphotrapezoidal joint**
Pantrapezial osteoarthritis is one of the most frequent presentations to the hand clinic. Trapeziectomy remains the gold standard management for relief of pain caused by thumb carpometacarpal joint osteoarthritis in combination with STTJ osteoarthritis. The most common cause of persistent pain following trapeziectomy is residual scaphotrapezoidal joint (STJ) osteoarthritis. STJ involvement can be assessed intraoperatively and an excision arthroplasty can be performed at the time of trapeziectomy. The thumb metacarpal may subside causing impingement on the scaphoid but this is less common than persistent STJ pain. A tendon interposition at the time of trapeziectomy has not been shown to improve post-operative pain, neither has hyperextension of the thumb MCPJ (the reason you would perform an MCPJ stabilisation). The approach used to excise the trapezium has also not been proven to significantly affect the incidence of post trapeziectomy pain.

Rhee PC, Shin AY. Complications of trapeziectomy with or without suspension arthroplasty. *J Hand Surg Am.* 2014;**39**:781–783.

65. Answer A. **Marginal excision is curative**
Glomus tumours are rare benign tumours of the glomus body, often occurring in the subungual region. The condition is typically seen in patients between the ages of 20 and 40 who present with a painful subungual mass with bluish discolouration. Diagnosis is made with a biopsy showing a well-defined lesion lacking cellular atypia or mitotic activity with the presence of small round cells with dark nuclei. Treatment is usually marginal excision. The average time to diagnosis remains at over 2 years and the most challenging aspect of the management of glomus tumours is the diagnosis, as not all lesions have the characteristic bluish tinge.

Anatomic location

- 75% occur in hand.
- 50% are subungual.
- 50% have erosions of distal phalanx (primary involvement of bone being very rare).
- Fewer common locations: palm, wrist, forearm, foot.

Anatomy

- Glomus body: the glomus body is a perivascular temperature regulating structure frequently located at the tip of a digit or beneath the nail.

Presentation

- Symptoms (classic triad).
  - Paroxysmal pain.
  - Exquisite tenderness to touch.
  - Cold intolerance.

Clinical examination

- Small bluish nodule.
- Often difficult to see, especially in the subungual location.
- Nail ridging or discolouration is common.
- Love test
  - Pressure to the area with a pinhead elicits exquisite pain.
  - 100% sensitive, 78% accurate.
- Hildreth test
  - Tourniquet inflation reduces pain/tenderness and abolishes tenderness to the Love test.
  - 92% sensitive, 91% specific.

Imaging

- Radiographs
  - Glomus tumours can produce a pressure erosion of the underlying bone and an associated deformity of the bone cortex.
  - MRI
    - Helpful to establish diagnosis.
    - Presents as a low T1 signal and high T2 signal.

Histology

- Well-defined lesion lacking cellular atypia or mitotic activity.
  - Small round cells with dark nuclei.
  - Associated small vessels in a hyaline/myxoid stroma.
- Can show gland-like or nest structures, separated by stromal elements.

Treatment

Operative

- **Marginal excision is curative.**
  - Indications.
    - Symptoms affecting quality of life.
  - Outcomes
    - Due to the benign nature of this disease, recurrence is uncommon.
    - Several cases of malignant glomus tumours have been reported in the literature.
- **Reconstruction of nail bed contour with autologous fat graft**
  - Indications.
    - For large defects after resection.

66. Answer A. **Proximal row carpectomy**

This patient has lunate degeneration most likely secondary to Kienböck's disease. Kienböck's disease is a rare (7 per 100,000) and progressive osteonecrosis of the lunate bone. The staging of this condition is based on the combination of plain imaging, MRI findings and arthroscopic examination. The modified Lichtman classification is most commonly used and is outlined below.

Stage I – lunate maintains normal architecture and density.

Stage II – characterised by an increase in lunate density and diffuse sclerosis of the lunate.

Stage IIIa – the lunate is collapsed but its carpal alignment and height remain unchanged.

Stage IIIb – in addition to lunate collapse, scaphoid palmar flexion occurs.

Stage IIIc – complete coronal plane split.

Stage IV – lunate collapse and radiocarpal or midcarpal degenerative arthritis.

This patient has stage 4 Kienböck's disease. There is loss of the lunate height and flexion of the scaphoid (circle sign on PA) with proximal migration of the capitate. There is also early radio-scaphoid arthritis. In the presence of lunate collapse and degenerative changes, the management of Kienböck's disease is a salvage procedure. Given the patient's current range of movement, the decision of which salvage procedure to choose is based on whether or not the patient wants to maintain their range of movement and what their occupation/hobbies are. A proximal row carpectomy is a salvage procedure which preserves wrist range of movement whereas a radiocarpal fusion does not. However, PRC does require that the capitate head and the lunate fossa are not arthritic. Given the age of the patient, the heavy job and the fact that the capitate head is not arthritic on the X-rays provided, the choice of PRC would be the best option for this patient. Radiocarpal fusion is also appropriate but less so given the occupation and current good range of movement.

The other options are for management of earlier stage Kienböck's disease.

Chojnowski K et al. Recent advances in assessment and treatment in Kienböck's disease. *J Clin Med.* 2022;**11**:664.

67. Answer D. **Natatory band**

This patient has Dupuytren's disease in the hand. Dupuytren's disease can affect all parts of the palmar fascial complex. The following make up the normal palmar fascial complex.

The palmar aponeurosis: originates at the wrist close to the palmaris longus tendon. It diverges from the wrist into:

Pretendinous bands, longitudinal strips that course toward the fingers.

In a sagittal plane, it divides into: superficial fibres which insert into the dermis, intermediate-depth fibres (which bifurcate into two separate strips; spiral bands and lateral digital sheet) and deepest fibres which pass almost vertically and dorsally (related to the metacarpal joint capsule and tendon flexor sheath).

Two sets of transverse fibres in the palm; superficial transverse palmar ligament and natatory ligament.

Bands are the normal palmar tissue; cords are the abnormal palmar tissue in Dupuytren's disease.

Natatory cords originate from the natatory ligaments and cause contractures of the second through to the fourth webspace. Changing the normal U-shaped web spaces into the classic V-shaped web in Dupuytren's disease. These contractures result in finger adduction. The distal natatory ligaments are found in the second to fourth webspace and the palmar digital junction acts to connect the adjacent web skin.

- The pretendinous cord is formed from pretendinous bands.
- The spiral cord is made up of the pretendinous band, spiral band, lateral digital sheet and Grayson ligament; this often occurs in the ring and little fingers and winds around the neurovascular bundle.
- The lateral cord is formed from the lateral digital band and is rarely observed, except on the ulnar aspect of the small finger.
- The central cord is the extension of the pretendinous cord in the palm; it is the most common cause of proximal PIP contracture.
- The natatory cord contributes to webspace contractures and passes superficial to neurovascular bundles.
- A natatory ligament runs transversely across each webspace distal to the MCP joint, giving fibres that blend with each lateral digital sheet and to the superficial aspect of the flexor tendon sheath.

Leibovic SJ. Normal and pathologic anatomy of Dupuytren disease. *Hand Clin.* 2018;**34**:315–329.

Rayan GM. Dupuytren disease: anatomy, pathology, presentation, and treatment. *J Bone Joint Surg Am.* 2007;**89**:189–198.

68. Answer B. **Normal pronation strength with the elbows fully flexed**

The anterior interosseous nerve innervates two of the deep muscles of the forearm and contributes 50% to the innervation of another.

- Flexor pollicis longus.
- Pronator quadratus (PQ).
- The radial (lateral) half of FDP (index and middle fingers).

The AIN supplies PQ. PQ is tested with the elbow fully flexed to defunction the pronator teres.

The AIN has no sensory innervation.

Flexion of the IPJ of the thumb is controlled by the flexor pollicis longus (FPL) supplied by the AIN.

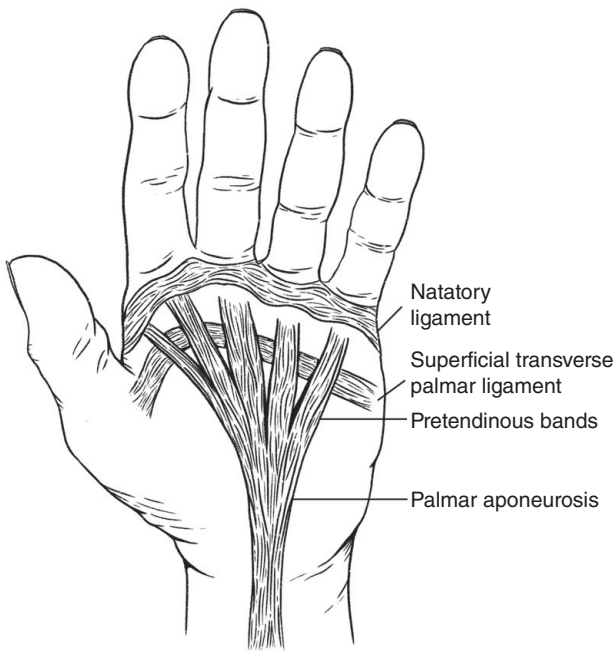


Figure 18.8 Natatory cords have transverse components and therefore cause adduction of finger. Reproduced with permission from Elsevier

Flexion of the DIPJ of the middle finger is controlled by flexor digitorum profundus (FDP) supplied by the AIN.

69. Answer E. **Toilet and dressing**
A volar fingertip injury without exposed bone involving 1cm or less of skin loss is best treated with toilet and dressing. The aim of any fingertip reconstruction is to maintain length, sensation and function of the affected digit. Advice should be given to the patient that the wound will take 6 weeks to heal and the contour and sensation of the tip will recover. Primary closure is not appropriate as this would leave a more abnormal contour to the fingertip. If the injury involved/exposed the bone of the distal phalanx, the options of treatment are to perform an advancement flap such as an Atasoy flap which involves mobilising more proximal skin over the defect in a V-Y pattern or to terminalise the digit. Terminalisation shortens the digit to allow for primary skin closure. Pedicled flaps such as a first dorsal metacarpal artery flap or a cross finger flap are not required for this injury as the size of the defect will allow for healing by secondary intention and split skin grafting is not performed for volar digital skin loss.

Whilst we realise that this SBA is similar to Q22 we have kept it in the chapter. The topic seems to have been repeated in several different diets of recent exams. More is more in this situation.

Golinvaux NS, Maslow JI, Hovis JP, Lee DH. Fingertip injury and management. *JBJS Essent Surg Tech.* 2019;**9**:e30.

70. Answer E. **Watchful waiting**
This patient has a classic history for Orf infection which is passed to humans from sheep, and in particular lambs. It is a viral infection (Parapoxvirus) and often starts as a small flat blue red circular lesion becoming bigger and more blister-like and eventually weeping. Systemic upset can be a feature of the infection and the digit can become very swollen and painful with restricted range of movement.

Orf is usually self-limiting and does not require any treatment and will usually clear up completely after 6 weeks.

71. Answer E. **Partial fasciectomy**

- Dupuytren's disease: Little finger PIPJ 60° flexion contracture.
- General: MCPJ >30° and/or PIPJ >20°
- Treatment options:

• **None:**	Mild, slowly progressive or patient refusal
• **Needle fasciotomy:**	Pretendinous cord (i.e. not just nodule)
• **Fasciectomy:**	Healthy skin with significant contracture
• **Dermofasciectomy:**	Poor skin, diathesis (e.g. young), revision
• **Amputation:**	'Finger-in-palm' disease, preference (e.g. severe)
• **PIPJ fusion:**	Coexisting severe PIPJ OA, preference (e.g. severe)

Chapter 18

Hand I Structured SBA

Emma Reay

HAND I STRUCTURED SBA QUESTIONS

1. A 75-year-old man with dementia is admitted after being found on the floor by his carer, who last saw him 12 hours ago. He has a swollen left upper limb and hand. His hand looks tense and is tender to palpation over his thenar and hypothenar eminences. On examination, he winces when his fingers are passively flexed. Pulses are present but you are unable to assess sensation due to cognitive impairment. He has had high-dose opioid analgesia in the ED.

   What is the most appropriate next step in the management?

   A. Admit for observation and reassessment of clinical signs after 4 hours
   B. Elevate arm and prescribe further opioid analgesia
   C. Perform urgent fasciotomies of the hand
   D. Request creatine kinase levels
   E. Request urgent hand compartment pressure monitoring

2. A 53-year-old right-handed patient sustained a small puncture wound to the palmar surface of her right index finger 10 days ago. Yesterday, she began to develop pain and swelling of the digit, which is worsening despite oral antibiotics from her GP.

   Which clinical signs would suggest she requires emergency surgical treatment?

   A. Erythema, extended finger position, flexor surface tenderness, pain on passive extension
   B. Erythema, flexed finger position, tenderness of palm at base of digit, pain on passive extension
   C. Fusiform swelling, flexor surface tenderness, fixed proximal interphalangeal joint on passive flexion and extension
   D. Fusiform swelling, flexor surface tenderness, pain on passive extension and semi flexed position
   E. Swelling into the palm, loss of normal palmar concavity, tenderness over proximal palmar crease

3. A 48-year-old right-handed patient underwent a washout for flexor sheath infection this afternoon. She does not have any known medication allergies.

   While waiting for microbiological analysis of the intraoperative samples, what is the most appropriate antibiotic management for this patient?

   A. Benzylpenicillin and flucloxacillin
   B. Cefuroxime
   C. Co-amoxiclav
   D. Flucloxacillin
   E. Flucloxacillin and metronidazole

4. A 26-year-old male patient has fallen from his motorbike at 50 mph and is transferred to the ED in your hospital. He is conscious and complaining only of pain in his left hand and wrist. His X-rays show a trans-scaphoid perilunate dislocation. He is also complaining of altered sensation of his thumb and index finger.

   What is the most appropriate initial management plan for this patient?

   A. MUA and carpal tunnel decompression on next available list
   B. MUA and fixation of scaphoid on next available operating list
   C. MUA, fixation of scaphoid and carpal tunnel decompression on next available operating list
   D. MUA in the ED
   E. MUA on next available operating list

5. A 35-year-old joiner presents with increasing pain and swelling of his right dominant hand after sustaining a puncture wound over the palmar aspect of his thumb MCPJ crease. On examination, he has restricted range of movement of his index and little fingers and has exquisite tenderness over the distal wrist crease where the hypothenar and thenar eminences meet.
Between which anatomical structures is the most likely pathology in this case?
   A. Flexor digitorum profundus tendons and pronator quadratus
   B. Flexor digitorum superficialis tendons and pronator quadratus
   C. Flexor pollicis longus and flexor digiti minimi
   D. Pronator quadratus and wrist capsule
   E. Transverse carpal ligament and median nerve

6. A 60-year-old patient presents with intermittent radial-sided altered sensation in their dominant hand occurring predominantly at night and when driving. Phalen's test is grossly positive, and there is no evidence of motor weakness or wasting.
Which would be the most likely findings on nerve conduction testing?
   A. Decreased median nerve conduction velocity compared with the ipsilateral ulnar nerve
   B. Fibrillation potentials and positive sharp waves on needle EMG
   C. Normal study
   D. Peak latency delay of median nerve sensory nerve action potential (SNAP)
   E. Unrecordable SNAP

7. Parents of a child who has a deformity of her right forearm present to your outpatient clinic wanting an explanation for her upper limb abnormality. On examination, you find an absent thumb and a flexed small index finger on the right hand with a radially deviated wrist and prominent ulnar head.
Which is the most likely explanation from the options below?
   A. It is caused by an abnormality of the apical ectodermal ridge
   B. It is caused by an abnormal Hox gene
   C. The condition occurs sporadically with no known cause
   D. This is an autosomal-dominant condition
   E. This is an X-linked genetic condition

8. A patient returns from an ice-climbing trip with acute pain in the right forearm and wrist. He describes the forearm as feeling tired and heavy. On examination, you find an inability to pinch items between the thumb and index finger.
Which of the following is most likely?
   A. Nerve conduction studies will show sensory nerve conduction slowing
   B. The patient will need a routine cervical MRI scan and referral to a neurosurgeon
   C. The symptoms are due to nerve compression by the tendinous edge of pronator teres
   D. The symptoms have an inflammatory cause analogous to Parsonage–Turner syndrome
   E. Urgent ultrasound and MRI of the forearm should be requested

9. You are about to perform revision surgery on the little finger of a patient with a benign fibroproliferative disorder of the palmar fascia.
Which of the following tests gives the most useful preoperative information?
   A. Allen's test
   B. Phalen's test
   C. Pincer grip test
   D. Tinel's test
   E. Watson's test

10. A 53-year-old right-handed patient sustained a small puncture wound to the palmar surface of her right index finger 10 days ago. Yesterday, she began to develop pain and swelling of the digit, which is worsening despite oral antibiotics from her GP. On examining her finger, you find she has fusiform swelling, flexor surface tenderness, pain on passive extension and slight flexed position of the digit.
What is the most appropriate management?
   A. Elevation, intravenous antibiotics and reassessment
   B. Open flexor sheath washout
   C. Closed flexor sheath washout
   D. Urgent ultrasound scan of the flexor sheath
   E. X-ray to rule out foreign body

11. A 27-year-old male patient presents to the hand clinic complaining of pain over the dorsoradial aspect of his left wrist. The pain is worse on loading his wrist in extension, and he complains of restricted range of extension of the wrist. He remembers falling onto his wrist 6 months ago while playing football. He had an X-ray and was informed he had no bony injury. On examination, he has point tenderness over the dorsum of his wrist between the second and third extensor compartments.

What is the most appropriate management plan for this patient?

A. CT scan
B. MRI scan
C. X-ray and CT scan
D. X-ray and gadolinium-enhanced MRI scan
E. X-ray and MRI arthrogram

12. A 46-year-old rock climber presents to the hand clinic 3 months after injuring her right dominant ring finger while climbing. She describes a pop and pain while taking her whole weight through that digit. She developed immediate swelling. She is now left with a strange appearance of her finger when she bends the PIPJ – she says the tendon 'seems to be pulling away from the finger'.

Which structures are most likely to have been damaged?

A. A3 and A5 pulleys
B. A1 and A2 pulleys
C. Volar plate of PIPJ
D. Collateral ligaments of PIPJ
E. A2 and A3 pulleys

13. A 55-year-old mechanic presents to the outpatient department complaining of a tender lump in his palm at the base of his ring finger without functional impairment. On examination, you observe a nodule and a thickened longitudinal band of tissue extending from the ring finger proximal compartment to the proximal palmar crease, causing a 15° flexion contracture at the MCPJ. Tabletop test is negative and there is no PIPJ contracture.

What would you advise?

A. Collagenase injection
B. Nodule excision
C. Percutaneous fasciotomy
D. Segmental fasciectomy
E. Watchful waiting

14. A 72-year-old woman has a displaced and comminuted distal radius fracture, which you have been asked to manage with a volar locking plate. You choose to approach the distal radius through the bed of flexor carpi radialis tendon.

Which anatomical structure is most commonly damaged during this procedure?

A. Extensor pollicis longus
B. Palmar cutaneous branch of the median nerve
C. Radial artery
D. Median nerve
E. Superficial branch of the radial nerve

15. A 56-year-old woman presents with a 6-month history of difficulty extending her ring and middle fingers of both hands after flexing into her palms. She needs to use her opposite hand to straighten the digits, and this is associated with pain in her palm at the base of the digits.

Which one of the following medical conditions is commonly associated with this pathology?

A. Carpal tunnel syndrome
B. Diabetes
C. Hypothyroidism
D. Psoriasis
E. Scleroderma

16. A 22-year-old semi-professional football player falls heavily onto his outstretched right hand during a tackle. He complains of a pop in his wrist, followed by pain and swelling of his wrist. He attends the ED, and a wrist X-ray is performed. At X-ray, the distance between the lunate and scaphoid appears increased.

Which of the following statements best describes the anatomical structure damaged following this injury?

A. Forty per cent of distal radial fractures will have an associated scapholunate ligament injury
B. Of the three parts of the scapholunate ligament, the anterior section is biomechanically strongest
C. The blood supply enters the scapholunate ligament through the arcuate ligament

D. The normal scapholunate angle is between 80° and 110°
E. The scapholunate ligament is less biomechanically important than the lunotriquetral ligament

17. A 15-year-old girl complains of an inability to actively flex the tip of her right middle finger after grabbing an opponent's collar during a judo bout yesterday. She is taken to theatre and found to have a type I injury of her flexor tendon.
What is most likely to be damaged?
A. A5 pulley
B. Both vinculae to flexor digitorum profundus
C. Flexor digitorum superficialis tendon
D. Vinculum brevis to flexor digitorum profundus
E. Vinculum longus to flexor digitorum profundus

18. You take a telephone referral from an urgent care centre about a patient who has injured themselves with a knife while removing the stone from an avocado. They have a laceration in their palm at the level of the distal palmar crease and are unable to actively flex their index and middle fingers.
How would you describe this injury?
A. Zone I flexor tendon injury
B. Zone II flexor tendon injury
C. Zone III flexor tendon injury
D. Zone IV flexor tendon injury
E. Zone V flexor tendon injury

19. A patient is assessed in the hand clinic following an injury where they fell onto their outstretched hand 3 months ago while skiing. X-rays show a scapholunate angle of 80°.
Which anatomical structure is most likely to be damaged?
A. Lunotriquetral ligament
B. Scapholunate ligament
C. Dorsal wrist capsule
D. Radioscapholunate ligament
E. Ligament of Testut

20. A window cleaner falls from the top of his ladder onto an outstretched left wrist. He attends the ED with a deformed and grossly swollen wrist. X-rays show no evidence of a distal radial fracture, but Gilula's lines within the carpus are broken and there is an associated scaphoid fracture.
Which of the following most accurately classifies this injury pattern?
A. Carpal instability complex
B. Carpal instability dissociative
C. Carpal instability non-dissociative
D. DISI deformity
E. VISI deformity

21. A patient presents with a laceration over the ulnar border of her forearm and complains of paraesthesia running from the level of the laceration down the ulnar border of her forearm into her little and ring fingers. At exploration, the ulnar nerve is found to be lacerated completely.
How would you classify this injury using the Sunderland Classification system for nerve injury?
A. First degree
B. Second degree
C. Third degree
D. Fourth degree
E. Fifth degree

22. An elderly patient caught the tip of his right middle finger in a circular saw as he was cutting wood. He presents to the ED with a 1cm defect in the skin of the tip of his pulp with no bone exposed. His X-rays show no associated bony injury.
What is the most appropriate management for this patient?
A. Atasoy flap
B. Primary closure
C. Terminalisation to the distal interphalangeal joint level
D. Toilet, dressings and wound review 1 week
E. Venkataswami flap

23. A medical student observes you suturing an incised skin wound and asks you what is involved in the stages of wound healing.
Which of the following most accurately describes the cellular sequence of healing of the wound?
A. Coagulation, fibronectin, collagen, granulocytes

B. Fibroblasts, coagulation, macrophages, cross-linked collagen
C. Granulocytes, macrophages, fibroblasts, collagen, cross-linked extracellular matrix
D. Macrophages, granulocytes, collagen, fibroblasts
E. Neutrophils, extracellular matrix cross-linking, granulocytes, macrophages

24. A 76-year-old female patient sustained a closed distal radius fracture, which was treated conservatively in a cast for 4 weeks. She presents to her GP complaining of an inability to use her thumb properly and with a reduced range of movement of her thumb. Her GP refers her back to the fracture clinic for review.

Which of the following thumb movements is most likely to be impaired in this patient?

A. Abduction
B. Adduction
C. Flexion
D. Opposition
E. Retropulsion

25. A 26-year-old falls and injures her right hand. There is no bony injury identified on X-ray, but she is noted to have a lytic lesion at the base of her middle finger proximal phalanx. The lesion demonstrates geographic bone destruction, bony expansion and cortical thinning. The lesion is asymptomatic.

What is the most appropriate management plan for this patient?

A. CT scan
B. MRI scan and review
C. Reassurance and discharge
D. Reassurance and observation with serial radiographs
E. Screening blood tests and chest X-ray

26. You have just repaired a zone II flexor tendon injury involving both flexor digitorum superficialis and flexor digitorum profundus. You are now filling in the hand therapy request form after applying a dorsal splint.

Which of the following post-operative rehabilitation regimens is most appropriate?

A. Early combined passive and active motion at days 3–5
B. Early full range active flexion
C. Early passive motion at days 3–5
D. Place and hold at 1 week
E. Splint 7 days, then combined passive and active motion

27. A patient sustained a proximal humeral fracture that was treated with plating while she was on holiday in Egypt. Six months later, she now presents with an inability to extend her wrist, fingers or thumb. Nerve conduction tests have already been organised by her GP and show no evidence of function of the affected nerve. She has read on the Internet about tendon transfers.

Which of the following tendon transfers would be most appropriate in this patient?

A. Brachioradialis to flexor pollicis longus
B. Flexor digitorum superficialis to adductor pollicis
C. Latissimus dorsi to triceps
D. Pronator teres to extensor carpi radialis brevis
E. Pronator teres to extensor carpi radialis longus

28. A 36-year-old rugby player sustained a forced abduction injury to his right dominant thumb during a match. He attends hand trauma clinic 24 hours later with a bruised and swollen right thumb, he is tender over the ulnar border of the MCPJ with a palpable lump over the ulnar side of the joint. On examining the joint, there is no firm end point to radial deviation in either full extension or 20° of flexion.

Which of the following most accurately describes the most likely anatomical injury?

A. Avulsion of ulnar collateral ligament from distal insertion
B. Midsubstance ulnar collateral ligament injury
C. Stener lesion
D. Ulnar collateral ligament and volar plate injury
E. Volar plate injury

29. You are asked to assess a motorcyclist who was involved in a serious RTA 2 weeks ago. He has open fractures to both lower limbs which have been nailed. He complains of weakness in his left upper limb. When you examine him, he has

weakness of flexion and extension of his wrist and fingers including his thumb. He is also unable to actively pull his arm into his side against resistance. He cannot cross his fingers when asked.

Which is the most likely level of brachial plexus injury based on the above clinical examination?

A. C5, C6
B. C5, C6, C7
C. C7
D. C7, C8, T1
E. C8, T1

30. A patient presents with a pattern of upper limb injury suggestive of brachial plexus damage. You notice that he is unable to fully open his eye on the ipsilateral side.

At what level within the brachial plexus is this lesion?

A. Root level
B. Trunk level
C. Division level
D. Cord level
E. Nerve level

31. You are asked to assess a pedal cyclist who fell off his bicycle 2 weeks ago. At that time, he was diagnosed with a lower brachial plexus injury resulting in weakness of his left upper limb. He has now returned to clinic with pain on active and passive movement of his shoulder.

What is the most appropriate next step for this patient?

A. Angiogram left arm
B. CT myelogram
C. MRI cervical spine
D. Nerve conduction testing
E. Shoulder and chest X-rays

32. A 55-year-old male patient presents to your outpatient clinic complaining of pain, swelling and restricted range of movement of his right dominant wrist. The pain occasionally occurs at night and it is affecting his ability to do his job. He remembers an injury to his wrist as a young man. X-rays show osteoarthritic change in the radioscaphoid articulation and the capitoscaphoid articulations.

What is the most appropriate next course of management?

A. CT scan
B. Four corner fusion
C. Proximal row carpectomy
D. Steroid injection and CT scan
E. Total wrist fusion

33. A 27-year-old cleaner presents to the hand clinic with an inability to actively extend the distal interphalangeal joint (DIPJ) of her right middle finger after changing a bed. On examination, she has mild swelling and bruising over the dorsum of the DIPJ and an extensor lag of 30°. X-rays show no bony injury.

What is the most appropriate management plan in this patient?

A. DIPJ splinting for 4 weeks in extension
B. DIPJ splinting for 6 weeks in extension, followed by plain radiographs
C. Surgical repair
D. Percutaneous K-wire fixation
E. DIPJ splinting for 6 weeks in extension, then 2 weeks at night only

34. A 30-year-old builder presents with fractures to the shafts of his 3rd, 4th and 5th metacarpals, which are closed injuries. There is no rotational deformity, although it is difficult to examine him because of pain on flexion of his digits. The fractures are oblique midshaft comminuted fractures.

What is the most appropriate management plan for this patient?

A. Buddy taping and mobilisation
B. Cast immobilisation
C. Moulded thermoplastic splinting
D. MUA and cast immobilisation
E. Operative fixation

35. After sustaining an axial load type injury to their right ring finger, a 22-year-old factory worker attends the hand trauma clinic with a painful proximal interphalangeal joint (PIPJ), and X-rays show a comminuted intra-articular fracture to the base of their middle phalanx and confirm a dorsal triangle sign.

What is the most appropriate management for this patient?

A. Dynamic external fixation
B. Open reduction and internal fixation

C. Non-operative management with buddy taping
D. Splinting in flexion
E. Static external fixation

36. A 76-year-old female patient complains of pain over the radial side of her hand and around her thumb with an inability to open her hand fully and decreased grip strength because of pain. She is unable to knit for more than 10 minutes. X-rays show grade IV changes at both the thumb CMC joint and the STT joint.

Which other anatomical structure should be examined during the consultation?

A. IPJ of the thumb
B. Median nerve
C. Radial artery
D. Superficial radial nerve
E. Ulnar nerve

37. A patient returns to clinic 6 months after carpal tunnel decompression complaining that they have not felt any improvement in their symptoms post-operatively. They are 89 years old and had preoperative nerve conduction testing, which showed severe compression of the median nerve. They also have evidence of abductor pollicis brevis wasting.

Which is the most important prognostic indicator following carpal tunnel decompression?

A. Age
B. Comorbidities
C. Duration of symptoms
D. Presence of muscle wasting
E. Severity of compression on NCT

38. A 43-year-old sustained a twisting injury to her wrist when picking up a heavy suitcase while on holiday 2 weeks ago. She attends the hand trauma clinic with a painful wrist, and on examination she has tenderness over the fovea of her ulnar head and her distal radioulnar joint appears lax.

Which anatomical structure provides most stability to the distal radioulnar joint?

A. Bony anatomy
B. Deep head of pronator quadratus
C. Extensor carpi ulnaris
D. Intraosseous membrane of forearm
E. Triangular fibrocartilage complex

39. A patient presents with functional problems in her hand after repair of a flexor digitorum profundus avulsion injury of her left middle finger. She describes being unable to fully flex her index and ring fingers when she flexes her repaired middle finger into her palm.

What is the anatomical basis for this problem?

A. Adhesions within flexor sheath of repaired middle finger
B. Damage to nerve supply to flexor digitorum profundus
C. Rupture of flexor digitorum profundus tendons to index and ring fingers
D. Shared muscle belly of all four flexor digitorum profundus tendons
E. Tethering of flexor digitorum profundus tendons in forearm

40. A 45-year-old factory worker presents with a long-standing history of a painful wrist that she localises to the dorsum, worse on extension. X-rays show sclerosis of the lunate, and an MRI organised by the musculoskeletal service shows proximal lunate collapse.

What is the most appropriate management option to discuss with the patient?

A. Immobilisation and rehabilitation
B. Lunate replacement
C. Proximal row carpectomy
D. Radial shortening
E. Vascularised bone graft to lunate

41. A 52-year-old manual worker presents to the ED after amputating part of his little finger with a circular saw. On examination, he has a jagged, dirty wound at the level of the PIPJ. He hands you the amputated digit, which he recovered from the scene. The amputated digit has no evidence of vessels or nerves on inspection. X-rays show severe comminution of the middle and distal phalanges of the amputate.

What advice are you going to give him when he asks what can be done for his finger?

A. Amputation at the level of the MCPJ
B. Ray amputation
C. Replantation
D. Terminalisation
E. Wound debridement and closure in the ED

42. A 52-year-old manual worker presents to the ED after amputating part of his dominant thumb with a circular saw. On examination, he has a jagged, dirty wound at the level of the MCPJ. He hands you the amputated digit which he recovered from the scene. The amputated digit has no obvious vessels or nerves on examination. X-rays show severe comminution of the proximal and distal phalanges of the amputated thumb.
What is the most appropriate management of this patient?
A. Amputation at the level of the MCPJ
B. Ray amputation
C. Replantation
D. Terminalisation
E. Wound debridement and closure in the ED

43. A 45-year-old female patient presents with a recent history of pain at the tip of her right middle finger. She also complains of hypersensitivity to cold stimulus at the tip of the finger. On examination, a small mass lesion is palpated in the tip and there is slight discolouration of the nailbed.
What is the most likely diagnosis?
A. Glomus tumour
B. Malignant melanoma of the nailbed
C. Mucous cyst
D. Osteoid osteoma
E. Pulp abscess

44. A patient who is studying biology at university is about to undergo carpal tunnel decompression. They ask you to describe to them the anatomical structures that can be encountered during the operation.
Which of the following structures is most at risk during a carpal tunnel decompression?
A. Deep palmar arch
B. Extra-ligamentous recurrent motor branch of the median nerve
C. Flexor digitorum superficialis tendons
D. Palmar cutaneous branch of the median nerve
E. Superficial recurrent motor branch of the median nerve

45. A 76-year-old male patient presents with weakness in his left hand and altered sensation in the little and ring fingers. He has guttering of the small muscles of the hand and a mild flexible claw deformity of his little and ring fingers.
Where is the most likely nerve pathology in his case?
A. Arcade of Struthers
B. Cubital tunnel
C. Exit from flexor carpi ulnaris
D. Guyon's canal
E. Midforearm

46. An elderly patient undergoes treatment for her pantrapezial osteoarthritis with a trapeziectomy through a dorsal approach.
Which anatomical structure is not at risk through this approach?
A. ECRB tendon
B. EPB tendon
C. Flexor carpi radialis tendon
D. Radial artery
E. Superficial radial nerve branches

47. A patient presents to hand trauma clinic with pain in his palm after using his palm to knock down some tent pegs during a recent camping trip. He has tenderness over his hypothenar eminence and weakness of abductor digiti minimi and first dorsal interosseous muscle but no sensory loss.
What imaging would be most appropriate?
A. Angiography
B. MRI wrist
C. Nerve conduction testing
D. Ultrasound scan
E. X-ray

48. You have been asked to perform a diagnostic wrist arthroscopy and are being quizzed about the best port sites to use.
Which of the following portal sites is the best for accessing the wrist?
A. 3–4
B. 4–5
C. 6R
D. 6U
E. Radial midcarpal

49. A chef has sustained a laceration to the dorsum of her right index finger at the MCPJ level.

Which zone of extensor tendon injury is this?

A. Zone I
B. Zone III
C. Zone V
D. Zone VI
E. Zone VIII

50. A 55-year-old patient with severe rheumatoid deformities in her hands, wrists and elbows has asked for your advice regarding her surgical options to improve her function. She has severe pain in her right elbow and wrist and her right hand MCP joints.

Which procedure should be performed first in the sequence of management for her joint pathology?

A. Elbow replacement
B. Finger MCP joint replacements
C. PIPJ fusions
D. Thumb MCP joint fusion
E. Wrist fusion

51. You are asked to describe the anatomy of the forearm.

Which of the following descriptions most accurately describes the forearm musculature?

A. Flexor pollicis longus muscle takes its origin from the mid ulnar shaft
B. Flexor digitorum profundus muscle is supplied in part by the radial nerve
C. Flexor digitorum superficialis muscle has two heads
D. Flexor digitorum superficialis tendons to the index and middle finger are deep to the ring and little finger tendons
E. Pronator quadratus is supplied by the posterior interosseous nerve

52. A patient presents with painful swollen deformed distal interphalangeal joints (DIP joint) of both of his hands with shortened digits. He has pitting and onycholysis of his nails.

What finding would you not expect to see at X-ray?

A. Chondrocalcinosis
B. Interphalangeal ankylosis
C. Joint subluxation
D. 'Pencil in cup' appearance of joints
E. Resorption of bone

53. A patient presents to the ED after being bitten by her cat 3 days ago. She has erythema and swelling over the palmar surface of her hand and over the thumb. She has multiple small, healing puncture wounds. You take her to the operating theatre and wash the wounds out. Intraoperative microbiology swabs are taken.

What is the most likely organism cultured from the swabs?

A. *Corynebacterium*
B. *Neisseria*
C. *Pasteurella*
D.
E. *Streptococcus*

54. A 45-year-old patient presents with altered sensation and tingling in the radial three digits of her right dominant hand, which she says intermittently also affects the ulnar two digits particularly when she is driving. She is Phalen's positive at the wrist and provocation testing for cubital tunnel syndrome is grossly negative.

What is the most likely explanation for her symptoms?

A. Diabetes
B. Hypothyroidism
C. Martin–Gruber anastomosis
D. Peripheral neuropathy
E. Ulnar nerve entrapment at elbow

55. A 3-year-old patient comes into clinic after having a set of scaphoid X-rays performed. Their mother asks why there aren't as many bones on the 3-year-old's X-rays as there were on her own scaphoid X-ray.

Which is the last carpal bone to ossify?

A. Capitate
B. Hamate
C. Lunate
D. Pisiform
E. Trapezium

56. A 53-year-old female patient with a history of diabetes presents with pain over the radial border of her right dominant wrist. On examination, she has tender nodularity over her radial styloid and pain on ulnar deviation of her wrist with her thumb flexed.

What is the most likely diagnosis?

A. Base of thumb arthritis
B. De Quervain's tenosynovitis
C. Flexor carpi radialis tendonitis
D. Intersection syndrome
E. Superficial radial nerve neuroma

57. A 3-year-old child is brought to the hand clinic after her parents noticed she was unable to fully extend the IPJ of her left thumb. There has been no history of injury and she is functioning normally. On examination, the IPJ of her left thumb is fixed in 30° of flexion and you palpate a nodule in her palm at the base of the digit. What management should you propose?
A. Observation
B. Observation and splinting
C. Thumb A1 pulley release
D. Ultrasound scan of flexor sheath
E. X-ray of thumb

58. A 21-year-old football player has been diagnosed with an undisplaced scaphoid waist fracture. He wants to get back to training as soon as possible and asks for your advice regarding management.
What management option would you suggest?
A. Cast for 6 weeks and CT scan to assess union
B. Cast for 6 weeks and X-ray again
C. Open reduction and internal fixation with headless compression screw
D. Percutaneous fixation with headless compression screw
E. Scaphoid plate

59. A 65-year-old patient presents to the fracture clinic 12 weeks after her cast was removed following conservative treatment of her right distal radius fracture. Check radiographs show a healing fracture that is well aligned. She is complaining of a constant burning pain in her wrist. She describes the skin over her wrist being very sensitive and swollen. On examination, her wrist is swollen and red and her skin appears thin and shiny.
What is the most likely incidence of the above condition, following distal radius fracture?
A. 1%
B. 5%
C. 10%
D. 20%
E. 40%

60. A 56-year-old female patient presents to the hand clinic with a painful, swollen right ring finger proximal interphalangeal joint (PIP joint). The pain occurs at rest and at night, requiring regular analgesia. On examination, she has an arc of movement of 10–80°at the PIP joint, and her radial collateral ligament is lax. She expresses a wish to maintain as much movement at the joint as possible to allow her to continue her hobbies. Radiographs show complete loss of joint space at the PIPJ level.
What is the most appropriate management option for this patient?
A. PIP joint fusion
B. PIP joint injection
C. PIP joint pyrocarbon replacement
D. PIP joint silastic replacement
E. Watchful waiting

61. A family is referred to your hand clinic by the paediatric team. Their baby was born yesterday with the upper limb difference illustrated in Figure 18.1. This is their first child and they are planning to have more children.

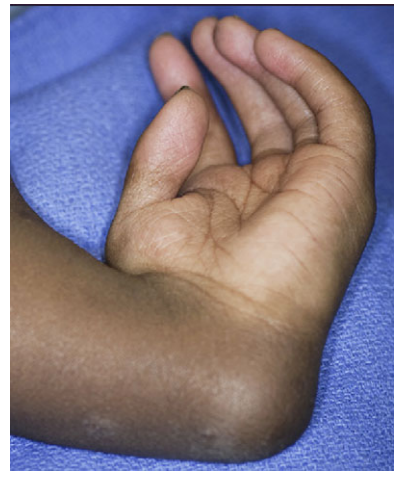


Figure 18.1 Clinical picture hand (Photograph courtesy of Shriners Hospital for Children, Philadelphia, PA)

Choose the most appropriate initial management plan from the options below.
A. Consent for surgical correction
B. Genetic testing
C. Renal ultrasound, echocardiogram and full blood count
D. Serial splintage and stretching
E. Skeletal survey

62. A 2-year-old child is brought to the trauma clinic having trapped their middle finger in a door. Their mother is concerned about the fact they are unable to fully straighten the finger. X-ray findings are shown in Figure 18.2.

Figure 18.2 Lateral radiograph middle finger

Involvement of which anatomical structure must be assumed with this X-ray appearance?

A. Epiphysis of distal phalanx
B. Nail bed
C. Nail plate
D. Terminal extensor tendon
E. Triangular ligament

63. A window cleaner falls from their ladder onto an outstretched left wrist sustaining the following injury (Figure 18.3).

Which surgical approach will give you the best exposure to repair the damaged structures?

A. 2nd and 3rd extensor compartment splitting approach
B. 3rd and 4th extensor compartment splitting approach
C. Radial approach
D. Ulnar approach
E. Volar approach through carpal tunnel

64. A 65-year-old recently retired lecturer presents to your clinic with pain at the thumb base and reduced grip strength. They have squaring of the thumb base and an adducted thumb metacarpal with tender thumb carpo-metacarpal joint and scaphotrapeziotrapezoidal joint (STTJ). You choose to perform the gold-standard surgery for this pathology.

Figure 18.3 Anteroposterior (AP) radiograph wrist

To prevent the most common cause of persistent post-operative pain, which of these manoeuvres should be performed intraoperatively?

A. Excise the scaphotrapezoidal joint
B. Perform a metacarpal suspension-plasty
C. Perform a tendon interposition
D. Stabilise the thumb metacarpophalangeal joint
E. Use a volar approach

65. A patient presents with a long-standing history of the lesion pictured (Figure 18.4). Pressure to the area elicits exquisite pain.

Which of the following statements is correct?

A. Marginal excision is curative
B. Mean age at presentation is 60 years
C. The patient is likely to have presented with heat intolerance
D. The recurrence rate following surgical excision is 50%
E. Tourniquet inflation increases pain

66. A 47-year-old scaffolder presents with an 8-month history of wrist pain which is not relieved with painkillers and is now keeping them awake

Figure 18.4 Photograph of left index finger

at night. On examination there is swelling over the dorsum of the wrist with restricted extension but preserved flexion. Radiographs are shown in Figure 18.5.

What is the most appropriate surgical treatment option?

A. Proximal row carpectomy
B. Radial shortening
C. Radiocarpal fusion
D. Ulnar lengthening
E. Vascularised bone grafting

67. A 69-year-old alcoholic patient presents with problems related to their right hand. On examination, there is a thickening and pitting of the skin, and the little finger is held in an adducted position.

The structure most likely to be involved is:

A. Commissural band
B. Grayson ligament
C. Lateral digital sheet
D. Natatory band
E. Pretendinous band

Figure 18.5 (a) AP radiograph and (b) lateral radiograph wrist

68. **A patient with anterior interosseous nerve (AIN) palsy due to entrapment at the tendinous edge of the deep head of pronator teres will have all the following except:**
    A. Intact sensation at base of thenar eminence
    B. Normal pronation strength with the elbows fully flexed
    C. Weakness of flexion to the index finger DIPJ
    D. Weakness of flexion of the DIPJ of the middle/long finger
    E. Weakness of flexion of the IPJ of the thumb

69. A 72-year-old patient caught the tip of the right middle finger in a circular saw sustaining loss of the tip of the volar surface of the finger with a 1cm skin defect without exposed bone.
    Which of the following treatments is most appropriate?
    A. Advancement flap
    B. Pedicled flap
    C. Primary closure
    D. Split skin grafting
    E. Toilet and dressing

70. A farmer presents to hand trauma clinic with a painful blister on the right index finger. There is no history of injury but they have been very busy with lambing season. The clinical picture of the finger is illustrated in Figure 18.6.

Figure 18.6 Photograph of right index finger

Which of the following management plans is most appropriate for this condition?
A. Acyclovir
B. Biopsy
C. Flucloxacillin
D. Surgical excision
E. Watchful waiting

71. An otherwise healthy 50-year-old left hand-dominant man has a fixed deformity as is shown in Figure 18.7. Examination reveals a thickened cord.

Figure 18.7 Clinical picture hand

Which of the following would be the procedure of choice with regards to treatment?
A. Dermofasciectomy and skin graft
B. Fusion of the PIP joint
C. Needle fasciotomy
D. No treatment is necessary
E. Partial fasciectomy

HAND I STRUCTURED SBA ANSWERS

1. Answer C. **Perform urgent fasciotomies of the hand**
   Compartment syndrome of the hand is a rare but functionally devastating condition and is often more difficult to diagnose in the hand because of the number of differential diagnoses that can cause similar symptoms. The history suggests a prolonged period of compression on the left upper limb combined with the clinical findings of pain not controlled with adequate analgesia and pain on passive stretch of the tendons passing through the hand. Emergent treatment in the form of formal hand fasciotomies is required to preserve muscle tissue.

2. Answer D. **Fusiform swelling, flexor surface tenderness, pain on passive extension and semi flexed position**
   The clinical picture points to a diagnosis of flexor sheath infection (pyogenic flexor tenosynovitis); the four signs described in the correct answer are collectively known as Kanavel's signs and indicate the need for emergency treatment. The findings described in answer E suggest a potential deep space infection rather than pyogenic flexor tenosynovitis.

3. Answer D. **Flucloxacillin**
   The most common organism isolated in flexor sheath infection is *Staphylococcus aureus*, which will respond well to flucloxacillin.

4. Answer A. **MUA and carpal tunnel decompression on next available list**
   A perilunate dislocation must be reduced emergently in the presence of carpal tunnel symptoms. The ideal situation would be an MUA in theatre to reduce the perilunate dislocation and to allow for carpal tunnel decompression. Scaphoid fixation can be performed on a less emergent basis if the skill set of the admitting general trauma team allows. The Tavernier closed technique for reducing a perilunate dislocation involves hyper-extending the wrist to accentuate the deformity while applying traction to the hand. Place the thumb on the lunate to stabilise it and then bring the hand into flexion. This will allow the capitate head to seat itself back into the lunate. Closed reduction of a perilunate dislocation often fails, as the lunate has breached the volar wrist capsular structures and is unreducible without opening the carpal tunnel.

5. Answer A. **Flexor digitorum profundus tendons and pronator quadratus**
   A flexor sheath infection within the flexor pollicis longus bursa can communicate proximally into the potential space of Parona. The potential space of Parona occurs in the palm between the FDP sheath and pronator quadratus muscle.

6. Answer D. **Peak latency delay of median nerve sensory nerve action potential (SNAP)**
   Nerve conduction testing in mild carpal tunnel syndrome, as described by the clinical scenario in the question, is controversial. When reviewing nerve conduction results for mild to moderate compression, often the only finding is a slight delay in the peak latency of the sensory nerve action potential. The motor parameters are not usually affected in mild to moderate compression, and needle EMG is rarely performed. If needle EMG is performed, fibrillation potentials and positive sharp waves are late signs. In 25% of those presenting with mild carpal tunnel symptoms and signs, the study is normal.

7. Answer C. **The condition occurs sporadically with no known cause**
   This is an example of a severe radial longitudinal deficiency, which can be associated with a number of other syndromes such as TAR, VACTERL or VATER. As yet, we do not know the cause, and in the majority of cases there is no genetic predisposition. It is believed to be an abnormality of the sonic hedgehog protein or an abnormality within the zone of polarising activity (ZPA) which causes the underdevelopment of the radial side of the hand and forearm. In some rare cases, it has been passed genetically in autosomal recessive or autosomal dominant forms.

8. Answer C. **The symptoms are due to nerve compression by the tendinous edge of pronator teres**

Anterior interosseous nerve (AIN) syndrome is most commonly caused by compression at the edge of pronator teres muscle. Parsonage–Turner syndrome, although rarer, can mimic AIN palsy and should be considered, and a thorough history of viral illness should be sought. The history does not suggest a cervical spinal pathology in this case, and although an X-ray should be performed to rule out rare bony pathology causing the palsy, an urgent ultrasound or MRI is not indicated. The AIN does not have a sensory component; therefore, nerve conduction test results would be unlikely to show sensory slowing.

9. Answer A. **Allen's test**
Revision Dupuytren's surgery has a higher incidence of neurovascular damage, and it is vital to assess both the sensation and vascular supply of each digit to be revised prior to surgery. Allen's test assesses the blood supply of the hand or digit by exsanguinating the digit, then releasing each neurovascular bundle in turn to see if the digit revascularises, i.e. turns pink. An accurate assessment of the blood and nerve supply to the digit will allow pre-operative planning and to accurately counsel the patient regarding the risks of surgery, including amputation.

10. Answer C. **Closed flexor sheath washout**
The clinical examination signs described above are known collectively as Kanavel's signs. They indicate flexor sheath infection (pyogenic flexor tenosynovitis) and the need for emergent treatment. Optimal management would be a closed flexor sheath washout using two incisions and a small catheter – usually a paediatric feeding tube. The tube is inserted proximal to the A1 pulley through a small palmar incision, and a second incision at the DIPJ crease allows the irrigation fluid to wash out of the flexor sheath. The flexor sheath is irrigated after microbiological samples are taken.

11. Answer D. **X-ray and gadolinium-enhanced MRI scan**
The patient describes a proximal pole scaphoid fracture. His young age and the high-energy injury, along with the location of the symptoms, indicate a diagnosis of proximal pole scaphoid fracture until proven otherwise.

Proximal pole scaphoid fractures are often missed on the first X-ray, so history and examination must be combined with a high index of suspicion. The X-ray confirms the diagnosis, and the MRI with gadolinium is to assess the vascularity of the proximal pole to plan further management.

12. Answer E. **A2 and A3 pulleys**
The most commonly injured pulley in rock climbers is the A2, but rupture of this pulley would not cause significant bowstringing of the tendons as described by the patient. Both the A2 and the next most distal annular pulley, the A3 pulley, would need to be ruptured to allow the tendons to bowstring. In some cases, the A2, A3 and A4 pulleys are all ruptured, causing significant functional impairment.

13. Answer E. **Watchful waiting**
This gentleman is presenting with early Dupuytren's disease. He has both a Dupuytren's nodule and an abnormal pretendinous cord. The inflammatory stage of the condition can cause the nodules to become painful, and this may be exacerbated by his job as a mechanic. The tabletop test is performed by asking the patient to place their hand palm down on the table. If they are unable to get the palm flat on the table, then this is a positive test and suggests significant MCPJ contracture. Until functional impairment occurs, conservative management is advocated in most cases.

14. Answer B. **Palmar cutaneous branch of the median nerve**
Published literature suggests all of the answer choices can be damaged, but the most likely injury is to the palmar cutaneous branch of the median nerve. It arises 5cm proximal to wrist crease from the radial aspect of the nerve, but ulnar to the flexor carpi radialis.

15. Answer B. **Diabetes**
Trigger finger, particularly in multiple digits, is often associated with diabetes, and new patients presenting with triggering should be questioned

about diabetes as well as gout and rheumatoid arthritis history.

16. Answer A. **Forty per cent of distal radial fractures will have an associated scapholunate ligament injury**
The scapholunate ligament is divided into three sections – the anterior, intermediate and posterior. The posterior section is the strongest, being able to withstand 260N of force vs the anterior section at 118N. It is the most important of the interosseous ligaments in the carpus and is frequently damaged following a distal radial fracture. The injury can be partial or complete, and the normal scapholunate angle is between 30° and 60°. The blood supply of the scapholunate ligament enters through the radioscapholunate ligament via the radial artery.

17. Answer B. **Both vinculae to flexor digitorum profundus**
The Leddy and Packer classification describes closed flexor digitorum profundus injuries:
Type I – avulsion into the palm with complete avulsion of the vinculae system. Type II – avulsion of FDP through the A4 but not the A2 pulley, therefore the possibility of maintaining the long vinculum Type III – avulsion of FDP but with the stump not retracted through the A4 pulley.

18. Answer C. **Zone III flexor tendon injury**
The zones of injury of the flexor tendons (or Verdan's zones) are as follows:
Zone I: FDP only from its insertion onto the distal phalanx to the insertion of FDS on the middle phalanx.
Zone II: From the insertion of FDS onto the middle phalanx to the proximal edge of the A1 pulley.
Zone III: Proximal edge of A1 pulley to the entry of the carpal tunnel – transverse carpal ligament distal border.
Zone IV: Carpal tunnel.
Zone V: Proximal to carpal tunnel in forearm.

19. Answer B. **Scapholunate ligament**
The natural tendency of the scaphoid is to flex, and the natural tendency of the triquetrum is to extend. The intraosseous ligaments between these bones keep these two competing forces balanced. When the scapholunate ligament (SLL) is ruptured, the scaphoid will naturally adopt a flexed position, increasing the SLL angle and creating a dorsal intercalated segment instability (DISI) deformity. When the lunotriquetral ligament is damaged, the triquetrum will extend, allowing the lunate to flex under the control of the scaphoid and the intact SLL, creating a volar intercalated segment instability (VISI) deformity.

20. Answer A. **Carpal instability complex**
The carpal instability patterns are divided into three main groups:
Injuries occurring between the carpal bones – carpal instability dissociative (CID).
Injuries occurring between the carpal rows or distal radius – carpal instability non- dissociative (CIND).
Complex injuries that are a mixture of the two – carpal instability complex (CIC).
Perilunate injuries are a combined injury and therefore fall into the CIC group.

21. Answer E. **Fifth degree**
This is an example of neurotmesis, which means the nerve is completely severed including the endoneurial tube.
First degree – segmental demyelination that occurs in crush or minor traction injuries
Second degree – axon disruption but intact endoneurium, perineurium and epineurium
Third degree – a severed axon and endoneurium, but perineurium and epineurium are intact
Fourth degree – a severed axon, endoneurium and perineurium, but intact epineurium
Fifth degree – complete division of all elements

22. Answer D. **Toilet, dressings and wound review 1 week**
A volar fingertip injury without exposed bone with a surface area of less than 1cm will heal very well with conservative management with wound toilet and regular dressings. The other options could be performed for this injury, but the best cosmetic and functional outcomes are observed following conservative management. It will take

around 6 weeks for the pulp to heal, and the patient will regain his normal fingerprints and sensation, and most of the bulk of the tip, without any surgical scarring.

23. Answer C. **Granulocytes, macrophages, fibroblasts, collagen, cross-linked extracellular matrix**
The healing of skin after an incised wound follows a defined pattern with inflammatory, late-inflammatory, proliferative and maturation phases. Each phase is associated with a particular cell type. First, there are inflammatory cells, such as neutrophils and granulocytes; then, during the late inflammatory phase, the macrophages arrive and stimulate angiogenesis and epithelialisation. Fibroblasts are activated during the late inflammatory phase and deposit collagen. During the proliferative phase, granulation tissue starts to form as a loose network of collagen, fibronectin and hyaluronic acid. During the maturation phase, more collagen is laid down and the extra-cellular matrix becomes cross-linked, strengthening the scar tissue.

24. Answer E. **Retropulsion**
The patient has a closed extensor pollicis longus (EPL) rupture with the classic loss of retropulsion. Ask the patient to place their hand flat on the table palm down. Now ask them to lift the thumb off the table. An EPL rupture prevents this movement.

25. Answer D. **Reassurance and observation with serial radiographs**
This is a classic presentation of an enchondroma. These lesions represent 10–25% of all benign bone tumours and commonly present in the hands and feet. An MRI would show chondroid calcification, or a 'popcorn' appearance, to the lesion. Histologically, these lesions show low cellularity, regular distribution, abundant chondroid matrix and encasement. The cells have small hyperchromatic nuclei without mitoses. The most appropriate management is observation.

26. Answer A. **Early combined passive and active motion at days 3–5**
Flexor tendon rehabilitation is as important as the surgical repair in gaining a good outcome. Following flexor tendon injury, research suggests rehabilitation should start no later than day 7, which is the point at which the gliding resistance is lower. The work of flexion is related to force and oedema, and it has been shown that force and work increase progressively for the first 4 days, then remain constant from days 4–7, making it the best time to start rehabilitation. The Manchester Group has shown that a combination of passive and controlled active motion gives the best results. Passive movement maintains glide, but it needs to be augmented by active movement, which has been shown to reduce adhesions and inflammation and to increase tensile strength. Early full active flexion is not advocated because of the increased resistance to digital flexion that occurs in the final range of motion – increasing the potential for rupture of the repair.

27. Answer D. **Pronator teres to extensor carpi radialis brevis**
This patient has a radial nerve palsy likely at the midhumeral level. The most appropriate tendon transfer would be the median nerve innervated pronator teres transfer to extensor carpi radialis brevis to allow wrist extension. The ability to extend the wrist is one of the most important aspects of improving function in radial nerve palsy, as wrist flexion further de-functions the hand long flexors and is cosmetically undesirable for patients. There is no mention of elbow weakness, so the triceps transfer is not required. Brachioradialis to flexor pollicis longus is for a high median nerve palsy, and flexor digitorum superficialis to adductor pollicis is for ulnar nerve dysfunction.

28. Answer C. **Stener lesion**
This injury pattern and the examination findings suggest a Stener lesion until proven otherwise. For there to be no end point in either partial flexion (tests ulnar collateral ligament) or extension (tests volar plate), both of these structures must have been damaged. The lump over the ulnar collateral ligament territory has been described as highly suggestive of a Stener lesion, and when the clinical picture includes joint laxity with no firm end point, this requires surgical exploration. A Stener lesion occurs when the

torn end of the ulnar collateral ligament flips over the edge of the adductor aponeurosis and becomes superficial, thus preventing the ligament from healing without surgical intervention.

29. Answer D. **C7, C8, T1**
The most common pattern of brachial plexus injury in motorcyclists is at the C8/T1 level with or without some contribution from C7. The intrinsic muscles of the hand and long flexors of the digits are supplied by C8. Weakness of these suggests a C8 lesion. If extensor digitorum and extensor pollicis longus are also involved, it suggests a radial nerve lesion, which is a C7 innervated nerve. Weakness of the latissimus dorsi muscle suggests a thoracodorsal nerve palsy which is exclusively supplied by C7.

30. Answer A. **Root level**
Horner's syndrome occurs due to damage to the sympathetic ganglion as it lies close to the T1 nerve root. Developing a Horner's syndrome (miosis, ptosis and anhidrosis) suggests a root-level avulsion and therefore a supraclavicular injury, which is the most common type of plexus injury in motorcyclists following an RTA as described by the commonly quoted Narakas rule of 'seven seventies':

70% of brachial plexus injuries are due to RTAs.

Of those RTAs, 70% are motorcycle/pedal bicycle riders.

Of those riders, 70% have multiple injuries. Of those 70% have supraclavicular injuries. Of the supraclavicular injuries, 70% have at least one root avulsed.

Of the avulsed roots, 70% are of the lower plexus: C7, C8, T1.

Of those with avulsed roots, 70% are left with chronic pain.

31. Answer E. **Shoulder and chest X-rays**
There are a number of injuries associated with brachial plexus injuries and many of the investigations in the answer choices are appropriate during the course of the patient's management. The most immediate priority should be ensuring there is no cervical spine, chest or shoulder girdle injury. This is usually achieved first with plain imaging and then with further tests. Nerve conduction testing is more useful after 6 weeks post-injury, and a CT myelogram looking for root avulsions is most sensitive 3–4 weeks post-injury.

32. Answer D. **Steroid injection and CT scan**
This patient is presenting with a stage II or III scaphoid non-union advanced collapse. Recent studies have suggested that radiographs alone are not reliable in identifying the extent of the arthritic change, so a CT scan is indicated in anyone who is considered for operative management. Immediate symptomatic treatment in a patient with night pain is a local anaesthetic and steroid injection. If the CT scan shows that the lunocapitate articulation is also involved, this changes the decision-making process; an arthritic head of the capitate articulating with the lunate fossa after proximal row carpectomy will still cause pain.

33. Answer E. **DIPJ splinting for 6 weeks in extension, then 2 weeks at night only**
This is a mallet injury of the terminal extensor tendon. Without bony injury, the majority of these injuries are treated with 6 weeks in an extension splint (either custom made or the classic Stack splint), followed by 2 weeks of night splinting. Patients may never regain full extension even if they are fully compliant with treatment.

34. Answer E. **Operative fixation**
The management of metacarpal fractures is controversial, although there are a number of factors that, when present, should indicate a surgical management plan. Multiple unstable metacarpal fractures are one indication; open fractures, rotational deformity, gross angulation and excessive displacement are some of the others. Some surgeons would still manage these scenarios conservatively, but the outcome has been shown to be worse. The surgical technique employed is down to the choice and expertise of the surgeon, and no single technique has been shown to be best. The principle should always be to get the hand moving as quickly as possible. Plating, intramedullary wiring and percutaneous transverse wiring have all been described.

35. Answer A. **Dynamic external fixation**
This is a pilon fracture of the PIPJ. These fractures are difficult to treat, and the outcome is often poor. Operative management is indicated if the joint is subluxed, which is identified by the dorsal triangle sign on X-ray. In this case, the main aim of management is to maintain joint congruity. This can be achieved in a number of ways, but many surgeons prefer dynamic external fixation, as this method theoretically maintains some joint movement.

36. Answer B. **Median nerve**
Carpal tunnel syndrome can occur in association with base of thumb arthritis in up to 43% of patients. It is essential that a median nerve examination is performed and documented. It is also necessary to examine the MCPJ for evidence of a compensatory hyperextension of the joint caused by the relative stiffness of the arthritic CMCJ. The ulnar nerve is not usually affected in base of thumb arthritis but can form part of the routine hand examination. The superficial radial nerve can be damaged during the approach to the trapezium, as can the radial artery.

37. Answer A. **Age**
All of the answer choices are prognostic indicators for the outcome following carpal tunnel decompression, but age is the most significant. Counselling the patient well preoperatively and documenting that discussion is imperative. There is unlikely to be any improvement in the symptoms in the patient described in the scenario and, in some cases, as the nerve begins to reinnervate, patients also describe shooting pains in the nerve distribution.

38. Answer E. **Triangular fibrocartilage complex**
All of the other components lend stability to the joint, but the primary stabiliser is the triangular fibrocartilage complex (TFCC). The deep head of pronator quadratus is a dynamic stabiliser, and it is the distal oblique bundle of the intraosseous membrane that lends most support to the joint. In a study that sectioned these components individually, it was found that the TFCC alone could support the joint, but that without the TFCC and with the other components intact, the joint would still maintain stability.

39. Answer D. **Shared muscle belly of all four flexor digitorum profundus tendons**
This patient is describing the quadriga effect. This is a condition in which the flexor tendon excursion is reduced in an unaffected finger when the excursion of the flexor digitorum profundus (FDP) tendon of the adjacent finger is altered by stiffness, injury or adhesion. This has occurred in the scenario after repair of the FDP. The tendon has been overly shortened during repair; because all of the other FDP tendons arise from the same muscle belly in the forearm, the index and middle fingers are unable to flex fully. There is evidence that inter-tendinous connections are as important in contributing to this phenomenon, although they are rarely mentioned in the textbooks.

40. Answer C. **Proximal row carpectomy**
This patient has Kienböck's disease, and the staging of this condition is now based on a combination of plain imaging, MRI findings and arthroscopic examination. The classification and management options have recently been modified by Lichtman. The broad categories of management depend upon whether the lunate is intact, compromised or unreconstructable and whether the wrist is compromised or unreconstructable. In the scenario, the patient has evidence of lunate compromise.

41. Answer D. **Terminalisation**
In this case, the amputated digit is not reconstructable due to the severe damage to the soft tissues and bones. Without obvious neurovascular structures to repair to, the amputated digit would be insensate and avascular. To get this patient back to work and full function as soon as possible, a terminalisation of the remaining digit down to good-quality soft tissue and bone is the best option. Eventually, he may require further surgery in the form of a more proximal amputation, but this is best assessed after the patient has tried functioning with the digit.

42. Answer C. **Replantation**
The thumb contributes 40–50% of the function of the hand. In a fit and well manual worker, dominant thumb replantation should be

attempted if possible. It may be that the function of the thumb is poor, but creating a stable, static post is still a better functional outcome than losing the thumb entirely.

43. Answer A. **Glomus tumour**
A glomus tumour is a tumour of the glomus body, which is a thermoregulatory organ found in large numbers in the digits. It is classically moderately painful, associated with temperature hypersensitivity and point tenderness. It occurs most commonly between the ages of 30 and 50 but is still a rare tumour. Malignant melanoma of the nailbed can present as a discolouration of the nail. A mucous cyst is a dorsal swelling around the DIPJ crease secondary to OA. Osteoid osteomas are painful mainly at night, are rare in the hand and show the classic nidus on CT scan. A pulp abscess could present in a similar way, but the onset would be more acute and may be associated with an injury.

44. Answer E. **Superficial recurrent motor branch of the median nerve**
All of the structures presented are potentially at risk during carpal tunnel decompression. Recognition of the normal anatomy of the approach makes damage to the common structures less likely. However, anatomical variations make damage to those structures more likely. The recurrent motor branch of the median nerve has five recognised patterns of anatomical variation. The normal pattern, which is extraligamentous and recurrent, is less likely to be damaged, as most surgeons will be aware of its course. The superficial branch, which occurs in around 10% of the population, sits superficial to the transverse carpal ligament and can be inadvertently damaged. The superficial palmar arch can be damaged by an incision made too distally, and damage to the palmar cutaneous branch of the median nerve is possible if the incision is made too radially.

45. Answer B. **Cubital tunnel**
This clinical picture fits with a high ulnar nerve palsy, and the most common cause is compression in the cubital tunnel. A high ulnar nerve palsy occurs when the damage to the ulnar nerve is proximal to the branches of the nerve that supply the flexor carpi ulnaris and flexor digitorum profundus. All of the other sites are potential areas for ulnar nerve compression but are less common.

46. Answer A. **ECRB tendon**
All of the other anatomical structures must be identified and protected throughout the procedure. The approach centres over the middle of the thumb metacarpal and the radial styloid with the CMCJ at the midpoint. The superficial branches of the radial nerve and cephalic vein are mobilised and gently retracted, followed by the extensor tendons of the anatomical snuffbox. The radial artery is then identified over the STTJ and mobilised and protected. The FCR tendon is found in the base of the wound after removal of the trapezium and should be identified and protected.

47. Answer E. **X-ray**
Initial management is to rule out a hook of hamate fracture, which can be performed with a carpal tunnel view plain radiograph. The patient's symptoms indicate that a hook of hamate fracture is more likely, as this fracture occurs in zone I or II of Guyon's canal where the ulnar nerve is either mixed or purely motor. One of the differential diagnoses in this case is 'hypothenar hammer syndrome', in which an aneurysm forms on the ulnar artery after repetitive injury to the palm. This occurs in zone III, which is purely sensory.

48. Answer A. **3–4**
The most commonly used of the wrist arthroscopy portals is the 3–4 portal. It is in the interval between the third and fourth extensor compartments just distal to the distal lip of the distal radius. You can visualise the scaphoid and lunate fossae as well at the TFCC and scapholunate ligament from this port site. It also allows direct vision for the creation of the 6R portal.

49. Answer C. **Zone V**
The zones of injury of the extensor tendons are useful for describing the injury and also for categorising the management and subsequent rehabilitation options. Numbers are allocated to different zones of the hand, wrist and forearm.

Odd numbers are allocated to joints (I = DIPJ; III = PIPJ; V = MCPJ; VII = Wrist) and even numbers represent the remaining structures (II = middle phalanx; IV = proximal phalanx; VI = dorsum of hand; VIII = forearm).

50. Answer A. **Elbow replacement**
With rheumatoid arthritis, the surgical sequence in most cases is to start with the most proximal joint that is affected and work distally. If the patient is unable to place her hand in space because she has a painful, stiff elbow, replacing her finger MCPJs will not improve her overall function, although it will help with pain. Replacing or fusing her wrist joint will correct the wrist deformity, which will in turn enable later finger MCPJ replacements to have the maximum functional benefit.

51. Answer C. **Flexor digitorum superficialis muscle has two heads**
The flexor pollicis longus takes its origin from the midradial shaft, not the ulnar shaft; the flexor digitorum profundus is supplied by the anterior interosseous nerve and the ulnar nerve. The flexor digitorum superficialis splits into four tendons with the index and little finger tendons running deep to the middle and ring finger tendons. The pronator quadratus is supplied by the anterior interosseous nerve.

52. Answer A. **Chondrocalcinosis**
This patient has psoriatic arthritis, which occurs in 10–30% of patients who suffer from psoriasis. The majority of these patients will have arthritis affecting their hands and a minority will develop arthritis mutilans (around 5%). Arthritis mutilans is a severe form of arthritis that affects both patients with rheumatoid arthritis and those with psoriatic arthritis. Severe forms cause bone loss and telescoping of the digits, with a classic 'pencil in cup' appearance of the joints.

Chondrocalcinosis is not usually associated with arthritis mutilans.

53. Answer C. ***Pasteurella***
Pasteurella spp. are the most common pathogen found in both cat and dog bite wounds. All of the other bacteria are also found in cat bites but less frequently than *Pasteurella*.

54. Answer C. **Martin–Gruber anastomosis**
A Martin–Gruber anastomosis is an anatomical variant that connects the ulnar and median nerves in the forearm. All of the other conditions listed can cause neurological symptoms. The examination findings in this case suggest a lesion at the elbow is unlikely, Phalen's test is positive, suggesting definite median nerve compression at the wrist, ruling out a peripheral neuropathy. Diabetes is associated with carpal tunnel syndrome, as is hypothyroidism, but specific ulnar nerve symptoms present only in the hand point to a Martin–Gruber anastomosis as the most likely scenario.

55. Answer D. **Pisiform**
The carpus ossifies in a reliable sequence starting with the capitate and ending with the pisiform. The sequence is as follows:

Capitate, hamate, distal radius, triquetrum, lunate, scaphoid, trapezium, trapezoid, pisiform, distal ulna.

The carpal radiographs can be used to assess the difference between chronological age and physiological age in children with developmental delay.

56. Answer B. **De Quervain's tenosynovitis**
De Quervain's tenosynovitis is a tendon entrapment syndrome affecting the first dorsal extensor compartment. It presents as pain and tenderness over the radial aspect of the wrist joint proximal to the anatomical snuffbox. Intersection syndrome occurs over the second compartment tendons and the pain is usually more proximal.

57. Answer A. **Observation**
The clinical picture is one of trigger thumb. The nodule in the palm is a Notta's nodule, which is a thickening of the flexor tendon. The management is controversial. In young children under the age of 5, there is some evidence that there may still be spontaneous resolution of the trigger thumb even after years of observation. The literature supports either non-operative or operative management.

58. Answer D. **Percutaneous fixation with headless compression screw**
There is no conclusive evidence that fixation gives a better long-term outcome or a quicker

return to work. However, in this case the patient needs to get back to sporting activities as soon as possible. Following successful percutaneous fixation, a cast may not be required, and mobilisation can begin almost immediately. The patient needs to be counselled as to the risks of surgery vs cast and advised that healing may still take the same length of time.

59. Answer A. **1%**
Chronic regional pain syndrome presents as a spectrum of symptoms and signs, but the most defining feature is debilitating pain. There are two types of the disorder: Type 1 has no associated nerve injury and type 2 is associated with nerve injury. The most commonly used diagnostic criteria are the Budapest criteria. In a large population study from the Netherlands in 2004, the overall general population incidence was defined at 26.2 per 100,000 with the highest incidence occurring in women (3:1 ratio) between the ages of 60 and 70 years and post fracture. A study looking specifically at conservatively managed distal radial fractures described an incidence of 1%.

60. Answer D. **PIP joint silastic replacement**
In this case, the patient wants to maintain range of movement. The symptoms and signs are such that an injection is only a very short-term solution. The time for watchful waiting has passed and operative intervention is now the best option to improve pain. Joint replacement is the only option that will allow preservation of range of movement. The laxity of the radial collateral ligament is important in planning which type of prosthesis you will choose. The silastic implant is a hinged implant that will compensate for the loss of the radial collateral ligament. The pyrocarbon implant does not lend any stability to the joint and would be likely to fail in this scenario.

61. Answer C. **Renal ultrasound, echocardiogram and full blood count**
The clinical photograph above shows a patient with a radial longitudinal deficiency which is one of a spectrum of limb differences which occur when the radial forearm and hand anatomy fails to develop normally. This patient has a thumb but has a deficient radius which produces the radial deformity and the prominence of the ulnar at the wrist. The condition is associated with several potentially life-threatening conditions including Holt Oram syndrome and Fanconi anaemia as well as cardiac and gastrointestinal abnormalities hence the urgent need for renal ultrasound, echocardiogram and full blood count. It is also important to start treatment for the forearm deformity with initiation of splintage and stretching exercises but these start after the child has had other more life-threatening conditions ruled out. Genetic testing is not likely to be helpful as the aetiology of radial longitudinal deficiency remains unknown. Surgical correction may be warranted in older children with the aim of realigning the carpus onto the radial shaft but in newborns, splintage is the preferred initial management. A full skeletal survey will not be necessary but it will be useful to perform plain radiography of the affected limb to plan further management of the deformity.

Maschke SD, Seitz W, Lawton J. Radial longitudinal deficiency. *J Am Acad Orthop Surg.* 2007;**15**:41–52.

62. Answer B. **Nail Bed**
The clinical radiograph of the above skeletally immature patient shows a deformity of the physis of the distal phalanx of the right middle finger which represents a Salter Harris 2 fracture. This is a classic presentation of a Seymour fracture which is a variation of a mallet injury and occurs in children. With the history of a crush injury and the above radiographic appearance an associated nail bed injury must be assumed until proven otherwise. The nail bed becomes approximated within the physis preventing either normal bony healing or nail regrowth or both. The nail plate is not involved in the fracture neither is the terminal extensor tendon (true mallet injury) or the triangular ligament which is part of the extensor hood found just proximal to the terminal extensor tendon.

63. Answer B. **3rd and 4th extensor compartment splitting approach**
The clinical radiograph above shows a perilunate dislocation of the wrist. The 'workhorse' approach to the wrist for carpal trauma is a dorsal approach through the interval between

the 3rd and 4th extensor tendons. This approach allows for direct visualisation of the scapholunate ligament and the lunotriquetral ligament both of which will be damaged following the above injury. A volar approach through the carpal tunnel may be needed in the acute setting if the lunate is irreducible but will not allow adequate visualisation of the dorsal structures allowing repair. Neither a radial or an ulnar approach would allow enough access to repair the scapholunate and lunotriquetral ligaments or adequately hold the lunate reduced. An approach through the 2nd and 3rd compartments would also only provide limited exposure to the lunate.

64. Answer A. **Excise the scaphotrapezoidal joint**
Pantrapezial osteoarthritis is one of the most frequent presentations to the hand clinic. Trapeziectomy remains the gold standard management for relief of pain caused by thumb carpometacarpal joint osteoarthritis in combination with STTJ osteoarthritis. The most common cause of persistent pain following trapeziectomy is residual scaphotrapezoidal joint (STJ) osteoarthritis. STJ involvement can be assessed intraoperatively and an excision arthroplasty can be performed at the time of trapeziectomy. The thumb metacarpal may subside causing impingement on the scaphoid but this is less common than persistent STJ pain. A tendon interposition at the time of trapeziectomy has not been shown to improve post-operative pain, neither has hyperextension of the thumb MCPJ (the reason you would perform an MCPJ stabilisation). The approach used to excise the trapezium has also not been proven to significantly affect the incidence of post trapeziectomy pain.

Rhee PC, Shin AY. Complications of trapeziectomy with or without suspension arthroplasty. *J Hand Surg Am.* 2014;**39**:781–783.

65. Answer A. **Marginal excision is curative**
Glomus tumours are rare benign tumours of the glomus body, often occurring in the subungual region. The condition is typically seen in patients between the ages of 20 and 40 who present with a painful subungual mass with bluish discolouration. Diagnosis is made with a biopsy showing a well-defined lesion lacking cellular atypia or mitotic activity with the presence of small round cells with dark nuclei. Treatment is usually marginal excision. The average time to diagnosis remains at over 2 years and the most challenging aspect of the management of glomus tumours is the diagnosis, as not all lesions have the characteristic bluish tinge.

Anatomic location

- 75% occur in hand.
- 50% are subungual.
- 50% have erosions of distal phalanx (primary involvement of bone being very rare).
- Fewer common locations: palm, wrist, forearm, foot.

Anatomy

- Glomus body: the glomus body is a perivascular temperature regulating structure frequently located at the tip of a digit or beneath the nail.

Presentation

- Symptoms (classic triad).
  - Paroxysmal pain.
  - Exquisite tenderness to touch.
  - Cold intolerance.

Clinical examination

- Small bluish nodule.
- Often difficult to see, especially in the subungual location.
- Nail ridging or discolouration is common.
- Love test
  - Pressure to the area with a pinhead elicits exquisite pain.
  - 100% sensitive, 78% accurate.
- Hildreth test
  - Tourniquet inflation reduces pain/tenderness and abolishes tenderness to the Love test.
  - 92% sensitive, 91% specific.

Imaging

- Radiographs
  - Glomus tumours can produce a pressure erosion of the underlying bone and an associated deformity of the bone cortex.
  - MRI
    - Helpful to establish diagnosis.
    - Presents as a low T1 signal and high T2 signal.

Histology

- Well-defined lesion lacking cellular atypia or mitotic activity.
  - Small round cells with dark nuclei.
  - Associated small vessels in a hyaline/myxoid stroma.
- Can show gland-like or nest structures, separated by stromal elements.

Treatment

Operative

- **Marginal excision is curative.**
  - Indications.
    - Symptoms affecting quality of life.
  - Outcomes
    - Due to the benign nature of this disease, recurrence is uncommon.
    - Several cases of malignant glomus tumours have been reported in the literature.
- **Reconstruction of nail bed contour with autologous fat graft**
  - Indications.
    - For large defects after resection.

66. Answer A. **Proximal row carpectomy**

This patient has lunate degeneration most likely secondary to Kienböck's disease. Kienböck's disease is a rare (7 per 100,000) and progressive osteonecrosis of the lunate bone. The staging of this condition is based on the combination of plain imaging, MRI findings and arthroscopic examination. The modified Lichtman classification is most commonly used and is outlined below.

Stage I – lunate maintains normal architecture and density.

Stage II – characterised by an increase in lunate density and diffuse sclerosis of the lunate.

Stage IIIa – the lunate is collapsed but its carpal alignment and height remain unchanged.

Stage IIIb – in addition to lunate collapse, scaphoid palmar flexion occurs.

Stage IIIc – complete coronal plane split.

Stage IV – lunate collapse and radiocarpal or midcarpal degenerative arthritis.

This patient has stage 4 Kienböck's disease. There is loss of the lunate height and flexion of the scaphoid (circle sign on PA) with proximal migration of the capitate. There is also early radio-scaphoid arthritis. In the presence of lunate collapse and degenerative changes, the management of Kienböck's disease is a salvage procedure. Given the patient's current range of movement, the decision of which salvage procedure to choose is based on whether or not the patient wants to maintain their range of movement and what their occupation/hobbies are. A proximal row carpectomy is a salvage procedure which preserves wrist range of movement whereas a radiocarpal fusion does not. However, PRC does require that the capitate head and the lunate fossa are not arthritic. Given the age of the patient, the heavy job and the fact that the capitate head is not arthritic on the X-rays provided, the choice of PRC would be the best option for this patient. Radiocarpal fusion is also appropriate but less so given the occupation and current good range of movement.

The other options are for management of earlier stage Kienböck's disease.

Chojnowski K et al. Recent advances in assessment and treatment in Kienböck's disease. *J Clin Med.* 2022;**11**:664.

67. Answer D. **Natatory band**

This patient has Dupuytren's disease in the hand. Dupuytren's disease can affect all parts of the palmar fascial complex. The following make up the normal palmar fascial complex.

The palmar aponeurosis: originates at the wrist close to the palmaris longus tendon. It diverges from the wrist into:

Pretendinous bands, longitudinal strips that course toward the fingers.

In a sagittal plane, it divides into: superficial fibres which insert into the dermis, intermediate-depth fibres (which bifurcate into two separate strips; spiral bands and lateral digital sheet) and deepest fibres which pass almost vertically and dorsally (related to the metacarpal joint capsule and tendon flexor sheath).

Two sets of transverse fibres in the palm; superficial transverse palmar ligament and natatory ligament.

Bands are the normal palmar tissue; cords are the abnormal palmar tissue in Dupuytren's disease.

Natatory cords originate from the natatory ligaments and cause contractures of the second through to the fourth webspace. Changing the normal U-shaped web spaces into the classic V-shaped web in Dupuytren's disease. These contractures result in finger adduction. The distal natatory ligaments are found in the second to fourth webspace and the palmar digital junction acts to connect the adjacent web skin.

- The pretendinous cord is formed from pretendinous bands.
- The spiral cord is made up of the pretendinous band, spiral band, lateral digital sheet and Grayson ligament; this often occurs in the ring and little fingers and winds around the neurovascular bundle.
- The lateral cord is formed from the lateral digital band and is rarely observed, except on the ulnar aspect of the small finger.
- The central cord is the extension of the pretendinous cord in the palm; it is the most common cause of proximal PIP contracture.
- The natatory cord contributes to webspace contractures and passes superficial to neurovascular bundles.
- A natatory ligament runs transversely across each webspace distal to the MCP joint, giving fibres that blend with each lateral digital sheet and to the superficial aspect of the flexor tendon sheath.

Leibovic SJ. Normal and pathologic anatomy of Dupuytren disease. *Hand Clin.* 2018;**34**:315–329.

Rayan GM. Dupuytren disease: anatomy, pathology, presentation, and treatment. *J Bone Joint Surg Am.* 2007;**89**:189–198.

68. Answer B. **Normal pronation strength with the elbows fully flexed**

The anterior interosseous nerve innervates two of the deep muscles of the forearm and contributes 50% to the innervation of another.

- Flexor pollicis longus.
- Pronator quadratus (PQ).
- The radial (lateral) half of FDP (index and middle fingers).

The AIN supplies PQ. PQ is tested with the elbow fully flexed to defunction the pronator teres.

The AIN has no sensory innervation.

Flexion of the IPJ of the thumb is controlled by the flexor pollicis longus (FPL) supplied by the AIN.

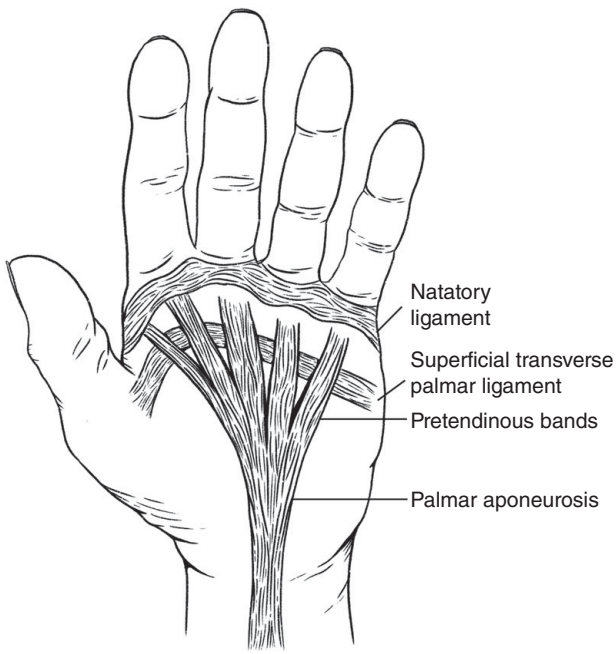


Figure 18.8 Natatory cords have transverse components and therefore cause adduction of finger. Reproduced with permission from Elsevier

Flexion of the DIPJ of the middle finger is controlled by flexor digitorum profundus (FDP) supplied by the AIN.

69. Answer E. **Toilet and dressing**
A volar fingertip injury without exposed bone involving 1cm or less of skin loss is best treated with toilet and dressing. The aim of any fingertip reconstruction is to maintain length, sensation and function of the affected digit. Advice should be given to the patient that the wound will take 6 weeks to heal and the contour and sensation of the tip will recover. Primary closure is not appropriate as this would leave a more abnormal contour to the fingertip. If the injury involved/exposed the bone of the distal phalanx, the options of treatment are to perform an advancement flap such as an Atasoy flap which involves mobilising more proximal skin over the defect in a V-Y pattern or to terminalise the digit. Terminalisation shortens the digit to allow for primary skin closure. Pedicled flaps such as a first dorsal metacarpal artery flap or a cross finger flap are not required for this injury as the size of the defect will allow for healing by secondary intention and split skin grafting is not performed for volar digital skin loss.

Whilst we realise that this SBA is similar to Q22 we have kept it in the chapter. The topic seems to have been repeated in several different diets of recent exams. More is more in this situation.

Golinvaux NS, Maslow JI, Hovis JP, Lee DH. Fingertip injury and management. *JBJS Essent Surg Tech.* 2019;**9**:e30.

70. Answer E. **Watchful waiting**
This patient has a classic history for Orf infection which is passed to humans from sheep, and in particular lambs. It is a viral infection (Parapoxvirus) and often starts as a small flat blue red circular lesion becoming bigger and more blister-like and eventually weeping. Systemic upset can be a feature of the infection and the digit can become very swollen and painful with restricted range of movement.

Orf is usually self-limiting and does not require any treatment and will usually clear up completely after 6 weeks.

71. Answer E. **Partial fasciectomy**

- Dupuytren's disease: Little finger PIPJ 60° flexion contracture.
- General: MCPJ >30° and/or PIPJ >20°
- Treatment options:

• **None:**	Mild, slowly progressive or patient refusal
• **Needle fasciotomy:**	Pretendinous cord (i.e. not just nodule)
• **Fasciectomy:**	Healthy skin with significant contracture
• **Dermofasciectomy:**	Poor skin, diathesis (e.g. young), revision
• **Amputation:**	'Finger-in-palm' disease, preference (e.g. severe)
• **PIPJ fusion:**	Coexisting severe PIPJ OA, preference (e.g. severe)

Chapter 19

Hand II Structured SBA

Matthew Brown and David Yeoh

HAND II STRUCTURED SBA QUESTIONS

1. A 23-year-old female presents 2 days following an impact to her middle finger whilst playing netball. Her finger is bruised and swollen and movement is limited. Radiographs are shown in Figure 19.1.

Figure 19. 1 Lateral radiograph finger

What is the most appropriate management step?
A. Hemihamate reconstruction
B. K-wire fixation
C. Neighbour strapping to the ring finger
D. Ultrasound to exclude FDS avulsion
E. Volar splintage excluding DIPJ

2. A 36-year-old fireman presents with dorsal wrist pain on exertion. He does not recall an injury. Grip strength is reduced. Radiographs are shown in Figure 19.2.

Figure 19.2 (a) Posteroanterior and (b) lateral radiograph wrist

Which is the most appropriate management option?
A. Intercarpal ligament repair
B. Open reduction and temporary K-wire fixation
C. Scaphoidectomy and four-corner fusion
D. Scapholunate ligament reconstruction using tendon graft
E. Wrist denervation

3. A 39-year-old market stall holder presents with a painful 'snapping' sensation along their middle finger after punching a wall 3 months ago. Plain radiographs are unremarkable.
How would you manage this patient?
A. A1 pulley release
B. Central slip repair or reconstruction
C. Lateral band repair or reconstruction
D. Sagittal band repair or reconstruction
E. Ultrasound-guided cortisone injection

4. A 14-year-old school pupil presents with the injury shown in Figure 19.3. He explains that he hit out at a fellow pupil 2 days ago and the pain is slow to settle. He is accompanied by both of his parents.

Figure 19.3 (a) Oblique and (b) lateral radiograph hand

What is the priority when managing this patient?

A. Excluding digital scissoring
B. Providing an intrinsic minus ulnar gutter splint for comfort
C. Providing an intrinsic plus cast for 2 weeks
D. Reducing the fracture (e.g. using the Jahss manoeuvre)
E. Reporting the incident to the child safeguarding team

5. A 59-year-old presents with the closed injury as shown in Figure 19.4b. He was unable to initiate IPJ flexion. Post-reduction imaging is shown in Figure 1.4b. He complains of reduced sensation throughout the pulp (rated 5 out of 10). There is tenderness over the volar IPJ. He is able to demonstrate active flexion and extension of the IPJ.

Figure 19.4 Lateral thumb radiographs (a) pre-reduction and (b) post-reduction

What is the preferred definitive management?

A. Digital nerve exploration +/− repair
B. Dorsal blocking splint with active thumb flexion
C. Examination under anaesthesia +/− volar plate repair
D. Repair of the flexor pollicis longus tendon
E. Volar splint with immobilisation for 4 weeks

6. A 60-year-old roofer presents with a 2-year history of pain at the base of the thumb and wrist when gripping with his non-dominant hand. He is requiring time off work and his sleep is

increasingly affected. On examination there is moderate flattening of the thenar eminence and reduced opposition range. Plain radiographs are shown in Figure 19.5.

Figure 19.5 (a) Anteroposterior and (b) lateral thumb radiograph

What is the most appropriate definitive management?

A. First CMC joint arthrodesis
B. Anti-rheumatic DMARD therapy
C. Carpal tunnel decompression
D. STT joint arthrodesis
E. Trapeziectomy

7. Following minor trauma, a 30-year-old presents with the inability to initiate active middle finger DIPJ flexion. MCPJ and PIPJ motion is unaffected. The lateral radiograph demonstrates a small palmar opacity (see Figure 19.6).

Which of the following statements is true?

A. Early surgical repair is required
B. Primary end-to-end tendon repair is required
C. Soft tissue mallet has occurred
D. Tendon quadriga is preventing composite DIPJ flexion
E. Tethering of the superficialis and profundus tendons is likely

8. A 38-year-old GP presents with a 16-month history of a painless mass affecting her ring finger. There is no history of trauma and function is not affected. On examination the mass is firm, non-

Figure 19.6 Lateral radiograph finger

tender, immobile and not adherent to the overlying skin. Radiographs are shown in Figure 19.7.

Figure 19.7 (a) Anteroposterior and (b) lateral radiographs finger

Which combination of likely diagnosis and pre-operative investigation(s) is most appropriate for the featured case?

A. Angiosarcoma/ultrasound and chest radiograph
B. Giant cell tumour of the tendon sheath/fine needle aspiration cytology
C. Giant cell tumour of the tendon sheath/MRI
D. Lipoma/MRI
E. Liposarcoma/MRI and chest radiograph

9. A 40-year-old amateur pilot presents with a displaced intra-articular fracture of the thumb metacarpal base. Plain radiographs demonstrate a 2-part fracture as seen in Figure 19.8.

Figure 19.8 Lateral radiograph thumb

Regarding the management of such fractures:
A. Abductor pollicis longus and adductor pollicis are the primary deforming forces
B. Open reduction is required to ensure articular congruity
C. Reduction requires supination and longitudinal traction
D. The anterior oblique (beak) ligament is usually disrupted
E. Thumb spica application requires palmar pressure to be maintained

10. A 27-year-old female presents following a motorcycle accident with displaced, shortened spiral metacarpal shaft fractures. Mild malrotation of the index, middle and ring fingers is observed.
How would you manage this patient?
A. Closed reduction and intramedullary pinning
B. Closed reduction and splintage
C. External fixation
D. Open reduction and internal fixation
E. Metacarpal splintage and early digital movement with hand therapy

11. A 29-year-old professional tennis player presents with altered sensation in the radial three digits of their dominant hand. Sensation over the thenar eminence is reduced. Night symptoms are not a feature but certain movements can bring on the paraesthesia. Grade 5 power is observed in all muscle groups. Provocative tests over the carpal tunnel are unremarkable. Neurophysiological testing and magnetic resonance imaging are unremarkable.
What is the most likely diagnosis?
A. Carpal tunnel syndrome
B. Intersection syndrome
C. Pronator syndrome
D. Schwannoma
E. Wartenberg's syndrome

12. A 79-year-old retired butcher is referred with marked digital clawing. On examination there is altered sensation in his little finger.
Which of the following statements is correct?
A. A Martin–Gruber anastomosis will limit the outcome of surgical treatment
B. Amyotrophic lateral sclerosis is most likely
C. Clawing is secondary to FDS weakness (the ulnar paradox)
D. Clinical diagnosis, confirmed with nerve conduction studies, is the gold standard
E. The ligament of Struthers is a potential site of compression

13. A 49-year-old pharmacist with rheumatoid arthritis presents with a correctible deformity of her middle finger. Pain is not a feature and there is no history of trauma. There is resting hyperextension of the PIPJ and flexion of the DIPJ, and full active range of movement. Plain radiographs

demonstrate minimal erosive changes. Conservative measures including splinting by hand therapists have failed.

What is the most appropriate definitive management?

A. Extensor tenotomy
B. Flexor tendon tenodesis (FDS sling)
C. Oval-8 splintage
D. PIPJ arthrodesis
E. PIPJ arthroplasty and volar plate advancement

14. A 27-year-old veterinary assistant presents 10 hours after a dog bite to their dominant index finger. The digit is now painful, erythematous and held semi-flexed. His vital signs include blood pressure 130/82mmHg, heart rate 89/minute, respiratory rate 15/minute and temperature of 37.4°C.

What is the initial management of this patient?

A. Incision and drainage through a single incision
B. Intravenous antibiotics and elevation
C. Oral antibiotics and splintage
D. Urgent MRI
E. Urgent ultrasound

15. A 40-year-old carpenter presents with wrist pain. He takes regular analgesia but rates the pain as debilitating and affecting his ability to work. He has tried splinting and steroid injections without great benefit. Comparative views show >2mm scapholunate diastasis and DISI deformity which is fixed. MRI confirms SLIL rupture but no significant arthritis. Dynamic screening and arthroscopy reveal that the deformity is irreducible with no change in the scapholunate gap or angle.

The most appropriate surgical option is:

A. Modified Brunelli (three-ligament tenodesis) reconstruction
B. Radial styloidectomy
C. Scaphoid-trapezium-trapezoid (STT) fusion
D. Total wrist fusion
E. Total wrist replacement

16. A 35-year-old violinist was carrying out home improvements using an angle grinder. He sustained a right middle finger pulp laceration with a 2cm area of loss causing the tendon to be exposed.

The most appropriate surgical option would be:

A. Cross finger flap
B. Homodigital neurovascular island flap
C. Free toe transfer
D. Full thickness skin graft
E. Split thickness skin graft

17. A 65-year-old retired baker presents with an inability to extend her thumb. She sustained a distal radius fracture 3 months ago that was managed non-operatively.

How would you manage this patient?

A. EDC to EPL tendon transfer
B. EIP to EPL tendon transfer
C. Exploration of the posterior interosseous nerve (PIN)
D. Primary tendon repair
E. Thumb MCPJ fusion

18. A 25-year-old solicitor fell from her push bike. She has tenderness in the anatomical snuffbox. The radiographs are shown in Figure 19.9.

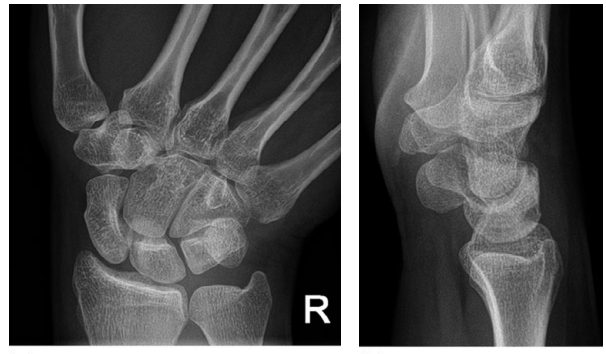


Figure 19.9 (a) Posteroanterior and (b) lateral radiographic projections

The most appropriate option would be:

A. Cast including thumb and MRI within next 2 weeks
B. Cast including thumb and repeat radiographs in 2 weeks
C. Cast with thumb free and CT within next 2 weeks
D. Cast with thumb free and MRI within next 2 weeks
E. Splint and repeat radiographs in 2 weeks

19. A 47-year-old manual worker presents with a deformity of their middle finger (see Figure 19.10). It is causing functional difficulty. The deformity is rigid and not passively correctable.

Figure 19.10 Lateral radiograph finger

The most appropriate surgical option is:

A. Distal interphalangeal joint fusion
B. Proximal interphalangeal joint fusion
C. Silastic replacement of the proximal interphalangeal joint
D. Soft tissue reconstruction of the extensor tendon
E. Zancolli lasso procedure

20. A 25-year-old management consultant presents with a painful dorsal wrist ganglion. She would like it removed. The diagnosis is confirmed and you are consenting her for surgical excision.

What is the likely rate of recurrence?

A. 1: 200
B. 1: 100
C. 1: 50
D. 1: 20
E. 1: 5

21. A 40-year-old plumber presents with a 1-year history of insidious onset and vague wrist pain. She has tried splinting for the last 3 months and is taking regular analgesia. She is a non-smoker. Recent radiographs are shown in Figure 19.11.

Figure 19.11 Posteroanterior radiograph wrist

Which of the following is the most appropriate treatment option?

A. Core decompression and arthroscopic debridement
B. Proximal row carpectomy
C. Radial shortening osteotomy
D. Scaphoidectomy and four corner fusion
E. Ulnar lengthening osteotomy

22. A 30-year-old manual labourer presents with a 12-month history of worsening wrist pain. He fractured the ipsilateral distal radius 3 years ago. There is pain on ulnar deviation during power grip. Plain radiographs demonstrate ulnar positive variance of 3mm and 10° of distal radius dorsal angulation. The TFCC is intact but attenuated.

How would you manage this patient?

A. Arthroscopic debridement and stabilisation
B. Darrach's procedure
C. Sauvé–Kapandji procedure
D. Ulna head replacement
E. Ulna shortening osteotomy

23. A 41-year-old veterinary surgeon presents with dominant radial-sided wrist pain of 6 months' duration. Thumb movements and ulnar deviation of the wrist are particularly uncomfortable. She lives with her husband and their two sons, aged 8 months and 3 years of age. The Eichhoff and Finkelstein tests are positive.

Which of the following is correct?

A. There are usually two tendon slips in the affected compartment
B. Early tendon sheath release is the treatment of choice

C. Intersection syndrome is most likely
D. The condition is often self-limiting
E. Ultrasound is required

24. A 65-year-old male undergoes carpal tunnel decompression under local anaesthetic.

Which local anaesthetic option would you choose?

A. 4mg/kg of bupivacaine 0.5%
B. 2.5mg/kg of bupivacaine 0.5% with adrenaline (1:200,000)
C. 3mg/kg of lidocaine 1% with adrenaline (1:10,000)
D. 8mg/kg of lidocaine 2% with adrenaline (1:200,000)
E. 6mg/kg of lidocaine 1% with adrenaline (1:10,000)

25. A 32-year-old tennis coach presents with chronic pain in their dominant wrist. Examination reveals a painful ulnar 'catch-up' clunk as the wrist is moved from radial to ulnar deviation. No history of trauma is recalled. She has Ehlers–Danlos syndrome.

What is the most likely diagnosis?

A. Distal radioulnar joint (DRUJ) instability
B. Dorsal intercalated carpal instability (DISI)
C. Flexor carpi ulnaris (FCU) instability
D. Midcarpal carpal instability
E. Triangular fibrocartilage complex (TFCC) tear

26. A 28-year-old cyclist falls from his bike and sustains a deep defect over his dominant thenar eminence. It measures 5×3cm and the underlying muscle and fascia are abraded. There are no signs of infection.

What is the most appropriate definitive management plan for this patient?

A. Full thickness skin graft
B. Meshed split-thickness skin graft
C. Moberg flap
D. Negative pressure wound therapy
E. Non-meshed split-thickness skin graft

27. A 53-year-old shopkeeper presents with a long history of morning stiffness and a symmetrical polyarthropathy of their hands. Serum testing identifies positive anti-CCP antibodies.

Which of the following clinical findings would not be expected?

A. Splenomegaly
B. Swan-neck deformity
C. Thumb boutonnière (Nalebuff 1)
D. Ulnar deviation and volar subluxation of the digits
E. Ulnar deviation of the carpus

28. A mechanic injects the tip of his non-dominant index finger with a high-power grease gun. He is otherwise fit and well and takes no regular medications.

What is the most appropriate first step in the management of this patient?

A. Broad-spectrum antibiotics and tetanus prophylaxis
B. Fluid resuscitation
C. Irrigation and debridement on the next available operating list
D. Plain radiographs
E. Urgent irrigation and debridement

29. A 19-year-old snowboarder falls onto his outstretched hand. Tenderness is maximal over the volar scaphoid tubercle and there is moderate pain upon axial loading through the thumb.

Which plain radiographic view is least helpful?

A. Clenched fist anteroposterior (AP)
B. Lateral
C. Posteroanterior (PA) with ulnar deviation
D. Posteroanterior (PA)
E. Semi-pronated oblique

30. A 29-year-old solicitor fell whist skiing 2 weeks ago. They present having sustained a proximal pole scaphoid fracture with <2mm displacement.

What is the most appropriate management plan?

A. Cast immobilisation
B. Internal fixation and iliac crest bone graft via volar approach
C. Internal fixation and vascularised bone graft via dorsal approach
D. Internal fixation via dorsal approach
E. Internal fixation via volar approach

31. A 58-year-old secretary presents with a flexion contracture of their ring finger secondary to Dupuytren's disease. The MCPJ is flexed to 40° and the PIPJ is flexed to 20°.

Which of the following structures is least likely to be affected?

A. Grayson's ligament
B. Lateral band
C. Lateral digital sheet
D. Pretendinous band
E. Spiral band

32. A 40-year-old roofer falls onto his outstretched hand from 4 metres and presents with severe wrist pain and median nerve symptoms. Your examination identifies markedly reduced wrist movements and swelling. Initial imaging is shown in Figure 19.12. He is a smoker.

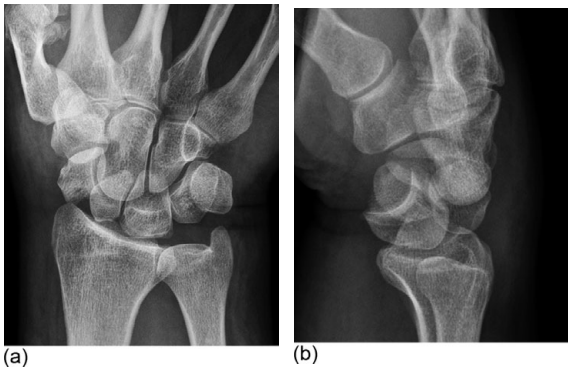


Figure 19.12 (a) Posteroanterior and (b) lateral radiograph wrist

Regarding the injury seen:

A. Carpal tunnel decompression is usually required
B. Closed reduction is unlikely to be successful
C. Open scapholunate ligament repair is required
D. Salvage options include total wrist fusion
E. There is a risk of Preiser's disease

33. A 30-year-old chef sustains a palmar thumb laceration at the level of the proximal phalanx. Painful triggering is seen. There is no neurovascular compromise.

How would you manage this patient?

A. Tendon debridement and A1 pulley release
B. Washout and closure in the emergency department with clinical review in one week
C. Washout and tendon repair for lacerations greater than 30% of cross-sectional area
D. Washout and tendon repair for lacerations greater than 50% of cross-sectional area
E. Washout, pulley repair or reconstruction and urgent referral to hand therapy

34. A 55-year-old female reports unilateral altered hand sensation affecting 'all fingers' that wakes them most mornings. It has been present for 18 months. They describe recent clumsiness when handling small objects. They experience no neck pain and wearing a splint can provide moderate symptomatic relief. Neurophysiology testing 8 months ago was normal.

What is true regarding the above condition?

A. Normal neurophysiology is a relative contraindication for surgery
B. Positive neurophysiology usually returns to normal following decompression
C. Pronator syndrome is the most likely diagnosis
D. Steroid injection should be administered radial to the palmaris longus tendon
E. Surgical decompression may improve their symptoms

35. A 20-year-old carpet fitter presents after sustaining a palmar knife laceration over the proximal phalanx. He is unable to flex his non-dominant index finger. Neurovascular examination is unremarkable.

What is the most appropriate management plan?

A. Urgent ultrasound
B. Two-strand core suture repair of FDS and FDP with early active mobilisation
C. Monofilament core suture repair with 5mm tendon purchase
D. Four-strand core suture repair with position of safe immobilisation (POSI) for 2 weeks
E. Four-strand core suture repair with early active mobilisation

36. A 45-year-old tree surgeon undergoes flexor tendon repairs of his index and middle fingers.

Which of the following post-operative management plans is most appropriate?

A. Dorsal splintage (MCPJs flexed) and active flexion from day 4
B. Place and hold mobilisation from day 3 (passive flexion and active extension)

C. Position of safe immobilisation dorsal splintage and active mobilisation from day 8
D. Position of safe immobilisation volar splintage and mobilisation from day 4
E. Volar splintage (wrist neutral, MCPJs flexed, PIPJs straight) and active extension from day 5

37. A 59-year-old grocer presents with ulnar-sided wrist pain and evidence of a triangular cartilage lesion.

Which of the following is true regarding this structure?

A. Magnetic resonance arthrography is the gold standard for diagnosis
B. Peripheral ulnar tears risk DRUJ instability
C. The 6U arthroscopy portal provides the best view
D. Traumatic (Palmer class I) tears are usually due to ulnar impaction syndrome
E. Ulnar minus variance is frequently implicated

38. A 57-year-old woman presents with an intrinsic minus hand posture with supple joints and good passive movement. Two years previously she sustained an elbow fracture treated with internal fixation. She subsequently developed ulnar nerve symptoms and underwent an ulnar decompression and transposition about 4 months later. She would like to improve the function and appearance of her hand.

The best option would be:

A. Nerve transfer: Supercharged AIN to ulnar nerve
B. Revision ulnar nerve decompression and transposition
C. Tendon transfer: Crossed intrinsic transfer
D. Tendon transfer: Extensor indicis (EI) to extensor pollicis longus (EPL)
E. Tendon transfer: Split flexor digitorum superficialis (FDS) to digital extensor tendon

39. A patient presents with ulnar nerve symptoms and a positive nerve conduction study confirming compression localised to the elbow. You offer surgical decompression.

Sites of compression that are released can include all of the following except:

A. Arcade of Struthers
B. Fascial bands within flexor carpi ulnaris (FCU)
C. Ligament of Struthers
D. Medial head of triceps brachii
E. Osborne's ligament

40. A 22-year-old electrician presents with radial-sided wrist pain 7 months after a fall. Examination of the wrist demonstrates a brisk active flexion-extension arc of 150°. Plain radiographs demonstrate scaphoid waist fracture non-union. There is a 9×9×8mm cyst at the fracture site. Carpal alignment is well-maintained.

What is the most appropriate management?

A. Antegrade screw fixation and vascularised bone graft
B. Limited carpal fusion
C. Percutaneous screw fixation
D. Retrograde screw fixation and corticocancellous bone graft
E. Wrist denervation (PIN and AIN)

41. A 31-year-old cabinet maker accidentally amputates his thumb obliquely through the proximal phalangeal base with a circular saw. Four hours later he arrives at the emergency department with the digit held in a carrier bag.

What is the preferred definitive management?

A. Debridement and primary closure
B. Debridement and replantation in order: artery, bone, nerve, vein, extensor, flexor
C. Debridement and replantation in order: artery, bone, vein, extensor, flexor, nerve
D. Debridement and replantation in order: bone, artery, vein, extensor, flexor, nerve
E. Debridement and replantation in order: bone, extensor, flexor, artery, nerve, vein

42. A 32-year-old barrister presents with pain over her middle finger 2 weeks following a closed injury whilst playing netball. Her PIPJ is swollen but stable. Modified Elson's test is positive.

How would you manage this patient?

A. Buddy strapping
B. Central slip repair
C. Dorsal blocking splint
D. Lateral band transfer (e.g. Littler procedure)
E. PIPJ extension splintage

43. A 40-year-old teacher presents with altered sensation, including paraesthesia and hypersensitivity, in the median nerve distribution following volar plate fixation of a distal radius fracture. Autonomic function remains intact. She describes no sensory impairment prior to surgery. Electromyography completed 6 weeks following surgery demonstrates fibrillations and positive sharp waves in abductor pollicis brevis. A Tinel response is elicited over the proximal scar.
Which pair represent the most likely nerve injury and most appropriate management plan?
A. Axonotmesis/nerve exploration
B. Axonotmesis/repeat nerve conduction studies in 6 weeks
C. Conduction block/clinical review in 6 weeks
D. Neurotmesis/nerve exploration
E. Neurotmesis/repeat nerve conduction studies in 6 weeks

44. A 42-year-old cyclist presents 3 months following radial head replacement surgery, which was complicated by a nerve palsy. They are now able to weakly extend the index, middle, ring and little fingers. Thumb retropulsion is not seen. A Tinel is present in the mid-forearm.
What is the most appropriate next step in management?
A. Electrophysiological studies and continued monitoring
B. Electrophysiological studies and nerve exploration
C. Extensor indicis (EI) to extensor pollicis longus (EPL) tendon transfer
D. Revision radial head replacement and neurolysis
E. Ultrasound scan

45. A 57-year-old pub landlord presents with a 4-month history of a painful palmar nodule in line with the ring finger at the level of the distal palmar crease. Full digital extension is observed. The contralateral ring finger MCP joint has an extension deficit of 20°.
Which of the following is most accurate?
A. Excision biopsy is required
B. Fine needle aspiration cytology will be useful
C. Myofibroblasts will predominate
D. Observation is required
E. Urgent ultrasound is indicated

46. A 4-year-old boy presents with a unilateral flattened thenar eminence and a small thumb. The MCP joint ulnar collateral ligament is lax and the radial collateral ligament is intact. Plain radiographs demonstrate intact MCP and CMC joints.
What is the most appropriate management plan?
A. Reassurance and annual observation
B. Opponensplasty and stabilisation
C. FDS to FPL tendon transfer
D. Pollicisation
E. Toe-to-thumb transfer

47. A 45-year-old graphic designer presents with a progressive flexion contracture of his right little finger. He thinks that his father has a similar problem. Corrective surgery 4 years ago provided improved extension range. On examination, there are flexion contractures of the MCPJ (65°, uncorrectable) and PIPJ (20°, partially correctable). A mature volar scar is visible. He is requesting treatment.
What is the most appropriate management plan?
A. Dermofasciectomy (full thickness skin graft)
B. Dermofasciectomy (split skin graft)
C. Limited fasciectomy
D. Observation and review in 6–12 months
E. Percutaneous needle fasciotomy

48. An 82-year-old man presents with a slowly enlarging mass on the volar aspect of his proximal forearm. It measures 5.5cm in maximal diameter. He denies a history of trauma. Plain radiographs are unremarkable. He lives alone and is just about managing.
What investigation should be performed next?
A. Fine needle aspiration cytology
B. Magnetic resonance (MR) imaging
C. Magnetic resonance (MR) imaging with gadolinium
D. Plain radiograph of the chest
E. Ultrasound by a musculoskeletal radiologist

49. A 35-year-old physicist presents with a chronic radial nerve palsy following a humeral fracture

sustained 17 months ago. Her hand function is compromised. She has satisfactory passive motion and no pain.

What is the most appropriate definitive management plan?

A. Radial nerve exploration
B. Tendon transfer: Extensor carpi ulnaris (ECU) to extensor carpi radialis brevis (ECRB)
C. Tendon transfer: Flexor digitorum superficialis (FDS, ring finger) to extensor carpi radialis longus (ECRL)
D. Tendon transfer: Palmaris longus (PL) to extensor carpi radialis longus (ECRL)
E. Tendon transfer: Pronator teres (PT) to extensor carpi radialis brevis (ECRB)

50. A 44-year-old pianist presents with the injury demonstrated in Figure 19.13. They stubbed their finger awkwardly at the supermarket 5 days ago. They complain of pain and swelling.

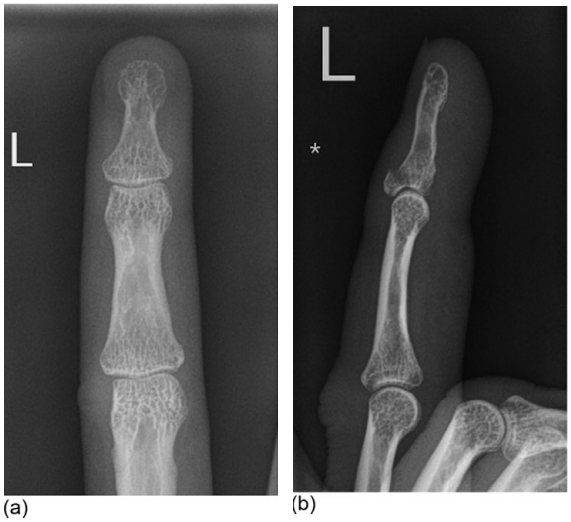


Figure 19.13 (a) Anteroposterior and (b) oblique radiograph finger

What is true of this injury?

A. K-wire fixation (e.g. Ishiguro technique) will help long-term function
B. Buddy strap and gentle mobilisation is indicated
C. Primary tendon repair may be required
D. Swan neck deformity is a risk
E. Boutonnière deformity will require splintage

51. A 70-year-old presents with pain when opening jars and at rest. Splintage and regular analgesia is now providing decreasing benefits. Steroid injection provided 6 weeks of moderate pain relief. Her medications include apixaban and metformin. Plain imaging is shown in Figure 19.14.

Figure 19.14 Anteroposterior radiograph hand

What would you recommend?

A. First CMCJ arthrodesis
B. Repeat steroid injection
C. Thumb base denervation
D. Trapeziectomy alone
E. Trapeziectomy with tendon adjunct

HAND II STRUCTURED SBA ANSWERS

1. Answer C. **Neighbour strapping to the ring finger**

   The radiographs demonstrate a congruent PIPJ with a small volar plate avulsion fragment at the base of the middle phalanx. The volar plate and collateral ligaments are the primary static stabilisers of the PIPJ. The volar plate attaches to the proximal phalanx via two tail-like extensions, known as the checkrein ligaments. With forced hyperextension (or axial loading of the flexed PIPJ), the volar plate will either fail or avulse from its middle phalanx insertion whilst the proximal checkrein attachments remain intact. Loss of this static restraint can result in dorsal subluxation.

   Uncomplicated volar plate injuries are managed non-operatively: neighbour strapping (to the longest adjacent finger), gentle active finger motion (avoiding hyperextension) and modification of activities. When small avulsion fragments are associated with PIPJ dorsal dislocation requiring reduction, a dorsal blocking splint holding the PIPJ reduced and in slight flexion is advised.

   When PIPJ volar middle phalanx fractures are associated with joint incongruence, reduction and a trial of a dorsal blocking splint with approximately 45° PIPJ flexion should be attempted in the emergency department and/or operating theatre. Such injuries are more stable (and congruent) in PIPJ flexion; however, volar middle phalanx fractures involving >30% articular surface have tenuous stability in flexion, and those with >50% are usually unstable (Weiss and Hastings classification).

   Unstable injuries with an intact dorsal cortex may be treated with K-wires, open reduction and internal fixation, volar plate advancement or hemihamate reconstruction. Hemihamate reconstruction is reserved for unreconstructable or multi-fragment variants. Fixed flexion deformity is a common outcome. Complete articular (transmetaphyseal) middle phalanx basal injuries (pilon-type injuries) require distraction, for example with external fixation.

2. Answer D. **Scapholunate ligament reconstruction using tendon graft**

   The scapholunate interosseous ligament (SLIL) is the most commonly injured wrist ligament. In the sagittal plane the ligament is C-shaped, with three structurally distinct parts: dorsal, proximal (membranous) and palmar. The dorsal component is the strongest and the primary stabiliser of the scapholunate (SL) articulation.

   Carpal instability secondary to SLIL injury can be classified as pre-dynamic, dynamic or static. The former is associated with mild sprains. Dynamic instability is a feature of early, complete ligament disruption and is evidenced by widening of the SL interval on dynamic PA plain radiographs (clenched fist or ulnar deviation). Resting (neutral) plain radiographs can appear normal for 3–12 months contributing to a delay in diagnosis. In dynamic instability, the SLIL remnants may be present and the secondary carpal ligamentous stabilisers remain largely intact, which help to prevent carpal malalignment or degenerative change (Andersson 2017). Following complete intrasubstance tears, the ligament remnants undergo rapid degeneration, and direct primary repair is likely to fail if not performed within the first 6 weeks. However, the majority of complete SLIL injuries are bony avulsions from the scaphoid (42%), which can be treated beyond 6 weeks (Andersson 2017).

   Static instability occurs months to years following injury, with resting plain radiographs demonstrating abnormal SL widening (>3mm, Terry Thomas sign). Altered carpal kinematics result in gradual attenuation of the secondary ligaments, leading to scaphoid flexion and lunate extension. The lunate follows the pull of the triquetrum via the intact lunotriquetral interosseous ligament (LTIL). Dorsal intercalated segment instability (DISI) is suggested by a SL angle >60° (normal range 30–60°) on lateral wrist radiographs. The other example of static carpal instability, known as volar intercalated segment instability (VISI), results from lunotriquetral ligament disruption, with the scaphoid and lunate assuming resting positions that are opposite to DISI.

   Aberrant carpal kinematics will lead to the predictable stepwise pattern of wrist osteoarthritis, termed scapholunate advanced collapse (SLAC). Therefore, SLIL reconstruction, for example using a modified Brunelli (or three-ligament tenodesis) procedure, is an option for a reducible DISI deformity exhibiting minimal degenerative change. It utilises a strip of the FCR tendon to

create a biological SL stabiliser. Following reduction of the scaphoid and lunate, the FCR graft is passed dorsal through a scaphoid drill hole and secured to the dorsal lunate and extrinsic wrist ligaments. Although the goals of SLIL reconstruction are to improve carpal kinematics, the evidence for preventing or delaying wrist degeneration is lacking.

Andersson JK. Treatment of scapholunate ligament injury: current concepts. *EFORT Open Rev.* 2017;**2**:382–393.

3. Answer D. **Sagittal band repair or reconstruction**
The radial and ulnar sagittal bands encircle each metacarpophalangeal joint (MCPJ) to centralise the extensor tendons during digital motion. Complete sagittal band rupture leads to subluxation or dislocation of the extensor tendon away from the injured band upon MCPJ flexion. Also termed the 'boxer's knuckle', sagittal band rupture may be mistaken for trigger finger due to the potential inability to actively extend the digit from a flexed position and the sudden jerk associated with relocation of the extensor tendon over the metacarpal head (termed pseudo-triggering). Flexor tendon triggering at the A1 pulley is associated with flexion of the IPJs but this is not seen with sagittal band injury. Closed sagittal band injury is more common than open lacerations. The radial sagittal band and the middle finger are most common. Sagittal band failure is also associated with inflammatory arthropathy, including rheumatoid arthritis.

A working knowledge of the extensor apparatus is important. The sagittal bands stabilise the extensor tendons centrally as they pass over the metacarpal heads. The extensor digitorum communis (EDC) does not directly insert into the proximal phalanx and MCPJ extension is therefore mediated through the pull of the sagittal bands, which surround the base of the proximal phalanx en route to their insertion onto the MCPJ volar plate (they also insert into the intermetacarpal ligaments). The EDC trifurcates over the proximal phalanx: the central slip inserts into the base of the middle phalanx and the lateral components unite with the lateral bands.

Acute sagittal band injuries with or without subluxation are often treated successfully in a splint for 8 weeks. Splint options permit active IPJ movement and include the relative motion (or yoke) splint or a volar hand splint that supports the MCPJ and proximal phalanx in mild hyperextension. Direct surgical repair or reconstruction is reserved for open injuries and those presenting late or when splintage has failed.

4. Answer A. **Excluding digital scissoring**
Metacarpal neck fractures (known as boxer's fractures) result from axial loading, for example, when landing a punch. The little finger is most commonly affected. The initial priorities are to exclude digital malrotation or scissoring (this being an indication for manipulation +/− fixation) and to confirm that it is a closed and isolated injury. The history provided fits with the injury seen and parental support is suggested.

There is little consensus regarding the accepted degree of angulation. The flexion angle should be measured on the lateral radiograph. Cadaveric studies demonstrate that fracture angles up to 30° result in near normal mechanics (Beredjiklian 2009). Functional studies have variously identified acceptable malunion flexion deformities ranging from 20–60°. Westbrook et al. (2008) concluded that angulation up to 50° (in the absence of malrotation) was not associated with deleterious outcomes at 2 years, including grip strength. Reduced knuckle contour and an extensor lag are seen in those with persistent angular deformity.

Most patients can be managed with neighbour strapping and encouraged to perform active mobilisation. Alternatively, those who present in significant pain may be managed for a week or so in a moulded ulnar gutter cast (in the intrinsic plus, or Edinburgh, position of safety) followed by strapping and mobilisation.

Off-ended neck fractures (or displaced transverse shaft fractures) are more likely to require reduction and fixation. Intramedullary K-wire fixation (using the bouquet technique) avoids impairment of tendon gliding over dorsal metalwork. Pre-contoured K-wires are advanced antegrade up the medullary canal. Fracture reduction using the Jahss technique is well described: flex the MCPJ and PIPJ to 90° and apply dorsal pressure through the proximal phalanx whilst stabilising the metacarpal. When reduced, the wires are advanced into the metacarpal head.

Beredjiklian PK. Small finger metacarpal neck fractures. *J Hand Surg.* 2009;**34**:1524–1526.

Westbrook AP, Davis TRC, Armstrong D, Burke FD. The clinical significance of malunion of fractures of the neck and shaft of the little finger metacarpal. *J Hand Surg Eur.* 2008;**33**:732–739.

5. Answer B. **Dorsal blocking splint with active thumb flexion**
This patient sustained a thumb IPJ dorsal dislocation which has been successfully reduced. The volar plate will have likely torn but does not require further assessment or repair. Dorsal blocking splints prevent hyperextension (and repeat dislocation) in the weeks following injury and will permit active flexion with hand therapy support. The volar plate is weakest at its proximal insertion and will heal satisfactorily following reduction. Traumatic volar plate injuries do not require repair, which is also the case for open dislocations requiring washout. Interposition of the FPL tendon or the volar plate can prevent closed reduction and would necessitate open reduction.

Prolonged volar splintage is not required for dorsal dislocations. There is no evidence to suggest that the FPL tendon is injured: pain and the mechanical effect of the dislocation will prevent normal FPL activity in this example. Reduced sensation in this closed injury is most likely secondary to digital nerve contusion (neurapraxia) and would be expected to improve with time.

6. Answer E. **Trapeziectomy**
The 1st carpometacarpal joint (CMCJ) is the second most common site of osteoarthritis in the hand (the distal interphalangeal joint is the commonest). The featured radiographs demonstrate pantrapezial osteoarthritis affecting both the 1st CMCJ and the scaphoid-trapezium-trapezoid joint (STTJ or triscaphoid joint). Trapeziectomy is a common and reliable definitive surgical treatment for both patterns of degeneration. In the absence of sensory symptoms, thenar muscle atrophy is most likely secondary to disuse. The severity of 1st CMCJ osteoarthritis has been classified into four stages, with Eaton–Littler stage IV representing pantrapezial disease (Kennedy et al. 2016).

Arthrodesis of the 1st CMCJ is a relative contraindication in those with STTJ osteoarthritis. Arthrodesis is a reasonable option for younger patients in manual occupations with isolated 1st CMCJ osteoarthritis (e.g. following intraarticular basal metacarpal fractures). STTJ arthrodesis is a treatment for isolated STTJ degeneration.

Kennedy CD, Manske MC, Huang JI. Classifications in brief: the Eaton–Littler classification of thumb carpometacarpal joint arthrosis. *Clin Orthop Relat Res.* 2016;**474**:2729–2733.

7. Answer A. **Early surgical repair is required**
Flexor digitorum profundus (FDP) avulsion injuries are also termed 'jersey finger' following the classic mechanism of player contact during sports. They are best treated urgently, especially when the tendon stump has retracted into the palm. The stump may include a piece of avulsed bone (sometimes visible on the lateral radiograph, as seen in the featured case). Large bone fragments will prevent tendon retraction through the pulley system.

Profundus tendon avulsion injuries have been classified by Leddy and Packer (1997) (see Table 19.1). Type IV requires careful diagnostic work-up to ascertain the level of the retracted tendon stump (ultrasound can prove useful). The ideal timing for surgical repair is inconsistently reported; however, urgency is proportional to the level of tendon retraction, with proximal retraction (e.g. type I) doing worse secondary to blood supply disruption (all vincular vessels are disrupted), and the difficulty regaining tendon length. However, as proven

Table 19.1 Classification of profundus tendon avulsion injuries (Leddy and Packer 1977)

Type	Level of tendon retraction	Timing of surgery (ideal)
I	Palm	Urgent (<1–2 weeks)
II	PIPJ (distal A2 pulley)	Urgent (<4 weeks)
III	DIPJ (distal A4 pulley)	Semi-urgent
Added later:		
IV (fracture with separate tendon avulsion)	Digit or palm	As for type I

by type IV injuries, radiographic findings can be inconsistent with the level of tendon retraction and it is safest to plan early surgical repair for all FDP avulsions, regardless of the predicted type or level of retraction.

FDP avulsion injuries are not amenable to end-to-end repair as they detach from their insertion site on the distal phalanx. Repair options include suture anchor fixation, transosseous tunnels (including pull-out buttons) or internal fixation (plate and screws) if a large bone fragment is present. As for other zone 1 flexor injuries, sound repairs can be mobilised using early active protocols.

Leddy JP, Packer JW. Avulsion of the profundus tendon insertion in athletes. *J Hand Surg.* 1977;**2**:66–69.

8. Answer C. **Giant cell tumour of the tendon sheath/MRI**

The featured radiograph demonstrates a soft tissue shadow with unremarkable bone appearances. When combined with the history of slow growth a benign mass is most likely. Giant cell tumour of the tendon sheath (GCTTS) is the second most common tumour seen in the hand after ganglion cysts. GCTTS are firm and painless masses that are distinct from giant cell tumours of bone (the two should not be confused) and arise from the tendon sheath or the synovial lining of a joint. Alternative names include tenosynovial giant cell tumour and pigmented villonodular tumours of the tendon sheath. They are most common in females aged 30–50 years.

Plain radiographs may demonstrate cortical erosions in 10–20% due to local GCTTS pressure effects (minimal volar cortex thinning in this case). MRI is a reliable imaging modality that can also provide valuable information regarding anatomical relationships when planning excision biopsy. It also provides information on the likelihood of the mass being benign. The characteristic low signal appearances on T1- and T2-weighted MRI are due to the presence of haemosiderin. Ultrasound is an alternative imaging modality that can provide information regarding consistency (e.g. solid or cystic). Preoperative fine needle aspiration is rarely required.

GCTTS are treated with excision. Excision becomes more difficult with increasing size as the neurovascular bundles characteristically become stretched over the yellow lobular mass. The risk of recurrence is high at 5–50%, although surgeons often quote 10–20%. Care must be taken to remove all visible traces of the GCTTS under loupe magnification. Risk factors for recurrence include incomplete excision, proximity to the DIPJ, degenerative joint disease, cortical erosions, satellite lesions and increased mitotic activity (Al-Qattan 2001; Athanasian 2016).

Sarcomas are rare and highly malignant tumours of mostly mesenchymal cell origin. Suspected sarcomas should be referred urgently to the regional sarcoma service.

Al-Qattan MM. Giant cell tumours of tendon sheath: classification and recurrence rate. *J Hand Surg Br*. 2001;**26**:72–75.

Athanasian EA. Bone and soft tissue tumors. In Wolfe SW, Pederson WC, Kozin SH, Cohen MS, ed. *Green's Operative Hand Surgery*, 7th Ed., 1987–2035. New York: Elsevier Churchill Livingstone; 2016.

9. Answer A. **Abductor pollicis longus and adductor pollicis are the primary deforming forces**

A partial articular fracture of the thumb metacarpal base is described. Such fractures are commonly referred to as Bennett fractures and they result from axial loading of the flexed thumb. The fracture should be distinguished from extra-articular (metaphyseal) fractures, complete articular (3-part) Rolando fractures and comminuted intra-articular fractures.

Fracture subluxation occurs, with the primary deforming forces being abductor pollicis longus (APL) and adductor pollicis (AP). APL inserts onto the metacarpal base and pulls the metacarpal both proximal and dorsal. AP inserts onto the ulnar base of the proximal phalanx and results in metacarpal adduction (narrowing the first web space) and supination. Successful reduction therefore requires longitudinal traction, pronation and dorsal thumb base pressure (Brown & Rust 2020). As per AO Trauma principles, anatomic restoration of the articular surface is required and intraoperative radiographs should be completed. The anteromedial 'Bennett' fragment, of variable size, is held in position by the anterior oblique ('volar beak') ligament, which remains intact (including for Rolando fractures). The anterior

oblique ligament connects the tubercle of the trapezium and the thumb metacarpal volar base.

Most thumb base fractures are unstable (Liverneaux et al. 2015). Stable patterns that maintain reduction after manipulation may be treated conservatively with a thumb spica cast. The majority of Bennett fractures require supplementary fixation, which can usually be achieved with percutaneous K-wire transfixion to the trapezium and/or index finger metacarpal. Open reduction and internal fixation (ORIF) is usually reserved for cases that cannot be reduced closed. Adduction malunion can be partially compensated for with thumb MCPJ hyperextension. Rolando fractures are not usually amenable to closed reduction techniques and ORIF is usually performed.

Brown MT, Rust PA. Fractures of the thumb metacarpal base. *Injury* 2020;**51**:2421–2428.

Liverneaux PA, Ichihara S, Hendriks S, Facca S, Bodin F. Fractures and dislocations of the base of the thumb metacarpal. *J Hand Surg Eur.* 2015;**40**:42–45.

10. Answer D. **Open reduction and internal fixation**

Multiple metacarpal shaft fractures are usually associated with high-energy trauma. They are considered highly unstable and frequently present with gross swelling and significant metacarpal shortening and/or malrotation. Open reduction and internal fixation will restore metacarpal length and alignment and permit early mobilisation and rehabilitation (Souer & Mudgal 2008).

Longitudinal dorsal incisions between the fractured metacarpals will permit internal fixation of up to two metacarpals. Transverse or short oblique fractures may be treated with plate and bicortical screw fixation spanning a minimum of four cortices proximal and four cortices distal to the fracture. Long oblique or spiral fractures may be treated with one or more lag screws. Fracture patterns that permit only a single lag screw will always require supplementary plate fixation. Intramedullary fixation using the bouquet technique is ideal for transverse metacarpal shaft or neck fractures. Periosteal closure over the metalwork and early digital mobilisation will help to minimise extensor tendon adhesions and stiffness.

Solitary metacarpal shaft fractures that are minimally displaced (with no malrotation) may be treated non-operatively. Unacceptable displacement includes shortening greater than 5mm and/or rotational malalignment and/or flexion deformities greater that 10–20° in the index and middle fingers or greater than 20–30° in the ring and little fingers (AO Trauma). Fractures of the ring and little finger metacarpals tolerate greater flexion deformity as their CMCJ movement in the sagittal plane can help compensate (assess this in your own hand).

AO Trauma Metacarpals. www2.aofoundation.org.

Souer JS, Mudgal CS. Plate fixation in closed ipsilateral multiple metacarpal fractures. *J Hand Surg Eur.* 2008;**33**:740–744.

11. Answer C. **Pronator syndrome**

A sensory neuropathy of the median nerve is described. In the hand, the median nerve innervates the palmar skin of the radial three and a half digits, the radial palmar skin (via the palmar cutaneous branch), the radial two lumbricals, and the three thenar muscles: opponens pollicis, abductor pollicis brevis and flexor pollicis brevis (via the recurrent motor branch). LOAF is a useful mnemonic when recalling these intrinsic muscles. A median nerve lesion proximal to the carpal tunnel is most likely given that thenar sensation is reduced. The palmar cutaneous branch of the median nerve (purely sensory) arises 5cm proximal to the proximal wrist crease. It travels between the flexor carpi radialis (FCR) and palmaris longus tendons and crosses the wrist superficial to the transverse carpal ligament.

Pronator syndrome is a rare compressive neuropathy but should be considered when median nerve symptoms present without the classic symptoms of carpal tunnel syndrome (e.g. diurnal variation). Neurophysiological testing is often normal in pronator syndrome and the diagnosis is usually one of exclusion. The most common neuropathy in the upper limb is carpal tunnel syndrome and diurnal variation is a common distinguishing feature. Isolated median nerve sensory disturbance (including the thenar skin) is classically described for pronator syndrome. Provocative tests include

resisted forearm pronation with the elbow extended, resisted middle finger flexor digitorum superficialis (FDS) flexion, and deep palpation (or a Tinel response) along the leading edge of pronator teres with the forearm held in maximal supination (Mackinnon and Novak 2016). Well-developed forearm musculature is a risk factor. Multiple areas of median nerve entrapment are described. Elbow radiographs to exclude a rare supracondylar humeral process (and ligament of Struthers) are required. If splintage and activity modification fail, surgical decompression of the median nerve should be considered: release of the bicipital aponeurosis, the interval between the ulnar and humeral heads of pronator teres and the aponeurotic arch of the FDS.

Although a median nerve schwannoma could account for the sensory disturbance described, normal MR imaging and no mention of a mass lesion make this diagnosis unlikely. Wartenberg's syndrome (known as *cheiralgia paraesthetica*) is a compressive neuropathy of the superficial radial nerve between the tendons of brachioradialis and extensor carpi radialis longus (ECRL) during pronation. Intersection syndrome is tenosynovitis between the first and second extensor compartments that is most often associated with repetitive wrist extension, for example in rowers. Although not listed, a cervical radiculopathy should be excluded with an MRI.

Mackinnon SE, Novak CB. Compression neuropathies. In Wolfe SW, Pederson WC, Kozin SH, Cohen MS, ed. *Green's Operative Hand Surgery*, 7th Ed., 921–958. New York: Elsevier Churchill Livingstone; 2016.

12. Answer D. **Clinical diagnosis, confirmed with nerve conduction studies, is the gold standard**
Cubital tunnel syndrome is a common compressive neuropathy in the upper limb, surpassed only by carpal tunnel syndrome. This patient presents with clawing, presumably of the ring and little fingers, which is an advanced feature of ulnar neuropathy. Diagnosis is a clinical one, although neurophysiological assessment may be performed to confirm the diagnosis (Mackinnon and Novak 2016). The surgeon must exclude a cervical radiculopathy (e.g. MRI cervical spine) and amyotrophic lateral sclerosis (neurophysiology). Amyotrophic lateral sclerosis (motor neurone disease) should be suspected when severe motor loss is associated with minimal sensory changes.

The ligament of Struthers is found on the medial aspect of the elbow and associated with a supracondylar humeral process. It is a potential site for median nerve compression and it should not be confused with the *arcade* of Struthers, which is a potential site of ulnar nerve compression at the elbow. The Martin–Gruber anastomosis relates to a normal variant motor branch of the median nerve joining the ulnar nerve, most commonly in the forearm, and its presence will not affect the outcome of surgical decompression. The ulnar paradox relates to the severity of claw deformity being more severe with distal ulnar nerve lesions (due to the preserved flexor activity of FDP to the ring and little fingers). Flexor digitorum superficialis (FDS) is innervated by the median nerve.

Mackinnon SE, Novak CB. Compression neuropathies. In Wolfe SW, Pederson WC, Kozin SH, Cohen MS, ed. *Green's Operative Hand Surgery*, 7th Ed., 921–958. New York: Elsevier Churchill Livingstone; 2016.

13. Answer B. **Flexor tendon tenodesis (FDS sling)**
Swan neck deformity is described in this clinical scenario. It is a common feature of rheumatoid arthritis affecting the hand and may coexist with boutonnière deformity in adjacent digits. Although inflammatory arthropathy is the commonest cause, swan neck deformity may result from intrinsic tightness secondary to MCPJ disease, FDS rupture, volar plate insufficiency, mallet deformity or extrinsic spasticity (McKeon & Lee 2015; Dickson & Harrison 2017).

Both swan neck and boutonnière deformities represent an imbalance between flexor and extensor forces. In rheumatoid arthritis, swan neck deformity can originate at either the DIPJ (following a mallet deformity) or at the PIPJ (secondary to synovitis and volar plate/capsule attenuation and/or FDS rupture).

Flexor tendon tenodesis using the FDS tendon (the 'sublimis sling') can be used to provide a soft tissue checkrein to correct PIPJ hyperextension. Other surgical options include oblique retinacular ligament reconstruction, lateral band mobilisation and, for end-stage disease (with

pain and stiffness), PIPJ arthrodesis (Dickson & Harrison 2017). Cases driven by a mallet deformity may be treated with DIPJ arthrodesis alone or combined with a PIPJ procedure.

Passive PIPJ correction with an Oval-8 (or Silver Ring) splint is an effective conservative treatment in patients with a correctible swan neck deformity; however, the featured case has failed conservative treatment. Extensor tenotomy over the middle phalanx is a treatment for DIPJ hyperextension seen in boutonnière deformity, not swan neck deformity.

Dickson DR, Harrison JWK. (2017). Hand oral core topics. In Banaszkiewicz PA, Kader DF, ed. *Postgraduate Orthopaedics*, 3rd Ed., 421–494. Cambridge: Cambridge University Press; 2017.

McKeon KE, Lee DH. Posttraumatic boutonnière and swan neck deformities. *J Am Acad Orthop Surg.* 2015;**23**:623–632.

14. Answer B. **Intravenous antibiotics and elevation**
Hand infections can result in severe disability and should be taken seriously. Intravenous broad-spectrum antibiotics should be commenced without delay. Plain radiographs will help exclude a retained foreign body or fracture. Pyogenic flexor tenosynovitis is an infection of the flexor tendon sheath, which usually results from penetrating trauma. The flexor sheaths are closed spaces and increased pressure from purulence will create tendon adhesions (leading to stiffness) and obstruct the vincula arterial system (a cause of tendon necrosis). It should be noted that there is potential for communication between the thumb and little finger flexor sheaths via the space of Parona (horseshoe abscess). Although *Staphylococcus aureus* remains the most common organism (up to 80%), animal (dog and cat) and human bites are often polymicrobial, with *Pasteurella* species and *Eikanella corrodens* proving common isolates, respectively (Flevas et al. 2019).

Although not all signs may be present in the early stages, Kanavel (1921, 1939) described four cardinal features of pyogenic flexor tenosynovitis:

- Semi-flexed digit.
- Fusiform digital swelling.
- Tenderness along the flexor tendon sheath.
- Pain on passive digital extension (diffuse and not localised to a particular joint).

Acute, mild presentations in the absence of a clear history of penetrating trauma may be managed in the first 24 hours with a trial of antibiotics and strict high elevation in a Bradford-type sling. Frequent serial examinations are essential and there should be a very low threshold for operative intervention. If conservative treatment does not realise clinical improvement within 12 or so hours (or if the presentation is severe or delayed) prompt surgical irrigation with normal saline via a two-incision technique will prevent tendon necrosis and long-term disability (Flevas et al. 2019). The featured case will require prompt irrigation (as animal bites are considered contaminated wounds); however, the *initial* management should prioritise intravenous broad-spectrum antibiotics and elevation. Dorsal-blocking splintage may be considered.

The two-incision technique utilises a proximal incision just proximal to the A1 pulley and a second incision at the DIPJ flexor crease, which permits access to the tendon sheath so that antegrade catheter irrigation can occur from proximal to distal (Carter et al. 1969). An alternative single midlateral incision technique to expose the entire tendon sheath is usually reserved for severe infection with tendon necrosis.

Differential diagnoses include cellulitis, septic arthritis, local abscess (e.g. felon), inflammatory arthropathy (e.g. rheumatoid arthritis, gout) or aseptic tenosynovitis.

Carter SJ, Burman SO, Mersheimer WL. Treatment of digital tenosynovitis by irrigation with peroxide and oxytetracycline: review of nine cases. *Ann Surg.* 1966;**163**:645–650.

Flevas DA, Syngouna S, Fandridis E, Tsiodras S, Mavrogenis AF. Infections of the hand: an overview. *EFFORT Open Rev.* 2019;**4**:183–193.

Kanavel A. *Infections of the Hand*, 4th Ed. Philadelphia, PA: Lee & Febiger; 1921.

Kanavel A. *Infections of the Hand*, 7th Ed. Philadelphia, PA: Lee & Febiger; 1939.

15. Answer C. **Scaphoid-trapezium-trapezoid (STT) fusion**
The scenario is describing static scapholunate (SL) dissociation. This is a difficult scenario to manage. There is no significant arthritis, but this

phase is associated with irreducible carpal malalignment with normal cartilage. Arthroscopy will reveal fibrosis and deformation of the joint surfaces due to fixed malalignment, but no cartilage damage. Plain radiographs will show fixed SL diastasis on the PA view and an increased SL angle on the lateral view (>60°). Irreducible malalignment means that the normal biomechanics of the wrist will never be restored. The best treatment options are those that maintain some range of motion while reducing pain.

With dynamic or reducible SL instability, options include SLIL reconstruction with the modified Brunelli (three-ligament tenodesis) technique. The development of scapholunate advanced collapse (SLAC) degenerative arthritis occurs in stages (1–4). Radial styloidectomy may be suitable for early or stage 1 SLAC. Options D and E can be considered for stage 4 (end-stage) SLAC osteoarthritis.

Konopka G, Chim H. Optimal management of scapholunate ligament injuries. *Orthop Res Rev.* 2018;**6**:41–54.

16. Answer B. **Homodigital neurovascular island flap**

Small fingertip defects (<1.5cm) are often left to heal by secondary intention with the aid of semi-occlusive dressings and the avoidance of surgical treatment.

Restoration of sensation is important in this case and thus options A, D and E are less appropriate. The standard cross finger flap (option A) risks digital stiffness, does not provide sensate soft tissue cover and is usually reserved for more proximal digital defects.

For finger pulp defects with exposed tendon or bone greater than 1.5–2cm, direct homodigital neurovascular island flaps are useful. Examples include extended Segmüller, modified Venkataswami, or pivot flaps. These are good choices because they preserve sensation. It is important to avoid tension on the nail bed to prevent a hook nail deformity.

Adani R, Tang JB, Elliot D. Soft and tissue repair of the hand and digital reconstruction. *J Hand Surg Eur.* 2021;**47**:89–97.

17. Answer B. **EIP to EPL tendon transfer**

Extensor pollicis longus (EPL) tendon rupture may complicate distal radius fractures. The accepted overall incidence is 0.07–0.88%, usually occurring 1–3 months following injury (Benson et al. 2006). Up to 5% of non-displaced fractures managed in a cast will experience EPL rupture (Roth et al. 2012).

Minimally or non-displaced fractures have an increased incidence when compared with markedly displaced fractures. It has been suggested that extravasation of blood and fracture debris into the third extensor compartment causes relative tendon ischaemia and attritional rupture. In fractures managed with volar plate fixation, EPL attrition may result from prominent dorsal screw tips (with Lister's tubercle sometimes masking screw tips with standard fluoroscopic techniques).

Extensor indicis proprius (EIP) to EPL tendon transfer is the most common treatment strategy. The three-incision technique requires the EIP tendon to be identified through an incision just proximal to the index finger MCPJ (EIP is identified ulnar to EDC). It is incised and retracted subcutaneously through a second incision at the wrist. The freed EPL tendon is passed subcutaneously and attached to the EPL through a longitudinal incision at the level of the thumb metacarpal. It is commonplace to tension and secure the tendons using a Pulvertaft weave technique.

Direct primary repair is not usually possible (option D). Option E would not be appropriate due to the lack of interphalangeal extension. The deficit is unlikely to be secondary to posterior interosseous nerve dysfunction (option C) as the hand otherwise examines normally. Some patients will adapt and choose to live with the symptoms and avoid surgical correction.

Benson EC, DeCarvalho A, Mikola EA, Veitch JM, Moneim MS. Two potential causes of EPL rupture after distal radius volar plate fixation. *Clin Orthop Relat Res.* 2006;**451**:218–222.

Roth KM, Blazar PE, Earp BE, Han R, Leung A. Incidence of extensor pollicis longus tendon rupture after nondisplaced distal radius fractures. *J Hand Surg.* 2012;**37**:942–947.

18. Answer D. **Cast with thumb free and MRI within next 2 weeks**

The scenario presents with an index of suspicion of an undisplaced scaphoid fracture. This is best demonstrated via a magnetic resonance imaging

Table 19.2 Methods for identifying scaphoid fractures

Modality	Sensitivity (%)	Specificity (%)
Radiographs	91.1	99.8
CT	85.2	99.5
MRI	97.7	99.8

(MRI) scan. If she does have an undisplaced fracture, the provision of cast immobilisation starts treatment and reduces the risk of displacement and delayed or non-union. The evidence does not support including the thumb in the cast (the 'scaphoid cast') as the rates of union are unchanged (Clay et al. 1991). The featured radiographs are normal and are ulnar deviated posteroanterior (PA) and lateral views.

MRI has a much higher sensitivity for identifying scaphoid fractures when compared with repeat radiographs or CT. MRI is also supported by NICE guidance for when a scaphoid fracture is suspected (NICE 2016).

Clay NR, Dias JJ, Costigan PS, Gregg PJ, Barton NJ. Need the thumb be immobilised in scaphoid fractures? A randomised prospective trial. *J Bone Joint Surg Br.* 1991;**73**:828–832.

Dias JJ et al. Acute scaphoid fractures: making decisions for treating a troublesome bone. *J Hand Surg Eur.* 2022;**47**:73–79.

National Institute for Health and Care Excellence. NICE Guideline 38. Fractures (non-complex): assessment and management; 2016. https://www.nice.org.uk/guidance/ng38/chapter/recommendations.

Yin ZG, Zhang JB, Kan SL, Wang XG. Diagnostic accuracy of imaging modalities for suspected scaphoid fractures: meta-analysis combined with latent class analysis. *J Bone Joint Surg Br.* 2012;**94**:1077–1085.

19. Answer B. **Proximal interphalangeal joint fusion**

The three principal drivers of a digital swan neck deformity are neglected mallet deformity, PIPJ volar plate injury or loss of flexor digitorum profundus (FDS). Whilst initially such deformities will be supple and passively correctable, rigidity can develop over time. One can consider soft tissue procedures when the deformity is correctable. Once rigid, bony procedures such as fusion are considered most appropriate. With poor soft tissues or rigid deformity, a silastic implant would not be appropriate. The Zancolli lasso procedure is a management option for claw hand (ulnar nerve dysfunction) and is not a treatment for swan neck deformity.

20. Answer E. **1: 5**

Dorsal wrist ganglions account for 50–60% of all hand and wrist ganglions. A meta-analysis in 2015 identified that the mean recurrence rate following open surgical excision was 21%, which compared with a recurrence rate of 59% for aspiration alone (Head et al. 2015). When counselling patients it is important to reference the high rates of recurrence associated with both treatments. The rate of recurrence is minimised when the ganglion is excised with its pedicle (dorsal wrist ganglia originate from the dorsal scapholunate ligament, which must be protected) and a small cuff of the surrounding wrist capsule (the cuff need not be closed).

Surgeons and patients must balance the relative merits of surgical excision for this benign condition. Many centres are avoiding surgical intervention altogether, unless intrusive pain or frequent functional deficit is described. It should be noted that Dias et al. (2007) reported the persistence of pain in more than a third of dorsal wrist ganglia treated with excision, and that around 40% of untreated dorsal wrist ganglia will resolve spontaneously within 5 years (Dias et al. 2007). In summary, non-operative treatment and reassurance is a very reasonable option.

Dias JJ, Dhukaram V, Kumar P. The natural history of untreated dorsal wrist ganglia and patient reported outcome 6 years after intervention. *J Hand Surg Eur.* 2007;**32**:502–508.

Head L, Gencarelli JR, Allen M, Boyd KU. Wrist ganglion treatment: systematic review and meta-analysis. *J Hand Surg Am.* 2015;**40**:546–553.e8.

21. Answer B. **Proximal row carpectomy**

The patient has avascular necrosis of the lunate, also known as Kienböck disease. Kienböck disease has a multifactorial aetiology (Lichtman et al. 2010). Ulnar negative variance is considered a risk factor, especially when compared with ulnar positive variance, with increased radio-lunate contact stresses described. The relationship between the lunate's coronal shape and ulnar length suggests that type I (trapezoid) lunates

(which coexist with ulnar negative variance) have the weakest configuration and the greatest potential for fatigue compared with the rectangular or pentagonal morphology of type II and III lunates, respectively (Antuna Zapico 1966). Three vascular anastomotic variants are described: Y pattern (59%), I pattern (31%) and X pattern (10%) (Gelberman et al. 1980). The I pattern represents a single vessel to the lunate and is considered at highest risk. Repetitive trauma and vascular disease are also risk factors.

The Lichtman classification describes four stages of Kienböck disease and may help guide management (Lichtman et al. 2010). It is graded according to plain radiographic (and magnetic resonance imaging) appearances. The featured case has stage IIIB disease, when lunate flattening or collapse is associated with scaphoid flexion. Distinguishing between stages IIIA and IIIB is important when planning treatment: stage IIIA has maintained carpal alignment and height, and stage IIIB has carpal rotation (scaphoid flexion) and proximal migration of the capitate. Stage IIIB disease is treated with partial fusions of the scaphocapitate or scaphoid-trapezium-trapezoid (STT) joints or proximal row carpectomy. Proximal row carpectomy (scaphoid, lunate and triquetrum) is appropriate if the lunate fossa is preserved: removal of the proximal carpal row will permit the capitate head to articulate with the lunate fossa and preserve some wrist motion. In stages I, II and IIIA, treatment options include capitate shortening (off-loading), radial shortening osteotomy (off-loading), distal radius core decompression (indirect revascularisation) or vascularised bone grafting (direct revascularisation).

Stage I is characterised by normal plain radiographs; however, MRI will demonstrate decreased signal intensity on both T1- and T2-weighted images. Radionuclide bone scanning will also be positive. Such cases are treated with a period of immobilisation. Stage II will show sclerosis but no lunate collapse, although multiple fracture lines may be visible. Such cases are often managed with a joint-levelling procedure (e.g. radial shortening osteotomy). Ulnar lengthening is less commonly performed as it requires two osteotomy sites and bone graft. The aim of such procedures is to offload the lunate to achieve neutral or slight ulnar negative variance. Stage IV represents perilunate arthritis and surgical options include denervation, total wrist replacement or wrist arthrodesis.

Antuna Zapico JM. Malacia del Semilunar. Tesis doctoral, Industrias y Editorial Sever Cuesta. Valladoid, Espana: Universidad de Valladoid; 1966.

Gelberman RH, Baumann TD, Menon J, Akeson WH. The vascularity of the lunate bone and Kienbock's disease. *J Hand Surg Am.* 1980;**5**:272–278.

Lichtman DM, Lesley NE, Simmons SP. The classification and treatment of Kienböck's disease: the state of the art and a look at the future. *J Hand Surg Eur.* 2010;**35**:549–554.

22. Answer E. **Ulna shortening osteotomy**

Ulnar impaction syndrome (also called ulnocarpal abutment) is seen with ulnar positive variance. It is one of the many causes of ulnar-sided wrist pain. The power grip can increase ulnar variance by 2mm, especially during pronation (Adams 2011), and pronated and/or power grip plain radiographs may identify a dynamic increase in ulnar variance. In cadaveric studies, a 2.5mm increase in ulnar variance is associated with a 42% increase in ulnocarpal loading (Palmer & Werner 1988).

In cases of ulnar impaction syndrome, the proximal and ulnar aspect of the lunate will often demonstrate subchondral sclerosis on MRI, with decreased signal intensity on both T1- and T2-weighted images. On occasions, high signal on T2-weighted images may be seen, representing bone oedema. Degeneration of the triangular fibrocartilage complex (TFCC) is a frequent association.

Distal radius (shortening) osteotomy with plate fixation is an option to achieve neutral or slight ulnar negative variance (not provided in the question).

An ulna shortening osteotomy preserves the articular cartilage and is suitable for most cases of ulnar positive variance. In cases secondary to distal radius malunion with up to 20° of dorsal angulation, joint-levelling with an isolated ulnar shortening osteotomy is a quicker and technically less demanding alternative with equivalent outcomes (Srinivasan et al. 2013). It is achieved using an oblique segmental resection and compression plating. The dorsal sensory branch of the ulnar nerve is at risk during the approach.

The arthroscopic wafer procedure is an alternative, which resects 2–4mm of distal ulna from beneath the TFCC. However, the wafer procedure removes the ulna articular cartilage and can destabilise the TFCC and distal radioulnar joint (DRUJ). Option A is incorrect as stabilisation is not indicated. Additionally, arthroscopic debridement is unlikely to provide long-term relief.

The Sauvé-Kapandji procedure, ulna head resection (Darrach procedure) and ulna head replacement are generally reserved for cases of DRUJ arthritis. The Darrach procedure is most often reserved for low demand, elderly patients due to the risk of stump instability and painful impingement. Ulna head replacement may fail in a manual labourer. The ballottement (or piano key) test assesses for pain and/or increased ulna head sagittal translation relative to the radius, and a positive test suggests DRUJ instability.

Adams BD. Distal radioulnar joint instability. In Wolfe SW, Hotchkiss RN, Pederson WC, Kozin SH, ed. *Green's Operative Hand Surgery*, Vol. 1, 6th Ed., 465–522. New York: Elsevier Churchill Livingstone; 2011.

Palmer AK, Werner FW. Biomechanics of the distal radioulnar joint. *Clin Orthop Relat Res.* 1984;**187**:26–35.

Srinivasan RC et al. Isolated ulnar shortening osteotomy for the treatment of extra-articular distal radius malunion. *J Hand Surg Am.* 2013;**38**:1106–1110.

23. Answer D. **The condition is often self-limiting**
The featured patient is most likely presenting with tenosynovitis of the first extensor compartment, known as de Quervain's tenosynovitis. This is a clinical diagnosis. Dorsoradial tenderness and local swelling 1–2cm proximal to the radial styloid combined with pain upon ulnar deviation of the wrist with the thumb clasped in the palm (Eichhoff's test) or pulled by the clinician (Finkelstein's test) is diagnostic.

Irritation of the abductor pollicis longus (APL) and extensor pollicis brevis (EPB) tendons as they pass through their short osseoligamentous tunnel (approximately 2cm) is common in the fifth and sixth decades of life and is up to six-times more common in females. It must be distinguished from other common causes of radial-sided wrist pain in this age group, including 1st CMC and scaphoid-trapezium-trapezoid (STT) joint osteoarthritis. Therefore, the most useful investigation at first presentation is plain radiography to exclude alternative causes of pain. The intersection syndrome between the tendons of the first and (underlying) second extensor compartments is far less common, with pain (and occasionally crepitus) experienced more proximally.

Management should begin with activity modification, analgesia (oral and/or topical) and wrist splintage. Cortisone injection is an effective second-line treatment option (with or without ultrasound guidance), especially in those with acute presentations and non-diabetics, with 50–80% success after one or two injections (Weiss et al. 1994). Patients should be advised of the risks of injection, which include infection, fat necrosis and skin depigmentation. Anatomic variation is a common cause of treatment failure and 'normal' anatomy consisting of two tendons and one tendon sheath may occur in fewer than 20% of cases (Jackson et al. 1986). The APL tendon is often comprised of several tendon slips and a separate EPB tendon subsheath may be seen.

Surgical decompression is reserved for refractory cases. The tendons of the first extensor compartment should be identified and fully decompressed: inspect for a separate EPB subsheath and release the septa. Identify and carefully retract the terminal branches of the superficial radial nerve to avoid iatrogenic injury. The radial artery is also at risk. Incise the sheath on its dorsal margin to prevent painful palmar subluxation of the tendons.

Jackson WT et al. Anatomical variations in the first extensor compartment of the wrist: a clinical and anatomical study. *J Bone Joint Surg Am.* 1986;**68**:923–926.

Weiss AP, Akelman E, Tabatabai M. Treatment of de Quervain's disease. *J Hand Surg Am.* 1994;**19**:595–598.

24. Answer B. **2.5mg/kg of bupivacaine 0.5% with adrenaline (1:200,000)**
Knowledge of the maximum doses for commonly used local anaesthetics is essential. Adrenaline (1:100,000 or 1:200,000) may be used for carpal tunnel decompression with the aim of

avoiding a painful tourniquet. Adrenaline 1:10,000 is incorrect and is the intravenous concentration used in cardiac arrest.

It is important to commit to memory that a 1% solution (e.g. lidocaine) contains 10mg of solute (the active ingredient) per millilitre of solution (10mg/ml). Therefore a 0.5% solution (e.g. bupivacaine) contains 5mg of solute per millilitre of solution (5mg/ml).

The maximum safe doses of commonly used local anaesthetics:

Bupivacaine 0.5%	2mg/kg
Bupivacaine 0.5% with adrenaline	2.5mg/kg
Lidocaine 1%	3mg/kg
Lidocaine 1% with adrenaline	7mg/kg

Plain lidocaine and bupivacaine provide 2–4 hours and 4–12 hours of local anaesthesia, respectively.

25. Answer D. **Midcarpal carpal instability**
Unlike radiocarpal instability, midcarpal instability may not be associated with a history of wrist trauma and hypermobile patients are at particular risk. Midcarpal instability is a type of non-dissociative carpal instability. Dissociative carpal instability represents instability *within* or between bones of the same carpal row (e.g. DISI, VISI).

The midcarpal shift (or catch-up clunk) test assesses for midcarpal instability (Feinstein et al. 1999). In midcarpal instability secondary to hypermobility, ulnar deviation causes the capitate to sublux dorsally over the scapholunate socket. Reactive contraction of the wrist extensors causes the distal carpal row to relocate abruptly with a clunk. Anterior and posterior drawer testing of the midcarpal joint can also assess for midcarpal instability.

Surgery should be avoided when managing midcarpal instability secondary to hypermobility. Conservative treatment consists of analgesia, splintage, activity modification and physiotherapy concentrating on proprioceptive control. Traumatic midcarpal instability in those without hypermobility is most commonly managed non-operatively; however, dorsal capsular reefing or limited midcarpal arthrodesis (e.g. lunocapitate) may be used for severe or refractory cases.

Feinstein WK, Lichtman DM, Noble PC, Alexander JW, Hipp JA. Quantitative assessment of the midcarpal shift test. *J Hand Surg Am.* 1999;**24**:977–983.

26. Answer A. **Full thickness skin graft**
This tissue defect requires coverage. Split-thickness skin grafts are avoided on the palmar surface of the hand due to high rates of contraction and low sensibility. Full thickness skin grafts contract less due to the presence of dermis. They also contain more epidermal appendages (including hair follicles, sweat glands and mechanoreceptors) and provide superior sensibility. Hence, they are preferred on the palmar aspect of the hand (Matsui et al. 2014). The glabrous skin (devoid of hair follicles) of the volar or medial forearm, antecubital fossa, groin crease and abdomen are the preferred donor sites.

The reconstructive ladder for tissue defects in the hand presents the options from the simplest to the most complex:
- Primary wound healing
- Healing by secondary intention
- Skin graft (split, full thickness)
- Flap (local, distant or free)

Full-thickness grafts must be meticulously defatted (to permit capillary ingrowth) and be immobilised and undisturbed for 10–14 days.

For skin grafts of all varieties, the recipient bed must be uncontaminated, free from infection and not have exposed tendon, bone or nerve present. Skin flaps include a vascular attachment and are used to cover exposed nerves and areas of bone lacking periosteum and tendon without peritenon (composed of the paratenon and epitenon). Split-thickness skin grafts are preferred on the dorsum of the hand. They can be meshed to increase the surface area and to permit the drainage of blood and serum which could otherwise compromise graft survival.

Negative pressure (or vacuum-assisted) wound therapy facilitates granulation and healing through the promotion of angiogenesis and cellular proliferation, wound contraction, oedema reduction and toxic exudate removal (Matsui et al. 2014). It can be used to expedite secondary wound healing and act as a bridge for staged reconstructive procedures. The preferred

definitive treatment for the featured case would be a full thickness skin graft.

Matsui J, Piper S, Boyer MI. Nonmicrosurgical options for soft tissue reconstruction of the hand. *Curr Rev Musculoskelet Med.* 2014;**7**:68–75.

27. Answer E. **Ulnar deviation of the carpus**
This patient presents with rheumatoid disease, a chronic autoimmune disease characterised by synovial joint destruction and multi-system involvement. A hallmark feature is synovial joint pannus formation, a fibrovascular tissue characterised histologically by prominent intimal hyperplasia.

The classical appearance of the rheumatoid hand includes any combination of digital swan neck and boutonnière deformities, triggering, rheumatoid nodules, ulnar deviation of the digits, radial deviation of the carpus and Z-deformity (e.g. boutonnière) of the thumb (classified according to Nalebuff). Advanced disease may be further complicated by attritional rupture of the flexor pollicis longus tendon (Mannerfelt syndrome) or sequential rupture of the extensor tendons, from ulnar to radial, starting with extensor digiti minimi (Vaughan–Jackson syndrome). Splenomegaly and neutropenia are features of Felty's syndrome, a rare complication of rheumatoid disease.

Anti-cyclic citrullinated peptide (anti-CCP) antibody testing is useful in the diagnosis of rheumatoid arthritis. It is present early in the disease process, has a high specificity (90%) and can help identify patients most at risk of severe disease with irreversible damage (Lee and Schur 2003). However, it has low sensitivity (66%) and only 25–50% of rheumatoid patients test positive. Rheumatoid factor (RF) is an IgM antibody that targets native IgG, forming an immune complex that is deposited in the tissues. RF has a sensitivity and specificity of 71% and 80%, respectively.

Lee DM, Schur PH. Clinical utility of the anti-CCP assay in patients with rheumatic diseases. *Ann Rheum Dis.* 2003;**62**:870–874.

28. Answer A. **Broad-spectrum antibiotics and tetanus prophylaxis**
Although this patient requires urgent irrigation and debridement, the question asks for the first step and this has to be option A. High-power injections are potentially devastating injuries, with all except the injection of air and water requiring urgent open irrigation and debridement. For toxic substances, including grease, paint and solvents, immediate decompression with irrigation and removal of foreign material is indicated. Injected material travels along planes of least resistance (including neurovascular planes) up into the forearm and the debridement of foreign material and soft tissue necrosis is essential. Amputation rates are high and debridement within 6 hours is advised (Amsdell and Hammert 2013). Those managed non-operatively should be observed for signs of compartment syndrome.

Amsdell SL, Hammert WC. High-pressure injection injuries in the hand: current treatment concepts. *Plast Reconstr Surg.* 2013;**132**:586e-91e.

29. Answer A. **Clenched fist anteroposterior (AP)**
Plain radiographs remain the standard initial imaging technique for suspected scaphoid fractures. However, 30–40% of scaphoid fractures will not be identified on initial four-view radiographs (Duckworth et al. 2011). The following four radiographic scaphoid views should be obtained (Rubin and Dalinka 2005):

- Posteroanterior (PA)
- PA with ulnar deviation
- Semi-pronated oblique
- Lateral

Alternative radiographic views include the semi-supinated oblique and the Ziter (oblique ulnar deviation) view. If early four-view radiographs appear normal despite the clinical suspicion of a scaphoid fracture, a repeat clinical and radiographic assessment may be performed at 10–14 days post-injury; however, MRI is the gold standard for equivocal cases (Smith et al. 2010). Scaphoid fracture displacement (and non-union) is best assessed and quantified using computed tomography (CT) imaging (Smith et al. 2010).

The clenched fist PA view is reserved for assessment of dynamic scapholunate instability, as seen with complete tears of the scapholunate interosseous ligament (SLIL). Traumatic dorsal wrist pain with tenderness over the scapholunate interval (just distal to Lister's tubercle) would be an indication for this view if the PA wrist

radiograph is inconclusive; however, this view is unlikely to prove useful in acute SLIL injuries when the secondary ligamentous stabilisers remain intact (so-called pre-dynamic instability).

Duckworth AD, Ring D, McQueen MM. Assessment of the suspected fracture of the scaphoid. *J Bone Joint Surg Br.* 2011;**93**:713–719.

Rubin DA, Dalinka RH. Expert Panel on Musculoskeletal Imaging. Acute Hand and Wrist Trauma [online publication]. Reston, VA: American College of Radiology (ACR); 2005.

Smith M, Bain GI, Turner PC, Watts AC Review of imaging of scaphoid fractures. *ANZ J Surg.* 2010;**80**:82–90.

30. Answer D. **Internal fixation via dorsal approach**
Fractures of the scaphoid are the most common of all carpal fractures. The injury is most often seen in young, active men. Fractures occur most frequently at the scaphoid waist, with proximal pole fractures (those occurring in the proximal 20%) comprising just 5% (Dias et al. 2022). Although cast immobilisation is acceptable for undisplaced waist and distal pole fractures, acute fixation is preferred for proximal pole fractures to reduce the risks of non-union and avascular necrosis (Suh & Grewal 2018). Approximately 34% of proximal pole fractures managed in a cast will progress to non-union.

The blood supply is easily disrupted in proximal pole fractures due to the retrograde blood supply. Gelberman and Menon (1980) confirmed the major blood supply to be from the radial artery, with a collateral supply from the anterior interosseous artery. Up to 75% of the vascularity (and all of the proximal pole) is provided by branches of the dorsal carpal branch, which enters via the dorsal ridge. The remaining 25% originates from the volar radial artery branches, which enter distally via the tubercle.

Proximal pole fractures are often approached dorsally (especially when displaced) to enable reduction under direct vision and to facilitate interfragmentary compression. Headless compression screw placed along the scaphoid's central longitudinal axis is the established fixation technique. The dorsal approach utilises the interval between the 3rd extensor compartment (extensor pollicis longus) and the 4th (extensor digitorum communis and extensor indicis). Care must be taken to preserve the dorsal ridge blood supply during dissection.

Dias JJ et al. Acute scaphoid fractures: making decisions for treating a troublesome bone. *J Hand Surg Eur.* 2022;**47**:73–79.

Gelberman RH, Menon J. The vascularity of the scaphoid bone. *J Hand Surg.* 1980;**5**:508–513.

Suh N, Grewal R. Controversies and best practices for acute scaphoid fracture management. *J Hand Surg Eur.* 2018;**43**:4–12.

31. Answer B. **Lateral band**
Dupuytren's disease is a benign fibroproliferative disease of the palmar and digital fascia that is characterised by subcutaneous cords and nodules and progressive flexion deformities. The ring finger is most often affected. The lateral bands are not implicated in Dupuytren's disease and are part of the extensor expansion (the conjoined lateral bands insert into the distal phalanx as the terminal extensor tendon). Normal fascial bands in the hand are termed cords when affected by Dupuytren's disease.

MCPJ flexion is caused by the central cord, which is comprised of the distal pretendinous cord. PIPJ flexion is caused by the spiral cord, which is comprised of four separate fascial structures (from proximal to distal): pretendinous band, spiral band, lateral digital sheet and Grayson's ligament. The spiral cord moves the digital neurovascular bundle both superficial and towards the midline and should be considered during fasciectomy to correct a PIPJ contracture due to the risk of injury. DIPJ contracture is caused by the retrovascular cord.

32. Answer A. **Carpal tunnel decompression is usually required**
The imaging confirms a trans-scaphoid perilunate dislocation: the lunate is articulating with the radius but the distal carpal row has dislocated dorsally. This devastating injury is associated with high-energy trauma. Median nerve sensory dysfunction is common and is an indication for emergency closed reduction with or without carpal tunnel decompression. Closed reduction requires prolonged longitudinal traction, followed by volar lunate pressure whilst the wrist is moved from extension through to flexion. Alternative reduction techniques may utilise

traction with finger traps. When lunate dislocations are associated with a scaphoid fracture, the scapholunate interosseous ligament (SLIL) is expected to remain intact (the energy bypasses the SLIL) and the lunotriquetral interosseous ligament (LTIL) will fail.

Surgical management is usually indicated, which comprises (1) lunate reduction (closed +/− open), (2) scaphoid fixation, (3) likely volar LTIL repair (through an extended carpal tunnel approach, option A), and (4) K-wire transfixation (buried and subsequently removed at 8–10 weeks). The carpal tunnel approach provides both access to the volar LTIL and a therapeutic decompression of the carpal tunnel. The LTIL is usually avulsed and some surgeons advocate bone anchor repair.

The Mayfield classification of progressive perilunar injury (which progresses from radial to ulnar):

Mayfield	Stage I rupture of the scapholunate ligament.
Stage II	Stage I plus dislocation of the capitolunate joint.
Stage III	Stage II plus rupture of the lunotriquetral ligament (perilunate dislocation).
Stage IV	Lunate dislocation.

The Mayfield classes may be modified if fractures have occurred, for example in the featured case (Mayfield III) where the SLIL remains intact but the scaphoid has fractured instead.

In stage IV, the lunate dislocates palmar into the 'space of Poirier' (with loss of all its normal articulations) whilst the remaining carpal bones remain in longitudinal alignment with the radius. It is important to distinguish lunate dislocations from perilunate dislocations (Mayfield III), when the entire carpus dislocates relative to the lunate, with the capitate (the easiest to visualise) moving dorsal to the lunate (the lunate continues to articulate with the lunate fossa of the radius). Stage IV represents the additional rupture of the dorsal radiocarpal ligament.

33. Answer D. **Washout and tendon repair for lacerations greater than 50% of cross-sectional area**

Active FDS and FDP function is usually maintained in partial tendon lacerations. However, painful active digital flexion, new onset triggering or neurovascular deficits should raise suspicions for a partial tendon injury. Lacerations up to 50% of tendon cross-sectional area may be adequately managed with tendon debridement alone (al-Qattan 2000). Lacerations greater than 50% are often debrided and repaired with a running epitendinous suture to avoid gap formation or triggering (Haidar et al. 2009). The treatment of near complete tears is the same as that for complete lacerations, with core suture placement and a supplementary running epitendinous suture (Dy & Daluiski 2014). The oblique pulley of the thumb is important and it should be repaired or reconstructed when injured.

al-Qattan MM. Conservative management of zone II partial flexor tendon lacerations greater than half the width of the tendon. *J Hand Surg Am.* 2000;**25**:1118–1121.

Dy CJ, Daluiski A. Update on zone II flexor tendon injuries. *J Am Acad Orthop Surg.* 2014;**22**:791–799.

Haidar R, Harfouche B, Koudeih M. Trigger finger after partial flexor tendon laceration: two case reports and review of the literature. *J Hand Surg Eur.* 2009;**34**:690–691.

34. **Answer E. Surgical decompression may improve their symptoms**

The patient presents with classic symptoms of carpal tunnel syndrome (CTS). This condition is twice as common in females when compared with males and is most common in the sixth decade. CTS is usually idiopathic but is also linked to wrist trauma, inflammatory arthritis and pregnancy. Some patients with CTS will initially suggest that 'all fingers' are affected; however, further questioning will often identify that the little finger is rarely or least affected. Of course, true CTS will only affect the radial 3.5 digits.

Neurophysiology testing as a diagnostic tool for CTS varies widely, and those with classic symptoms and signs do not necessarily require testing (especially if there are prolonged delays for investigation). However, many surgeons appreciate the diagnostic confirmation (and a baseline severity grading) in case of suboptimal

surgical outcomes and for medico-legal reasons. Neurophysiological CTS grading, known as the Canterbury grade, ranges from normal (grade 0) to extremely severe (grade 6, unrecordable sensory and motor potentials) (Bland 2000). The grade may improve following decompression; however, unless mild, the grade does not often return to normal.

For patients with typical CTS signs and symptoms but normal neurophysiology, decompression is often associated with a significant improvement in symptoms (i.e. QuickDASH score); however, the expected degree of improvement is less when compared with those with positive neurophysiology (Mackenzie et al. 2020). Severe grades are less likely to experience complete symptom resolution; however, decompression is advisable to prevent progression of symptoms and irreversible thenar atrophy.

Pronator syndrome is a rare presentation. Even with normal neurophysiology, carpal tunnel syndrome is still a more likely cause of this patient's symptoms. Pronator syndrome is suggested by pain in the proximal volar forearm, sensory changes in the palmar cutaneous branch of the median nerve, and a positive Tinel over the proximal volar forearm.

Steroid injections into the carpal tunnel should be placed just ulnar to palmaris longus to avoid iatrogenic injury to the median nerve and its palmar cutaneous branch.

Bland JD. A neurophysiological grading scale for carpal tunnel syndrome. *Muscle Nerve* 2000;**23**:1280–1283.

Kamath V, Stothard J. A clinical questionnaire for the diagnosis of carpal tunnel syndrome. *J Hand Surg Br.* 2003;**28**:455–459.

Mackenzie SP et al. Carpal tunnel decompression in patients with normal nerve conduction studies. *J Hand Surg Eur.* 2020;**45**:260–264.

35. Answer E. **Four-strand core suture repair with early active mobilisation**

This patient has sustained a zone 2 flexor tendon injury, an area associated with a high risk of adhesion formation and stiffness. The tensile strength of the tendon repair is proportional to the number of core sutures, however a balance between strength and bulk is necessary. Four-strand core suture repair is recognised as a sound compromise (Dy & Daluiski 2014). Both FDS and FDP tendons are usually repaired in zone 2 unless gliding through the A2 pulley becomes compromised. In such cases the profundus tendon alone is repaired. A supplementary continuous epitendinous suture increases the tensile strength and minimises bulk and gap formation. To improve tendon excursion, evidence suggests that partial division of the A2 pulley (up to 50%) (Mitsionis et al. 1999) and A4 (up to 100%) (Franko et al. 2011) does not substantially increase the work of flexion. Meta-analysis suggests that the modified Kessler core suture technique is associated with less adhesion formation (Dy et al. 2012); however, other techniques remain very popular (e.g. cruciate, Strickland, Adelaide). Biomechanical studies support tendon purchase of 7–10mm (measured from the cut tendon end to the transverse suture) (Tang et al. 2005).

Knowledge of the flexor tendon anatomic zones is essential. Zone 5 runs from the forearm flexor musculotendinous junction to the proximal edge of the carpal tunnel. Zone 4 includes the tendons contained in the carpal tunnel. Zone 3 runs from the distal edge of the carpal tunnel to the proximal aspect of the A1 pulley. Zone 2 runs onward to the FDS insertion and zone 1 runs distal to the FDS insertion and includes only the FDP tendon.

In the acute setting, ultrasound assessment is not required as surgical exploration is required and tendon retraction will be minimal. If the proximal tendon cannot be identified at the zone of injury, a proximal incision, for example in the palm, can help identify and deliver the tendon end ready for repair. Flexor tendons repaired with a sound 4-strand core suture technique should be mobilised early (from 3–5 days post-repair) to avoid stiffness and adhesion formation.

Dy CJ, Daluiski A. Update on zone II flexor tendon injuries. *J Am Acad Orthop Surg.* 2014;**22**:791–799.

Mitsionis G et al. Feasibility of partial A2 and A4 pulley excision: Effect on finger flexor tendon biomechanics. *J Hand Surg Am.* 1999;**24**:310–314.

Franko OI et al. Quantification of partial or completeA4 pulley release with FDP repair in

cadaveric tendons. *J Hand Surg Am.* 2011;**36**:439–445.

Dy CJ, Hernandez-Soria A, Ma Y, Roberts TR, Daluiski A. Complications after flexor tendon repair: a systematic review and meta-analysis. *J Hand Surg Am.* 2012;**37**:543–551.

Tang JB, Zhang Y, Cao Y, Xie RG. Core suture purchase affects strength of tendon repairs. *J Hand Surg Am.* 2005;**30**:1262–1266.

36. Answer A. **Dorsal splintage (MCPJs flexed) and active flexion from day 4**

For sound flexor tendon repairs, early mobilisation improves strength and minimises adhesion formation and joint stiffness (Strickland 2000). Depending on patient compliance factors, the ideal time to commence digital motion is 3–5 days post-repair as the work of flexion is increased (due to resistance to motion) as a consequence of increasing tendon oedema over the first 4 days (Wu & Tang 2013). Rehabilitation should be guided by a hand therapist.

The amount of tendon excursion (or glide distance) to prevent adhesion formation is 1.7–3.5mm (Boyer et al. 2001). Although this can be achieved with passive rehabilitation protocols, active flexion confers additional mechanical strength (Kubota et al. 1996). 'Early active motion' (EAM) protocols are considered routine for sound zone 1 and 2 flexor tendon repairs (excluding FPL). A popular EAM regime is the Manchester 'short splint' regime, with the dorsal splint permitting unlimited wrist flexion and extension up to 45° (Peck et al. 2014). MCPJ extension is limited to 30°. Alternative EAM protocols utilise the traditional forearm-based dorsal splint and stipulate neutral wrist alignment, MCPJ flexion (around 30°) and space to permit full IPJ extension. Peck et al. (2014) compared the Manchester short splint with forearm-based dorsal splints for zone 2 repairs managed with early passive and active motion and demonstrated improved IPJ flexion arcs ($p<0.001$) with no increased risk of rupture. Regardless of protocol, the use of dorsal hand splintage is key to preventing excessive extension and repair site tension. Young children unable to adhere to protected rehabilitation protocols are usually immobilised for up to 4 weeks.

'Place and hold' rehabilitation combines active and passive flexion and utilises the digital tenodesis effect seen with wrist extension and flexion. It is popular for rehabilitating hand injuries, including fractures; however, it is now less frequently used for flexor tendon rehabilitation.

Boyer MI et al. Intrasynovial flexor tendon repair: an experimental study comparing low and high levels of in vivo force during rehabilitation in canines. *J Bone Joint Surg Am.* 2001;**83**:891–899.

Kubota H, Manske PR, Aoki M, Pruitt DL, Larson BJ. Effect of motion and tension on injured flexor tendons in chickens. *J Hand Surg Am.* 1996;**21**:456–463.

Peck FH et al. The Manchester short splint: A change to splinting practice in the rehabilitation of zone II flexor tendon repairs. *Hand Ther.* 2014;**19**:47–53.

Strickland JW. Development of flexor tendon surgery: twenty-five years of progress. *J Hand Surg Am.* 2000;**25**:214–235.

Wu YF, Tang J. Tendon healing, edema, and resistance to flexor tendon gliding: clinical implications. *Hand Clinics* 2013;**29**:167–178.

37. Answer B. **Peripheral ulnar tears risk DRUJ instability**

The triangular fibrocartilage complex (TFCC) is an important stabiliser of the distal radioulnar joint (DRUJ). It also transmits 20% of axial load across the neutral wrist and cushions the ulnar carpus. Although magnetic resonance (MR) imaging (with or without arthrography) is useful, wrist arthroscopy is the gold standard when diagnosing TFCC tears. The TFCC is commonly visualised through the 3/4 or 4/5 portals. Specific DRUJ portals can provide an assessment of the TFCC's undersurface and the ulnar 'foveal' insertion but this is technically challenging and rarely used.

The TFCC is comprised of the central articular disc, the dorsal and palmar radioulnar ligaments, a meniscus homologue, the ulnar collateral ligament, the ECU subsheath and the ulnolunate and ulnotriquetral ligaments (Palmer and Werner 1984). The microvascular supply resembles that of the menisci of the knee, with a rich peripheral supply (with healing potential) and an avascular centre.

Palmer described a classification system to help guide treatment. Traumatic (type I) tears and atraumatic or degenerative (type II) tears are further classified as A–D (related to location) or

A–E (additive pathology), respectively. The TFCC's deep ulnar insertion onto the ulna head (at the fovea) is an important component of DRUJ stability and traumatic tears at this site are often associated with DRUJ instability. Degenerative tears are synonymous with ulnar impaction syndrome (also termed ulnocarpal abutment). Treatment is based on injury location and chronicity. The central two-thirds of the central disc can be debrided with no adverse kinematic effects.

Palmer AK, Werner FW. Biomechanics of the distal radioulnar joint. *Clin Orthop Relat Res.* 1984;**187**:26–35.

38. Answer E. **Tendon transfer: split flexor digitorum superficialis (FDS) to digital extensor tendon**

Clawing of the fingers in ulnar nerve palsy is due to the combined paralysis of the interosseous muscles of all the fingers and the lumbricals of the ring and little fingers. These intrinsic muscles flex the MCP joints and extend the IP joints of the fingers, and loss of their resting tone results in the 'intrinsic minus' posture of hyperextension at the MCP joints and flexion at the IP joints. The 'ulnar paradox' relates to the severity of claw deformity being more severe with distal ulnar nerve lesions (due to the preserved flexor activity of FDP to the ring and little fingers).

A single flexor digitorum superficialis (FDS) tendon (usually the middle finger, split into separate strips) can be transferred to the extensor expansion (lateral bands, option E) to provide a dynamic corrective tendon transfer option for supple ulnar claw hand. Additionally, multiple modifications have been described for this technique.

At this stage revision ulnar nerve decompression is unlikely to change the outcome. Nerve transfer is also unlikely to improve function due to the prolonged time period. Option C (crossed intrinsic transfer procedure) provides correction of ulnar drift in the rheumatoid hand. Extensor indicis (EI) to extensor pollicis longus (EPL) transfer is a treatment for extensor pollicis longus (EPL) rupture.

39. Answer C. **Ligament of Struthers**

Anatomically, the 'cubital tunnel' proper refers specifically to the fascial roof formed proximally by Osborne's ligament (its fibres run between the medial epicondyle and the olecranon process) and distally by the investing fascia of flexor carpi ulnaris (FCU). Sites of entrapment for cubital tunnel syndrome include:

1. Between the two heads of FCU.
2. Osborne's ligament.
3. Medial head of triceps brachii.
4. Medial intermuscular septum.
5. Fascial bands within FCU.
6. Arcade of Struthers.
7. Anconeus epitrochlearis (an anomalous muscle).

The arcade of Struthers is a hiatus or band of deep brachial fascia attached to the intermuscular septum that covers the ulnar nerve approximately 8cm proximal to the medial epicondyle. The arcade is not routinely explored or released with simple cubital tunnel decompression and some have questioned its role in ulnar nerve compression altogether.

The ligament of Struthers arises from the supracondylar process at the lower third of the humerus and part of the medial epicondyle (Caetano et al. 2017). When present, it can be a site of median nerve compression.

Caetano EB et al. Struthers' ligament and supracondylar humeral process: an anatomical study and clinical implications. *Acta Ortop Bras.* 2017;**25**:137–142.

40. Answer D. **Retrograde screw fixation and corticocancellous bone graft**

A delay in diagnosis and treatment has resulted in scaphoid fracture non-union. CT imaging will provide an accurate preoperative assessment of fracture displacement and bone resorption (cystic change). A sound fixation technique is probably more important than whether vascularised or non-vascularised bone graft is used, with the latter not yielding superior outcomes (Duncumb et al. 2022). Moreover, proximal fragments with impaired vascularity (e.g. MRI low signal, absence of intraoperative punctate bleeding, and necrosis on histopathological analysis) can reliably unite with non-vascularised grafting and fixation (Rancy et al. 2018). Waist fractures

are commonly fixed from the volar side with retrograde screw placement.

Bone graft should always be used for scaphoid non-union surgery, not least when cystic change is seen. Non-vascularised graft options include corticocancellous graft (for structural support including humpback deformity correction) and cancellous (no structural support). The site of graft harvest (distal radius or iliac crest) is not important (Duncumb et al. 2022).

Vascularised graft choice is largely dependent on surgeon preference and fracture location. The Kuhlmann graft utilises the palmar carpal artery and can be used for waist fractures approached volarly (Kuhlmann et al. 1987). The Zaidemberg graft utilises the 1,2 intercompartmental supraretinacular artery (1,2 ICSRA) superficial to the extensor retinaculum and can be used for proximal pole fractures approached dorsally (Zaidemberg et al. 1991).

Untreated scaphoid non-union will invariably progress to radiographic evidence of arthritis within 5 years (Mack et al. 1984). However, this is not always symptomatic. A predictable and sequential pattern of arthritis and carpal collapse often ensues, known as scaphoid non-union advanced collapse (SNAC, stages I–IV). Impingement between the flexed distal scaphoid and radial styloid produces the first signs of arthritis (SNAC grade I). Limited carpal fusion (e.g. four corner fusion of the capitate-lunate-hamate-triquetrum) is a salvage procedure for advanced SNAC wrist (SNAC grades II+) and is often combined with scaphoidectomy and radial styloidectomy. Denervation is a motion-preserving option for advanced wrist osteoarthritis with variable results.

Duncumb JW et al. Bone grafting for scaphoid nonunion surgery: a systematic review and meta-analysis. *Bone Joint J.* 2022;**104-B**:549–558.

Kuhlmann JN, Mimoun M, Boabighi A, Baux S. Vascularised bone graft pedicled on the volar carpal artery for non-union of the scaphoid. *J Hand Surg Br.* 1987;**12**:203–210.

Mack GR, Bosse MJ, Gelberman RH, Yu E. The natural history of scaphoid nonunion. *J Bone Joint Surg Am.* 1984;**66**:504–509.

Rancy SK et al. Scaphoid Nonunion Consortium: Success of scaphoid nonunion surgery is independent of proximal pole vascularity. *J Hand Surg Eur.* 2018;**43**:32–40.

Zaidemberg C, Siebert JW, Angfigiani C. A new vascularized bone graft for scaphoid nonunion. *J Hand Surg Am.* 1991;**16**:474–478.

41. Answer E. **Debridement and replantation in order: bone, extensor, flexor, artery, nerve, vein**
A common sequence for digital replantation is: bone, extensor, flexor, artery, nerve, vein (Kleinert & Tsai 1978). A useful mnemonic for learning this order is BE a FAN of V. The amputated part should be wrapped in saline-soaked gauze, placed in a sealed plastic bag with the air evacuated and placed in iced water ahead of transportation. Direct contact with ice should be avoided to prevent cellular disruption.

Crushed and non-viable tissue is excised and the bone may be shortened to provide a tension-free repair. Tension is the enemy of success in microvascular surgery and autologous nerve or vascular grafts may be required. Firstly, the amputated part is prepared and then set aside during preparation of the amputation stump. The stump is prepared and internal fixation of the bone provides stability for subsequent soft tissue repair. The tendons are repaired ahead of the more superficial and delicate neurovascular structures. Use of heparinised solution helps to avoid thrombosis and replant failure. Tissue perfusion is assessed following the arterial anastomoses. The dorsal veins may be allowed to bleed during neural repair to assess perfusion and prevent recirculation of accumulated toxins. Frequent post-operative checks (e.g. every 30–60 minutes) for colour, temperature and capillary refill are essential.

Compelling indications for replantation include any level of amputation in the thumb (including avulsion injuries), multiple digit amputations, and any level of amputation in a child (Higgins 2016). Relative contraindications to replantation include a digital warm ischaemia time exceeding 12 hours (or 6 hours for amputations proximal to the carpus due to their significant muscle content), digital amputations proximal to the FDS insertion (zone 2), segmental amputations, heavy contamination, poor patient motivation or impaired psychological status. Maximal cold ischaemia times are double those of the warm ischaemia times. Absolute

contraindications include extensive crush injury or improper storage of the amputated part.

Higgins JP. Replantation. In Wolfe SW, Pederson WC, Kozin SH, Cohen MS, ed. *Green's Operative Hand Surgery*, 7th Ed., 1476–1485. New York: Elsevier Churchill Livingstone; 2016.

Kleinert HE, Tsai TM. Microvascular repair in replantation. *Clin Orthop Relat Res.* 1978;**133**:205–211.

42. **Answer E. PIPJ extension splintage**

The patient presents with an acute injury of the central slip. Untreated central slip injuries will result in a boutonnière deformity, characterised by resting PIPJ flexion and DIPJ hyperextension. The deformity occurs secondary to volar subluxation of the lateral bands (Massengill 1992). Central slip disruption is classified as an extensor zone III injury.

The evidence for managing acute open and closed central slip injuries is limited (Geoghegan et al. 2019); however, acute closed and complete central slip tears are generally managed conservatively with the PIPJ splinted in extension for 6 weeks (e.g. a thermoplastic cylinder splint). The PIPJ splint excludes the DIPJ, which is actively mobilised through flexion and extension to prevent contraction of the oblique retinacular ligament and the formation of a boutonnière deformity. Static PIPJ splintage may be followed by a dynamic extension splint (e.g. Capener splint), which provides passive PIPJ extension at rest and permits active PIPJ flexion. Acute operative intervention is most appropriate for open injuries or lacerations, which require exploration, debridement and repair (Colzani et al. 2016).

A high index of suspicion is required for closed central slip injuries. A boutonnière deformity does not occur until late, when attenuation of the triangular ligament permits palmar subluxation of the lateral bands, thus converting a PIPJ extensor force to a flexor force. Neglected boutonnière deformities will establish progressive joint contractures that are not passively correctable.

Elson's test assesses for loss of central slip integrity. The classic test is performed by asking the patient to flex the PIPJ of the affected digit to 90° over the edge of a table. DIPJ mobility is assessed during resisted middle phalanx extension. A positive test will result in rigid extension of the DIPJ (it will remain floppy when the central slip is intact). Always compare with an unaffected digit. A positive test results from extension forces passing to the terminal tendon via the intact lateral bands. The modified Elson test avoids use of a table and is often easier to perform.

Colzani G et al. Traumatic extensor tendon injuries to the hand: clinical anatomy, biomechanics, and surgical procedure review. *J Hand Microsurg.* 2016;**8**:2–12.

Geoghegan L, Wormald JC, Adami RZ, Rodrigues JN. Central slip extensor tendon injuries: a systematic review of treatments. *J Hand Surg Eur.* 2019;**44**:825–832.

Massengill JB. The boutonnière deformity. *Hand Clinics* 1992;**8**:787–801.

43. Answer A. **Axonotmesis/nerve exploration**

The Tinel response and electromyography (EMG) findings suggest a degenerative nerve lesion. The Seddon classification categorises peripheral nerve injuries as neurapraxia, axonotmesis and neurotmesis. Axonotmesis and neurotmesis represent degenerative nerve injuries, with interruption of axoplasmic nutrient flow from the cell body resulting in Wallerian degeneration distal to the site of injury. A Tinel response is pathognomonic of a degenerative nerve lesion (axonotmesis and neurotmesis). The Sunderland classification sub-classifies axonotmesis according to the connective tissue layers injured (Sunderland grades 2, 3 and 4). Neurotmesis describes a nerve that has been completely severed or so markedly disorganised by scar tissue that axonal growth is impossible (Robinson 2000). Neurapraxia (also termed conduction block) is not a degenerative nerve lesion (the axons and surrounding connective tissue layers remain intact) and Wallerian degeneration does not occur (no Tinel would be present). There is temporary physiological derangement and minimal physical nerve injury, with recovery taking days to a few months. Positive sharp waves (seen 1–2 weeks following a degenerative injury) and fibrillations (2–3 weeks) indicate muscle denervation secondary to axonal loss.

A Tinel response is positive when tapping on a peripheral nerve along its course (from distal to proximal) produces paraesthesia and discomfort in the expected distal distribution of that nerve. A Tinel may be further classified as static or advancing, unfavourable and favourable prognostic signs, respectively. An advancing Tinel (usually 1–2 mm per day following a lag period of a few weeks) represents physiological recovery of a nerve. A static Tinel indicates either complete sectioning of a nerve or part of a nerve or a continuing insult secondary to local scarring or tethering.

In the featured case, the median nerve is most likely tethered at the level of the locking plate given the static Tinel at this level. The presence of altered sensation (rather than complete anaesthesia) and intact autonomic function (i.e. sweating) favour axonotmesis rather than neurotmesis. Expedient nerve exploration and decompression (neurolysis) is indicted. In reality most nerve injuries are somewhat mixed (e.g. combined neurapraxia and axonotmesis). Mixed lesions help to explain why clinical examination findings may overlap. For example, in a nerve with mixed axonotmesis and neurotmesis a static Tinel (neurotmesis) and an advancing Tinel (axonotmesis) would be expected.

Robinson LR. Traumatic injury to peripheral nerves. *Muscle Nerve* 2000;**23**:863–873.

44. Answer A. **Electrophysiological studies and continued monitoring**

The patient has sustained a low radial nerve palsy (distal to the elbow) affecting the posterior interosseous nerve (PIN). The PIN was most likely stretched or compressed at the time of radial head replacement. The nerve demonstrates signs of recovery: digital extension is returning and there is an advancing Tinel to the level of the mid-forearm. The nerve is therefore recovering at the expected rate (1–2mm per day). No intervention is required at the present time; however, electrophysiological studies may be performed at the clinician's discretion. In the acute setting, internal fixation of a fracture complicated by a nerve injury warrants nerve exploration in most cases. The acute management is not referenced in the featured case and may have included nerve exploration.

Wrist extension is usually preserved in PIN lesions due to the more proximal innervation of extensor carpi radialis longus (ECRL); however, extension with radial deviation occurs due to the absent pull of extensor carpi ulnaris (ECU). In the featured case, the Tinel has advanced to the mid-forearm and extensor pollicis longus (EPL) reinnervation (and a subsequent flicker of muscle activity) would be expected in the next few months. Therefore, tendon transfer is not indicated at the current time. The final muscle to be innervated by the PIN is usually the extensor indicis proprius (EIP) (Abrams et al. 1997).

The PIN is one of the terminal branches of the radial nerve. The radial nerve divides into the superficial and deep radial nerves over the lateral humeral epicondyle in the antecubital fossa. The superficial branch travels deep to brachioradialis and provides sensation to the dorsum of the hand. The deep branch is renamed the PIN as it passes between the two heads of supinator (which it innervates). The PIN is situated a few centimetres distal to the radio-capitellar joint and maintaining forearm pronation during radial neck and head surgery will move the nerve distally by around 1cm.

Abrams RA, Ziets RJ, Lieber RL, Botte MJ. Anatomy of the radial nerve motor branches in the forearm. *J Hand Surg.* 1997;**22**:232–237.

45. Answer D. **Observation is required**

The patient presents with signs and symptoms most suggestive of Dupuytren's disease. Hueston's table top test is negative, indicating that contracture has so far not developed. Luck (1959) classified Dupuytren's disease according to three chronological and histological stages:

Proliferative

Hypercellular nodule with fibroblasts being the most numerous cell type.

Involutional (contractile)

Myofibroblasts align along tension lines producing collagen (especially type III).

Residual

Hypocellular nodule with fibrocytes having replaced myofibroblasts, high collagen concentration.

The featured patient presents during the proliferative stage. The predominant cell type will be the fibroblast, not the myofibroblast. Although

rare, mild nodular pain may be a feature during this stage. When normal fascial structures become pathological, the following cords may be seen: pretendinous, spiral, central, natatory, abductor digiti minimi, lateral, retrovascular, commissural and radial thumb. Candidates should review the cords responsible for MCPJ, PIPJ and DIPJ flexion contractures, respectively. For example, the spiral cord can produce a severe PIPJ flexion contracture. Grayson's ligament is implicated in the formation of the spiral cord; however, Cleland's ligament is not implicated in Dupuytren's disease.

Treatment is generally reserved for digital contractures and no intervention is required for nodular disease. It has been demonstrated that radiotherapy or intralesional steroid injection (triamcinolone acetonide) may modify disease progression (Ketchum and Donahue 2000); however, both are very rarely offered. Dupuytren's nodule pain is usually short-lived and would be expected to settle.

Ketchum LD, Donahue TK. The injection of nodules of Dupuytren's disease with triamcinolone acetonide. *J Hand Surg.* 2000;**25**:1157–1162.

Luck JV. Dupuytren's contracture: a new concept of the pathogenesis correlated with surgical management. *J Bone Joint Surg Am.* 1959;**41**:635–664.

46. Answer B. **Opponensplasty and stabilisation**
This patient presents with congenital thumb hypoplasia. It may occur spontaneously or as part of a syndrome, usually combined with radial shortening or deficiency, including VACTERL, Holt–Oram syndrome and thrombocytopenia-absent radius (TAR) syndrome. The major determinant of optimal thumb mobility, and therefore function, is the presence of a well-formed and stable CMC joint (Tonkin 2011). The CMCJ is most easily assessed with plain radiographs.

The Blauth classification of thumb hypoplasia (grades I–V) is useful for guiding management, with differentiation between grades IIIA (stable CMCJ) and IIIB (unstable CMCJ) being of fundamental importance:

Blauth grade I (small thumb with thenar hypoplasia) is treated conservatively.

Blauth grades II (MCP joint ulnar collateral ligament laxity) and IIIA (no active IP and MCP joint movements with an intact CMC joint) are treated with MCP joint stabilisation, web space release (e.g. Z-plasty) +/− opponensplasty (using an ADM or FDS tendon transfer to restore movement).

Blauth grades IIIB (no active IP and MCP joint movements with a deficient CMC joint), IV (thumb attached by skin and neurovascular structures alone) and V (complete absence) are treated with amputation and pollicisation. Pollicisation utilises the ipsilateral index finger to create a working thumb. The index metacarpal is shortened to provide a suitable size match. An alternative to pollicisation is a thumb-to-toe transfer, most often utilising the second toe.

The Oberg, Manske and Tonkin (OMT) classification (Oberg et al. 2010) of upper limb congenital malformations has been adopted by the International Federation of Societies for Surgery of the Hand (IFSSH), superseding the Swanson classification (Swanson 1976). The OMT system separates malformations from deformations and dysplasias.

Oberg KC, Feenstra JM, Manske PR, Tonkin MA. Developmental biology and classification of congenital anomalies of the hand and upper extremity. *J Hand Surg.* 2010;**35**:2066–2076.

Swanson AB. A classification for congenital limb malformations. *J Hand Surg.* 1976;**1**:8–22.

Tonkin M. Surgical reconstruction of congenital thumb hypoplasia. *Indian J Plast Surg.* 2011;**44**:253.

47. Answer A. **Dermofasciectomy (full thickness skin graft)**
Dupuytren's disease is a benign fibromatosis of the palmar and digital fascia resulting in subdermal nodules and cords. It commonly results in progressive flexion contractures. This patient has Dupuytren's disease diathesis, which predicts a high risk of disease recurrence. First described by Hueston, the four original diathesis factors were bilateral (palmar) disease, a positive family history, ectopic lesions outside of the hand (i.e. Garrod's pads, plantar fibromatosis) and Caucasian ethnicity (Hueston 1983). More recently these factors have been joined by male gender and age of onset younger than 50 years (Hindocha et al. 2006).

When measuring interphalangeal joint range of motion always ensure that the metacarpophalangeal joints are flexed to avoid overestimating the distal flexion deformities.

Despite the high risk of recurrence, many surgeons will favour limited fasciectomy for primary treatment in those with Dupuytren's disease diathesis (unless very young), reserving dermofasciectomy for the most severe or recurrent cases, especially with skin involvement or skin shortage. Although rates of recurrence are greatly reduced with dermofasciectomy (Brotherston et al. 1994), the operative risks, including graft failure and donor site morbidity, are increased. Given this patient's significant recurrence, dermofasciectomy combined with full thickness skin grafting should be considered. Split thickness grafting is never indicated for the palmar surface of the hand.

Brotherston TM, Balakrishnan C, Milner RH, Brown HG. Long term follow-up of dermofasciectomy for Dupuytren's contracture. *Br J Plast Surg.* 1994;**47**:440–443.

Hindocha S, Stanley JK, Watson S, Bayat A. Dupuytren's diathesis revisited: evaluation of prognostic indicators for risk of disease recurrence. *J Hand Surg.* 2006;**31**:1626–1634.

Hueston JT. *Dupuytren's Contracture*, 51–120. Edinburgh: E&S Livingstone; 1963.

48. Answer E. **Ultrasound by a musculoskeletal radiologist**

Soft tissue sarcomas are relatively rare in the hand and forearm. According to the UK guidelines for the management of soft tissue sarcoma (Dangoor et al. 2016), soft tissue masses exhibiting any of the following features should be considered malignant until proven otherwise:

- Increasing in size.
- Greater than 5cm in diameter.
- Painful.

The greater the number of features present the greater the risk of malignancy, with increasing size the best individual indicator. All patients with a suspected soft tissue sarcoma should be managed by the specialist regional sarcoma multidisciplinary team (NICE 2015). Ultrasound (US) imaging by a musculoskeletal radiologist should be considered as the first-line investigation and may be supplemented by US-guided core biopsy (Dangoor et al. 2016). Magnetic resonance imaging and core needle biopsy are recommended prior to definitive surgery.

Dangoor A et al. UK guidelines for the management of soft tissue sarcomas. *Clin Sarc Res.* 2016;**6**:20.

National Institute for Health and Care Excellence. Sarcoma: Quality Standard 78; 2015. https://www.nice.org.uk/guidance/qs78.

49. Answer E. **Tendon transfer: Pronator teres (PT) to extensor carpi radialis brevis (ECRB)**

A tendon transfer relocates the insertion of a functioning muscle-tendon unit to help restore movement and function at another site (Sammer and Chung 2009). Transfer of the pronator teres (PT) tendon to the extensor carpi radialis brevis (ECRB) tendon is the classic tendon transfer for a 'high' radial nerve palsy (proximal to the elbow) to restore wrist extension. The radial insertion of PT is taken with a strip of periosteum to ensure adequate length.

This tendon transfer is often combined with (1) flexor carpi ulnaris (FCU) to extensor digitorum communis (EDC) and (2) palmaris longus (PL) to extensor pollicis longus (EPL). An alternative donor option for EPL is flexor digitorum superficialis (FDS) to the ring finger, with alternative options for EDC including flexor carpi radialis (FCR) or FDS (ring finger). Palmaris longus has insufficient power to restore wrist extension. Extensor carpi ulnaris (ECU) is not a donor option as it is innervated by the posterior interosseous nerve. Candidates should familiarise themselves with the principles for successful tendon transfer.

After 18–24 months of muscle denervation, irreversible functional loss occurs secondary to muscle fibrosis and neuromuscular junction dysfunction. Therefore, exploring the radial nerve at 17 months would be unlikely to result in functional gains. One indication for exploration and neurolysis at this time would be the presence of neuropathic pain and a static Tinel at the site of injury, indicating continuing nerve compression.

Sammer DM, Chung KC. Tendon transfers part I: principles of transfer and transfers for radial nerve palsy. *Plast Recon Surg.* 2009;**23**:169e.

50. Answer D. **Swan neck deformity is a risk**
All suspected mallet injuries should have radiographs completed at presentation to confirm the nature of the mallet injury (bony or soft tissue) and to inform management decisions. Closed soft tissue and minimally displaced bony mallet injuries such as this are usually managed in a DIPJ splint (neutral alignment) such as a Stack or bespoke thermoplastic splint both day and night. The DIPJ must be kept straight when the splint is removed temporarily for skin hygiene. Although practice varies, bony mallets are usually kept continually splinted for 6 weeks (compared with 8 weeks for soft tissue) and then weaned off over another few weeks. Mild resting DIPJ hyperextension is sometimes utilised for soft tissue mallet splints; however, there is a risk of fracture displacement when used for bony mallets. Patients should be advised of the long-term likelihood of an extensor lag and the risk of dorsal DIPJ fullness and pain for up to a year or more.

Non-operative management is associated with predictably good outcomes regardless of fracture size, joint congruence or subluxation, and pre-existing DIPJ degeneration (Trickett et al. 2021).

Kirschner wire fixation may be utilised for markedly displaced bony mallet fractures, especially when the DIPJ is incongruent or if the thumb avulsion concerns the thumb. The two-wire technique described by Ishiguro et al. (1997) is often described; however, the Hofmeister et al. (2003) two-wire technique using an oblique dorsal wire is perhaps more often used.

Tendon repair is not required as the avulsed fragment is distal to the insertion of the extensor mechanism. Swan neck deformity is a risk following all mallet injuries (bony and soft tissue) due to unequal extensor and flexor forces. Hyperextension of the PIPJ should be identified early so that splinting can be extended to include the PIPJ.

Hofmeister EP, Mazurek MT, Shin AY, Bishop AT. Extension block pinning for large mallet fractures. *J Hand Surg Am.* 2003;**28**:453–459.

Ishiguro T, Itoh Y, Yabe Y, Hashizume N. Extension block with Kirschner wire for fracture dislocation of the distal interphalangeal joint. *Tech Hand Up Extrem Surg.* 1997;**1**:95–102.

Trickett RW, Brock J, Shewring DJ. The non-operative management of bony mallet injuries. *J Hand Surg Eur.* 2021;**46**:460–465.

51. Answer D. **Trapeziectomy alone**
The hand radiograph demonstrates advanced 1st CMCJ changes with relative preservation of the STTJ articulation. Trapeziectomy is a long-established and reliable treatment for thumb base osteoarthritis. Although still a topic of debate (and with heterogeneous international practice) the research literature mostly supports trapeziectomy alone for the majority of patients with thumb base osteoarthritis. Short-term outcomes at one year (such as pain relief, hand function, thumb strength) are indistinguishable for the two forms of trapeziectomy listed (Davis et al. 1997; Davis and Pace 2009) and a Cochrane systematic review also demonstrated no significant differences (Wajon et al. 2015). The proposed benefit of tendon adjuncts is to maintain thumb length and theoretically minimise loss of grip strength and subluxation of the metacarpal base. The first popular tendon adjunct to accompany trapeziectomy utilises 50% of the FCR tendon as a suspensory ligament (Burton & Pellegrini 1986); however, many procedures have since been described.

Repeating the steroid injection when it previously provided only 6 weeks of relief is not recommended. Replacement of the 1st CMCJ is increasing in popularity, especially in active patients where loss of thumb height may affect function; however, most series highlight higher complication rates. Denervation of the thumb base can provide varying degrees of pain relief; however, the innervation pattern of the 1st CMCJ is variable and several techniques are described (Rezzadeh et al. 2022). Denervation is less reliable when compared with trapeziectomy but may be trialled in young or active patients where loss of thumb height may affect function.

Burton RI, Pellegrini VD Jr. Surgical management of basal joint arthritis of the thumb. Part II. Ligament reconstruction with tendon interposition arthroplasty. *J Hand Surg Am.* 1986;**11**:324–332.

Davis TR, Pace A. Trapeziectomy for trapeziometacarpal joint osteoarthritis: is ligament reconstruction and temporary stabilisation of the pseudarthrosis with a Kirschner wire important? *J Hand Surg Eur.* 2009;**34**:312–321.

Davis TR, Brady O, Barton NJ, Lunn PG, Burke FD. Trapeziectomy alone, with tendon interposition or with ligament reconstruction? *J Hand Surg Br.* 1997;**22**:689–694.

Rezzadeh K, Rossi K, Trerotola CC, Shah A. First carpometacarpal joint denervation: a systematic review. *J Hand Surg Am.* 2022;**47**:793.e1–793.e8.

Wajon A, Vinycomb T, Carr E, Edmunds I, Ada L. Surgery for thumb (trapeziometacarpal joint) osteoarthritis. *Cochrane Database Syst Rev.* 2015;**2**:CD004631.

Chapter 20

Children's Orthopaedics I Structured SBA

Hussein Noureddine and Sattar Alshryda

CHILDREN'S ORTHOPAEDICS I STRUCTURED SBA QUESTIONS

1. The hip US (Figure 20.1) is for a 3-week-old baby. Alpha angle is 45° and beta angle is 70°. **According to the Graf method, the following is correct.**
   A. Normal hip
   B. The scan is not in the standard plane and should be repeated
   C. This is type IIa hip
   D. This is type IIb hip
   E. Type IIc hip

2. What is the most appropriate next step in the above child's management?
   A. Reassure parents and discharge the baby from clinic as this is a normal hip
   B. Reassure parents and arrange for a follow-up appointment when the baby is 6 months old
   C. Request plain X-ray to confirm the hip is normal
   D. Repeat the hip US as it is not in the standard plane
   E. Treat for hip dysplasia as the hip US showed a significant dysplasia

3. The plain pelvic X-ray of an 8-year-old girl who presented with a 3-month history of knee pain and limping (Figure 20.2). There was no blood loss or constitutional symptoms. The child did not have any past history of significance and she

Figure 20.2 Anteroposterior (AP) radiograph of the hip

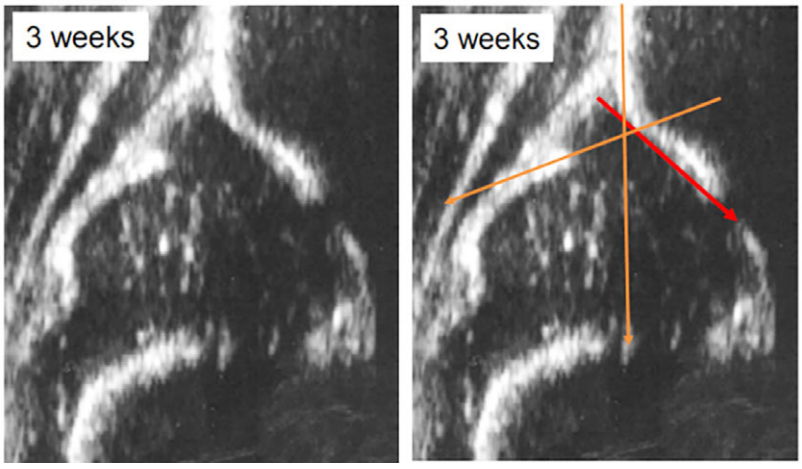


Figure 20.1 US scan hip

is fully vaccinated. Examination showed a global hip joint movement restriction with 0° abduction. Her blood tests (FBC, CRP, ESR, PCT and TFT) are all within normal. LCPD diagnosis was made.

The most appropriate treatment is:

A. Adductors release and petri cast for 6 weeks
B. Bed rest until pain subsides then resume gradual activities
C. Femoral varus osteotomy
D. Hip arthrodiastasis
E. Intensive physiotherapy

4. A 15-year-old boy who had a pinning *in situ* for moderate slipped capital epiphysis 4 years ago. He presented with groin pain which is worse on activity. He finds riding a bicycle is particularly painful. The pain gets worse after a recent long-haul flight to Australia. Examination showed an externally rotated limb, but he is able to correct it. Flexion is limited to 80° before obligatory external rotation happens. Blood is normal. Radiographs are shown in Figure 20.3.

The most appropriate treatment is:

A. Hip arthroscopy to shave cam lesion
B. Local anaesthetic and steroid injection to confirm the source of pain
C. Removal of metalwork then MRI scan to rule out AVN
D. Southwick or Imhauser femoral osteotomy
E. Surgical dislocation and femoral osteoplasty

5. A 3-year-old girl presented with asymmetry of her lower limbs. Radiographs and clinical pictures are shown in Figure 20.4. Radiological measurements are summarised in Table 20.1.

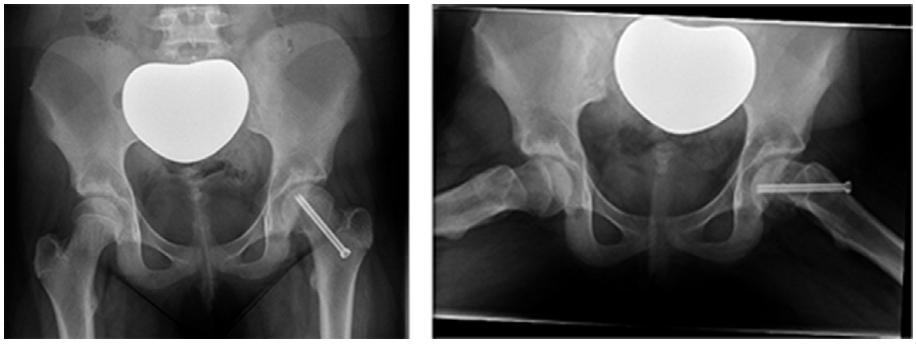
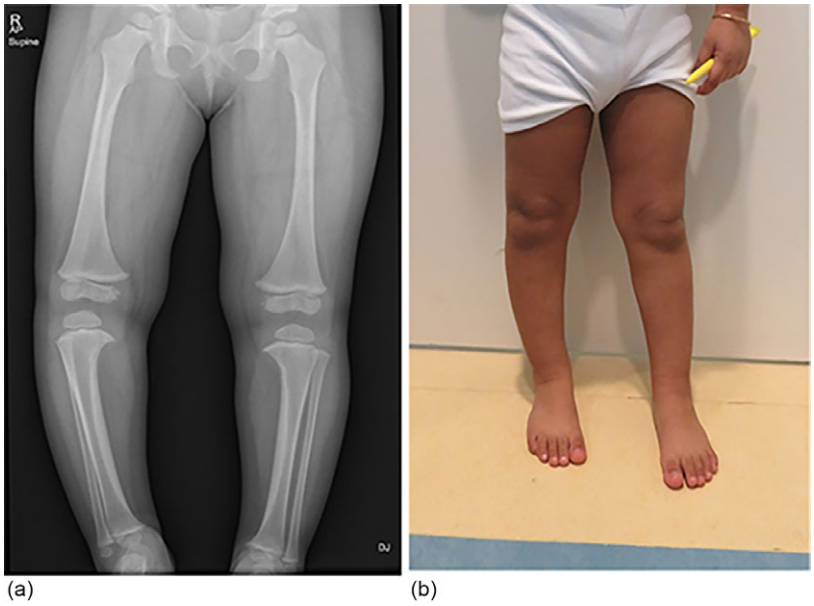


Figure 20.3 Anteroposterior (AP) and frog lateral radiograph pelvis



(a) (b)

Figure 20.4 (a) Full length radiographs and (b) clinical picture lower legs

Table 20.1 Radiological assessment deformity angles

Angles	Right	Left
Tibio Femoral Angle (TFA)	22°	5°
Mechanical Axis Deviation (MAD)	57mm	20mm
Epiphyseal-Metaphyseal Angle (EMA)	21°	13°
Tibial Metaphyseal Diaphyseal angle (TMDA) of Drennan	14°	9°
Femoral Metaphyseal Diaphyseal angle (FMDA)	10°	5°
Femoral Tibial Ratio of McCarthy (FTR)	1.4	1.5

The most appropriate next step is:

A. Given her age, bracing must be started soon for most effective outcome
B. Lateral hemiepiphysiodesis of the right proximal tibia using 8 plates
C. Lateral hemiepiphysiodesis of the right proximal tibia using Phemister technique
D. Observation only with a 6-month follow up
E. Proximal tibial osteotomy and stabilisation using K-wire and cast

6. A newly born child was referred to you with deformity of the right upper limb (Figure 20.5). The paediatric team performed a thorough investigation on the child including genetic testing and no abnormality was detected. Your examination shows that shoulder is normal, elbow motions ranged from 90° flexion to 30° short of full extension. The thumb is missing. X-ray shows complete absence of radius and bowed ulna.

Figure 20.5 Clinical photograph upper limb

The best strategic plan is:

A. Amputation as the outcome of reconstruction is unpredictable particularly with absent thumb
B. Bilobed skin flap to correct deformity asap
C. Centralisation of the ulna and free toe transfer aged 9 months
D. Radialisation of the ulna age 9 month and pollicisation of the index finger at 18 months
E. Serial casting and bracing until she is 3 years old

7. A 14-year child was brought in by his mother because he walks with both feet pointing inward (in-toeing) (Figure 20.6).

Figure 20.6 Clinical photograph in toeing left leg

Examine the clinical photograph carefully, the most likely cause of his in-toeing is?

A. Dynamic caused by biceps femoris muscle
B. Femoral torsion
C. Hallux varus
D. Metatarsus adductus
E. Tibial in-torsion

8. A 6-month-old baby has a foot deformity (Figure 20.7).

The most likely diagnosis is?

A. Calcaneovalgus foot
B. Club foot
C. Metatarsus adductus
D. Pes cavus
E. Rigid flatfoot

Figure 20.7 Clinical photographs right foot

9. A 9-year-old girl is brought to clinic as her parents noticed a swelling behind her knee (Figure 20.8). She has no symptoms whatsoever. She is fit and healthy otherwise. Her older sister died of lymphoma which presented swellings in her neck, groin and behind the knees. Her parents are worried this might be the same and requested a biopsy. MRI scan has confirmed the cystic nature of the cyst, but the radiologist was reluctant to commit as to whether the lesion is benign or malignant.

   The most appropriate next step is:

   A. Aspirate the cyst and send fluid for cytology
   B. Excise the cyst and send for histopathology
   C. Refer for a haematologist with an interest in lymphoma
   D. Perform CT guided biopsy to rule out lymphoma
   E. Reassure parents and arrange a follow up in 6 months

10. A 4-year-old boy was born with congenital pseudoarthrosis of the tibia and fibula (Figure 20.9). He was treated in a cast for nearly 4 months but the tibia did not unite. He has been in a brace for 3 years and his skin is starting to break down from the pressure effect. He is otherwise a fit and healthy child. He is very active and enjoys playing football with his cousins. He often removes the brace when playing football as it has become very uncomfortable. He was investigated for neurofibromatosis, and it was negative.

    The best option for this child is:

    A. Advise parents to encourage him with a different sport (swimming and cycling)
    B. Change the brace for a well-padded carbon fibre brace
    C. The best results have been reported with circular frame and bone graft

Figure 20.8 Clinical swelling posterior aspect right lower leg

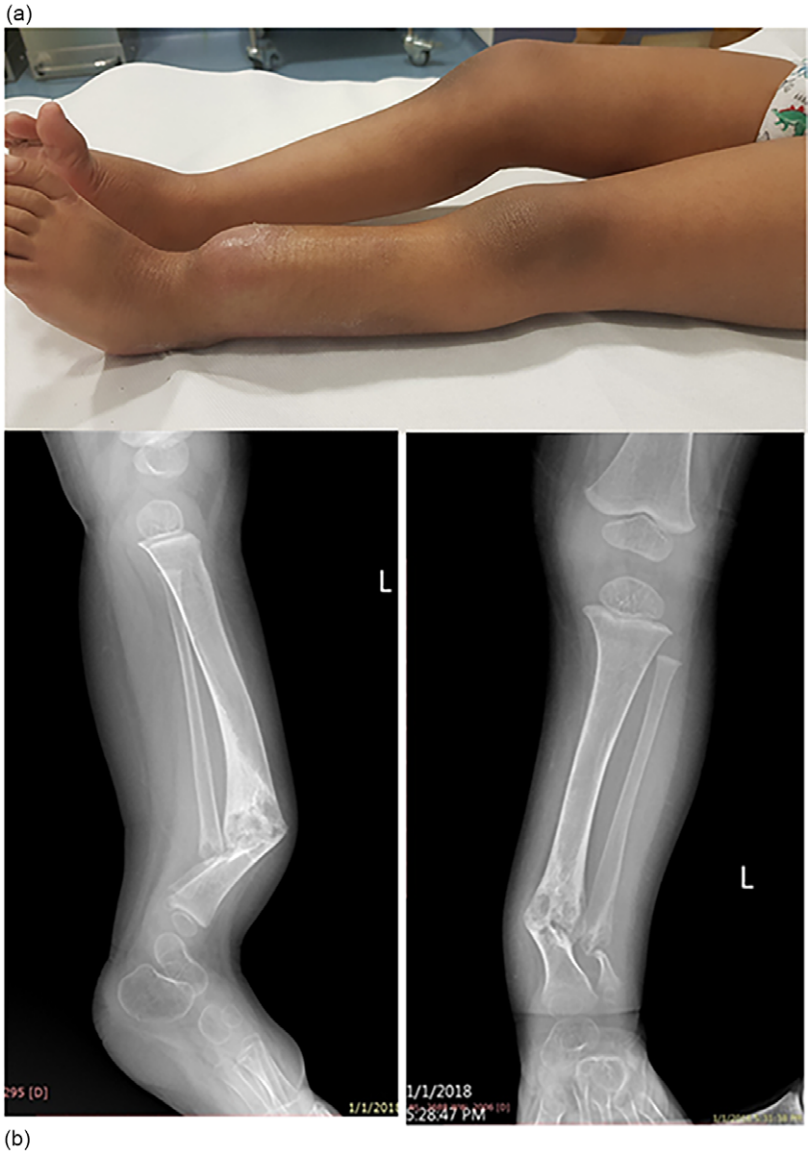


Figure 20.9 (a) Clinical photograph left lower leg and (b) anteroposterior (AP) and lateral radiographs left leg

D. Intramedullary rod stabilisation is an essential part of treatment
E. Open reduction and internal fixation using compression locking plate

11. On clinical examination of this 10-year-old boy (Figure 20.10) what feature is he most likely to have?
A. Generalised ligamentous laxity
B. Increased femoral anteversion
C. Increased genu valgum
D. Internal tibial torsion
E. Squinting patellae

Figure 20.10 Clinical picture

12. These two boys are standing on their left legs (Figure 20.11).

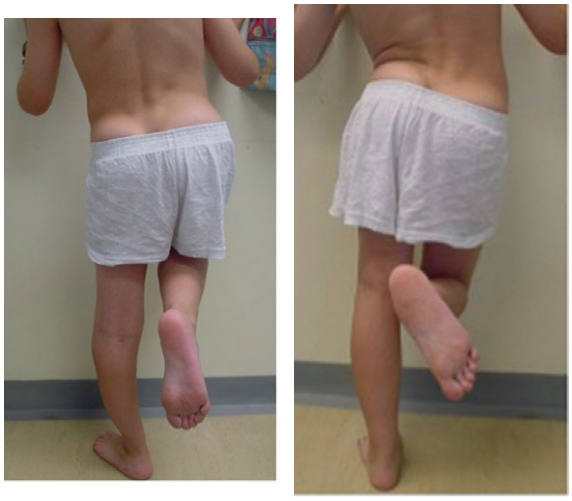


Figure 20.11 Clinical picture standing on one leg

Which statement would you consider most accurate?

A. Both boys have leg length discrepancies
B. The boy on the left has abductor muscle weakness
C. The boy on the right has a scoliosis
D. The boy on the right has abductor muscle weakness
E. The boy on the right has pes planus

13. Have a look at this patient (Figure 20.12).
What clinical feature is LEAST likely to be present?

A. Flattened lumbar lordosis
B. Leg lengths equal
C. Normal neurology
D. Normal plumbline
E. Right rib prominence

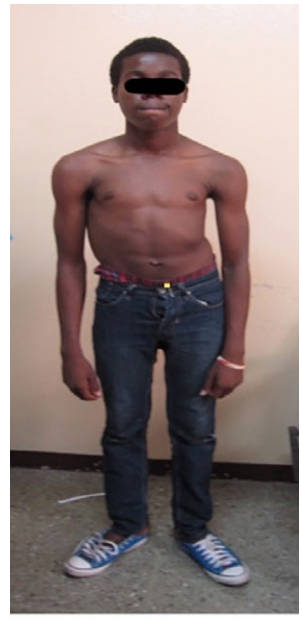


Figure 20.12 Clinical picture boy standing upright

14. This patient has a leg length inequality (Figure 20.13).
With regards to clinical assessment of this patient which statement is most accurate?

A. Block test is most reliable
B. True leg length measurement will be abnormal
C. Galeazzi test will be useful
D. Apparent leg length will be abnormal
E. Radiographic assessment will be best because clinical examination will be unreliable

Figure 20.13 Clinical picture bilateral feet

15. This clinical photograph of an adolescent gymnast reveals an exaggerated lumbar lordosis (Figure 20.14). She also has back pain.
What another clinical feature is she most likely to have?

A. Numbness over the knee
B. Scoliosis
C. Thoracic kyphosis
D. Tight hamstrings
E. Weak quads

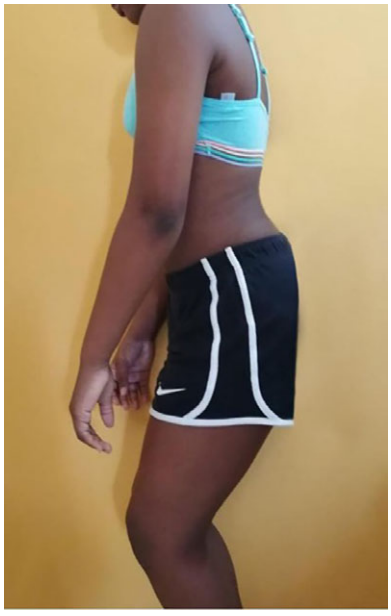


Figure 20.14 Clinical photo adolescent girl

16. A 4-year-old boy is brought to the orthopaedic paediatric clinic as his parents are concerned that his knees look bowed. Clinical pictures are shown in Figure 20.15.

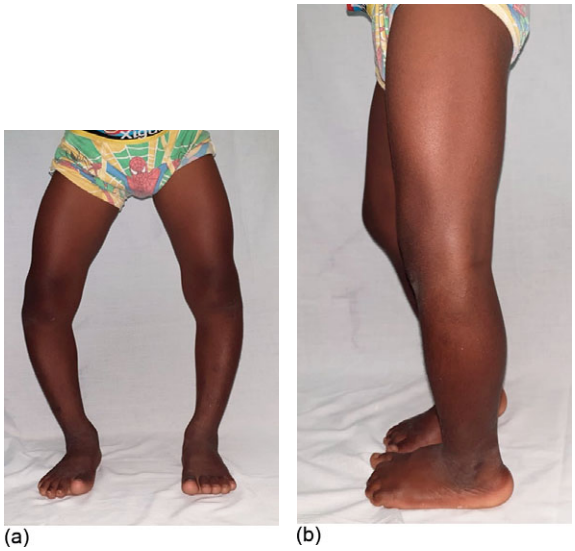


Figure 20.15 Clinical pictures legs (a) front and (b) side

Considering the most likely diagnosis the following are associated with the condition:

A. Blue sclera
B. External tibial torsion
C. Leg length discrepancy
D. Low vitamin D levels
E. Short stature

17. The parents of a 3-year-old girl have brought her to the paediatric orthopaedic clinic because of concern that she is always falling.

Concerning differences in gait pattern in childhood:

A. Absence of reciprocal arm swing
B. Decreased knee flexion instance
C. Pronounced heel strike
D. Leg internally rotated in swing
E. Increased stride speed lower and decreased cadence

18. On assessing flexibility of the spine in an infant with scoliosis.

What is the best way of doing this?

A. Ask the child to forward flex
B. Ask the child to lateral flex
C. Lifting the child up from under their arms
D. Patient prone, ask to hold the top of the bed and pull downward from the waist
E. Place the child on the examiner's knee with the concave side down

19. An 11-year-old with GMFCS I cerebral palsy presents with a right stiff knee gait failing to achieve adequate flexion.

Which test manoeuvre is best to assess the relevant muscle group tightness?

A. Patient is prone and the knee is gradually flexed and the elevation of the hemipelvis with knee flexion
B. Patient is prone, the knee is flexed, and the hip is hyperextended. The knee is then gradually extended and the movement of the ipsilateral hemipelvis is monitored
C. Patient supine and hip flexed to 90°, and knee extended and the angle between a vertical line and the tibia is measured
D. The patient is on the left lateral decubitus with the right side up, the knee is flexed, the hip is flexed to 90° and abducted and extended and then allowed to adduct. The angle between the thigh and the table is measured
E. The patient is supine, the hip is flexed to 45° similar to hip flexion in normal gait, and the knee extended and the angle between a vertical line and the tibia is measured

20. A 6-year-old patient who had a congenital clubfoot deformity treated with Ponseti method, returns with recurrence of forefoot adduction and midfoot cavus.

Which of the following is the most appropriate answer in his case?

- **A.** A tibialis anterior transfer is often needed in rigid recurrence cases
- **B.** Failure to achieve an adequate tenotomy is a prime reason for recurrence but if recurrence occurs in a patient who had an adequate tenotomy with dorsiflexion of >15° after the first cycle of treatment, then in those cases a repeat tenotomy is seldom needed
- **C.** If the deformity recurred but is correctable/flexible deformity, then it has better chance of responding to repeat casting
- **D.** In flexible recurrence and after completing the corrective intervention, the foot can be maintained in an ankle foot orthosis and not necessarily in a foot abduction brace/boots and bars
- **E.** The abduction brace (boots and bars) should be set at 60–70° of abduction with the heels far apart as the patient's shoulders similarly in all cases of primary or recurrent clubfoot

21. A 12-year-old girl presents with recurrent ankle sprains and a lateral view X-ray shows a C sign looking at the hindfoot.

Which of the following is most appropriate?

- **A.** A ball and socket ankle deformity can develop due to the mechanical impact of the underlying pathology
- **B.** MRI is the investigation of choice to look for ATFL and calcaneofibular ligaments
- **C.** Surgical intervention entails elevation of the extensor digitorum brevis to access the structures deep to it
- **D.** The choice of surgical treatment is significantly impacted by the Meary's angle
- **E.** The choice of what surgical treatment is most appropriate is significantly impacted by the amount of movement in the talonavicular joint

22. A 12-year-old patient presents with calcaneal gait after a surgical procedure.

Which of the following is NOT correct:

- **A.** The patient has a dorsiflexed ankle between heel off and toe off
- **B.** The patient has a normal heel strike
- **C.** The patient has weakness of the concentric contraction of the triceps surae in the 3rd rocker
- **D.** The patient is having inadequate eccentric contracture on the tibialis anterior in the first rocker of the stance phase of gait
- **E.** The patient is likely to have had overcorrection of a tight tendo-Achilles

23. A child is born with a rocker-bottom deformity of the right foot with a prominent talar head medially.

Which of the following is the most appropriate?

- **A.** An X-ray is not useful in the early stages in guiding the treatment as the foot bones are not ossified yet and are difficult to visualise
- **B.** Manipulation and serial casting are usually successful in treating the deformity
- **C.** The patient should be assessed for packaging disorders especially DDH
- **D.** The serial casting aims to achieve plantar flexion and eversion
- **E.** The treatment is a combination of serial casting followed by surgery in the form of soft tissue releases and bony stabilisation with K-wires and it is imperative to undertake the intervention as early as possible

24. A 3-year-old is brought in by his parents with a femoral shaft fracture. It is decided to manage the fracture with a cast.

Which of the following is most appropriate?

- **A.** Abdominal pain and vomiting after applying the cast should raise concern of a condition that is seen after scoliosis correction surgery
- **B.** If the angular alignment changes in the cast on the 1-week check X-ray then the treatment is removal of the cast and application of external fixator or IM flexible nails
- **C.** In cases of loss of femoral height applying the cast in 90° hip flexion and 90° knee flexion is recommended to achieve adequate closed reduction
- **D.** It is advisable that the cast is applied in valgus in the AP plane but only minimal anterior bow is tolerated in the lateral view
- **E.** The amount of shortening that is accepted is related to the age and the relative growth potential at the femoral physes

25. A 7-year-old male is referred for progressive difficulty going upstairs and jumping, and a recent blood test showed a markedly elevated CK.

Which of the following is the most appropriate?

A. Surgical intervention is contraindicated due to the risk of anaesthetic due to cardiomyopathy and possible malignant hyperthermia
B. Surgical intervention is likely to include a lateral column lengthening through a calcaneal osteotomy
C. Surgical intervention is likely to include adductor releases at the hip
D. Surgical intervention is likely to include tibialis posterior transfer to the dorsum of the foot
E. The examination is likely to show decreased or absent deep tendon reflexes

26. An 8-year-old male presents with the following presentation of the elbow, he describes having a previous fracture to his elbow (Figure 20.16).

Figure 20.16 Clinical picture left upper limb

Which of the following is the most appropriate answer?

A. Acute correction of a similar deformity secondary to an infection of the distal humerus is different from the acute correction of such deformity due to a fracture
B. As the patient is 8 years old the deformity is likely to improve and remodel
C. The aim of any intervention is primarily to improve function especially achieving full extension and full pronation
D. The deformity is, in most of the cases, due to failure to adequately reduce the fracture initially and fixation in a position with suboptimal alignment on the distal humerus column views
E. The previous injury is likely to be an extension type injury of the distal humerus with an inter-condylar split leading to lateral migration of the lateral condyle and the visible lateral prominence

27. A 7-year-old female with GMFCS 5 spastic cerebral palsy is referred to the neuromuscular clinic with bilateral hip pain with this X-ray (Figure 20.17).

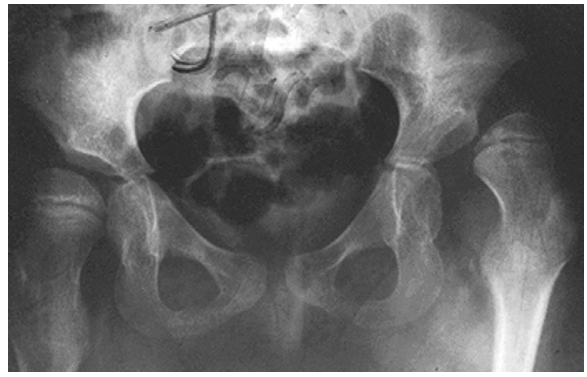


Figure 20.17 Anteroposterior (AP) pelvis

Which of the following is not considered an appropriate intervention?

A. An arthrogram performed prior to any further bony procedures could predict if the patient will have a high chance of developing worsening pain *despite* reducing the hip
B. Regarding the left hip a pelvic osteotomy is needed to correct the lateral and posterior acetabular lack of coverage
C. Regarding the left hip an open reduction is likely to be needed for the hip and then depending on stability and movement in the joint a decision could be made regarding the need for a proximal femur osteotomy

D. Regarding the left hip an osteotomy should include external rotation of the femur due to excessive femoral anteversion
E. Regarding the left hip and irrespective of the bony procedures a groin incision is used to release the adductors and possibly the gracilis, but the psoas is not released through the groin incision

28. An 11-year-old male presents with the fracture shown in Figure 20.18 (a) and (b) and the 6-month follow up X-rays are as shown in Figure 20.18 (c) and (d).

Which if the following is most appropriate:

A. Expected growth of less than 2 years (at the time of follow up) is an indication for surgical intervention while growth modulation is still possible
B. If the abnormality is at the centre of the physis then a metaphyseal window might be needed
C. The radiological findings suggest that the injury was to the hypertrophic zone of the physis
D. The surgical approach is a direct anterior distal tibia approach (intermuscular plane EHL-EDL) to access the abnormality at the different parts of the physis
E. The surgical technique varies depending on the extent of the abnormality relative to the overall physis but is not affected by the location within the physis

29. A 6-year-old male is admitted for a displaced femoral shaft fracture, you note that this was his 4th fracture. You also note that he has brown discoloured teeth.

Which of the following is incorrect?

A. Fracture malunion leading to an abnormal mechanical axis in those patients can lead to progressive deformity even after the initial fracture heals
B. Olecranon fractures are uncommon and when present should be treated with plating rather than TBW
C. The mainstay of medical treatment is a medication that inhibits farnesyl pyrophosphate synthase enzyme, which inhibits GTPase formation
D. The patient has a high risk of developing a Trendelenburg gait with a positive Trendelenburg test even if he never had hip/proximal femur fractures.
E. The patient is not likely to have delayed and impaired bone healing hence there is no need for more lengthy periods of immobilisation and protected weight bearing

30. A 2-year-old boy presents with a 5-day history of a painful swelling of his right hand. X-rays of his hands are shown (Figure 20.19). On examination, he has a low-grade fever with leucocytosis.

The most likely diagnosis is

A. JIA (juvenile idiopathic arthritis)
B. Osteomyelitis

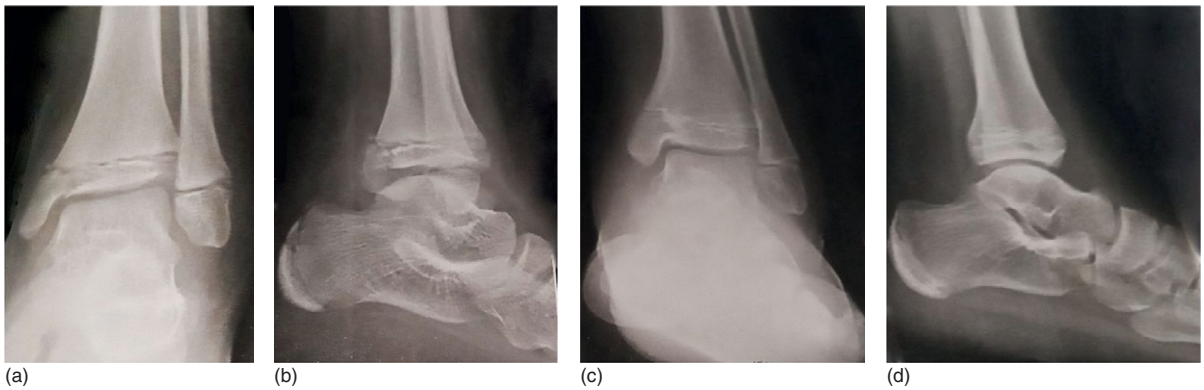


Figure 20.18 Radiographs left ankle fracture (a) anteroposterior (b) lateral immediately after fracture (c) anteroposterior and (d) lateral at 6 months

(a)

(b)

Figure 20.19 (a) Clinical and (b) radiographic pictures hand

C. Psoriatic arthropathy
D. Septic arthritis
E. Sickle cell dactylitis

31. A 4-year-old boy presents with a 24-hour history of right hip pain, severe painful hip movements and unable to weight bear. He has a fever.
Which of the following would be most helpful in confirming the presumed diagnosis?
A. CRP 25 mg/l
B. ESR 30
C. Pulse 120/min
D. Temp 37.5
E. WCC 11,500/μl

32. A 4-year-old boy who is well and active is brought in by his parents because there is a palpable swelling in his popliteal fossa. On examination, you find a non-tender, soft tissue swelling just medial to the midline and just above the joint line.
The most likely cause of the swelling is:
A. Lipoma
B. Lymph node
C. Popliteal aneurysm
D. Popliteal cyst
E. Semimembranosus bursa

33. This 16-year-old patient presents with pain on the upper medial side of his right leg when wearing his shin pads when playing football. Examination reveals a firm lump (Figure 20.20).

Figure 20.20 Clinical picture knees

Considering the presumed diagnosis which of the following statements is most accurate?
A. Further examination could reveal radial head dislocation
B. He is likely to present later with genu varum
C. The lump has a 2% chance of becoming malignant (5–10%)

D. This is most likely a subperiosteal haematoma
E. Transmission is autosomal recessive (AD)

34. A 16-year-old girl presents for the first time to clinic with a right T6–T11 scoliosis with a 35° curvature. Radiographs of the pelvis demonstrate a Rissler grade 5.
The most appropriate management option would be
A. Brace
B. CT scan
C. Discharge
D. Follow up 1 year
E. Surgery

35. **Which is likely to explain lytic radiographic findings with Madelung's deformity of the proximal humerus and elbow but no skin lesions?**
A. Diaphyseal aclasia
B. Infection
C. Maffucci syndrome
D. Marfan syndrome
E. Ollier disease

36. A 14-year-old girl presents with a 6-week history of pain in her right great toe. Radiographs are shown in Figure 20.21 (a). Surgery involved curettage of the lesion. This is shown in the intraoperative photo (Figure 20.21 (b)).
Further treatment should include which of the following
A. Antibiotic therapy
B. Chemotherapy
C. Nothing further
D. Post-operative radiation
E. Repeat curettage of the lesion


(a) (b)

Figure 20.21 (a) Radiographs and (b) intraoperative photos

37. A 9-year-old boy is brought to the paediatric orthopaedics clinic for clinical evaluation of tip toe walking.
Which of the following is NOT part of your assessment?
A. Examination of hip abduction and rotational range of movement
B. History regarding developmental milestones and behavioural development
C. Examination of calf muscles looking for calf pseudo-hypertrophy
D. Examining the mobility of the calcaneonavicular joint
E. History regarding brain injury perinatally

38. A 1-year-old male was brought to hospital with the radiograph shown in Figure 20.22.

Figure 20.22 Anteroposterior (AP) radiograph femur

Which of the following is correct?
A. As this is a transverse fracture which is longitudinally stable the recommended treatment is flexible intramedullary nails
B. At this age you can accept a degree of rotational deformity as it will remodel

C. Leg length discrepancy is not uncommon with shortening of the affected side the most likely outcome
D. The fracture morphology suggests that you should look for bucket handle fractures
E. This child is likely to have a genetic mutation affecting COL 1A genes

39. A 13-year-old male presented to the ED with an ankle fracture following a football injury. The foot is neurovascularly intact, an isolated closed injury. A CT was performed (Figure 20.23).

Figure 20.23 CT scans ankle

Concerning this injury which of the following is incorrect?

A. An epiphyseal screw is used in cases where there is displacement beyond 2mm and should be placed parallel to the physis
B. Angular deformity can be a consequence of the potential ensuing growth arrest of the tibia
C. Angular deformity can be a consequence of the potential ensuing growth arrest of the fibula
D. Because of the pattern of distal tibia physeal closure patients presenting with such fractures are generally older than those presenting with a Tillaux fracture
E. If total growth arrest occurs in this patient then he would have a leg length discrepancy of 9–12 mm according to the rule of thumb for growth

CHILDREN'S ORTHOPAEDICS I STRUCTURED SBA ANSWERS

1. Answer E. **Type IIc hip**
   This is type IIc according to Graf. This can be further classified into IIc stable and unstable. The sonographer should push on the leg upward and if the Beta angle moves to above 77°, then it is IIc unstable but if not, this is type IIc stable. See Table 20.2.

2. Answer E. **Treat for hip dysplasia as the hip US showed a significant dysplasia**
   Type IIc must be treated as there is a chance to progress to a full dislocation. Type IIa can be observed but treatment is recommended for other types.

3. Answer C. **Femoral varus osteotomy**
   Although all the mentioned options are recognised treatments of LCPD, the most appropriate is the femoral varus osteotomy. The hip is at risk (being a girl, age, stiff hip) and the hip is still in the sclerotic stage and started subluxing laterally. It needs effective containment that can last for the following stages (fragmentation and healing stages – around 12–18 months). None of the other options can provide this.

4. Answer D. **Southwick or Imhauser femoral osteotomy**
   The child has impingement symptoms evident by the pain getting worse with hip bending exercise (bicycle) and sitting for long distances. AVN is less likely after 4 years.

   Local anaesthetic and steroid injection to confirm the source of pain is useful if the clinical picture is not classic. Removal of metalwork has a high risk of complications in these patients, and it is not advisable. MRI scan is possible even with the screw *in situ* and if the screws are removed the MRI scan will still show abnormal signals for over a year. Hip arthroscopy to shave cam lesion is possible but it is not as effective as correcting the deformity using the Southwick or Imhauser femoral osteotomy.

   Surgical dislocation and femoral osteoplasty is excellent way to correct the deformity but the risk of AVN is prohibitive. In a child who has managed for nearly 4 years, a corrective extracapsular

Table 20.2 Graf Hip classification

Type	Alpha angle (α)			Beta angle (β)		Descriptions
I	>60°			<55°	Ia	Normal hip (at any age). This grade is further divided into (Ia; β <55°) and (Ib; β >55°). The significance of this subdivision is not yet established. Patient does not need follow up.
				>55°	Ib	
II	50–59°	IIa		<77°		If the child is <3 months. This may be physiological and does not need treatment; however, follow up is required.
		IIb		<77°		>3 months, delayed ossification.
	43–49°	IIc	Stable	<77°		Critical zone, labrum not everted. This is further divided into stable and unstable by provocation test.
			Unstable			
D	43–49°			>77°		This is the first stage where the hip becomes decentred (subluxed). It used to be called IId, but for the above reason, it is a stage on its own now.
III	<43°	IIIa				Dislocated femoral head with the cartilaginous acetabular roof is pushed **upwards**. This is further divided into IIIa and IIIb depending on the echogenicity of the hyaline cartilage of the acetabular roof (usually compared to the femoral head) which reflects the degenerative changes.
		IIIb				
IV	<43°					Dislocated femoral head with the cartilaginous acetabular roof is pushed **downwards**.

osteotomy has little risk of AVN and will give considerable relief.

5. Answer D. **Observation only with a 6-month follow up**
All the radiological parameters are not far from physiological (see Table 20.3). Observation is the best option (Figure 20.24).

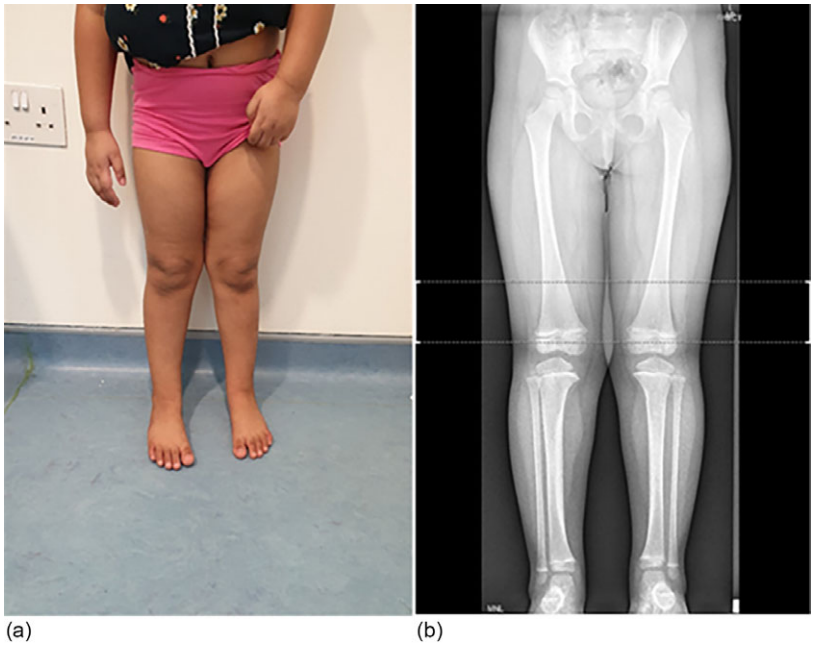
Table 20.3 Blount's disease radiological markers

Angles	Blount's disease	Physiological
Tibio Femoral Angle (TFA)	28±11°	22±8°
Mechanical Axis Deviation (MAD)	NA	NA
Epiphyseal-Metaphyseal Angle (EMA)	>20°	<20°
Metaphyseal Diaphyseal Angle (MDA) (also called TMDA where T stands for Tibial)	17±4°	8±4°
Femoral Metaphyseal Diaphyseal angle (FMDA)	7.4±5°	14±5°
Femoral Tibial Ratio of McCarthy (FTR)	0.48±0.4	2.6±3

6. Answer D. **Radialisation of the ulna age 9 month and pollicisation of the index finger at 18 months**
Amputation is not indicated even if reconstruction is not possible. Serial casting and bracing is a good initial treatment to bring the hand into a better position and stretch the skin, but it is not usually a long-term strategy unless the upper limb is not reconstructable (this is the case when the elbow is very stiff, and the hand does not reach the face) or the child has other serious comorbidities such as aplastic anaemia (Figure 20.25).

Centralisation of the ulna is usually possible, but 9 months is early. Moreover, free to transfer is not possible as there is no thumb at all.

Figure 20.25 Serial casting for radial club hand as a temporary measure



(a) (b)

Figure 20.24 (a) Clinical photo of the same child and (b) radiographs after 1 year

Radialisation of the ulna age 9 month and pollicisation of the index finger at 18 months is the usual approach for such a child. Radialisation (making the ulna a radius) is becoming more popular and has a lower recurrent rate and does not involve fusing the wrist, allowing some movement (Figure 20.26).

Bilobed skin flap alone to correct deformity is not effective but may augment other operations.

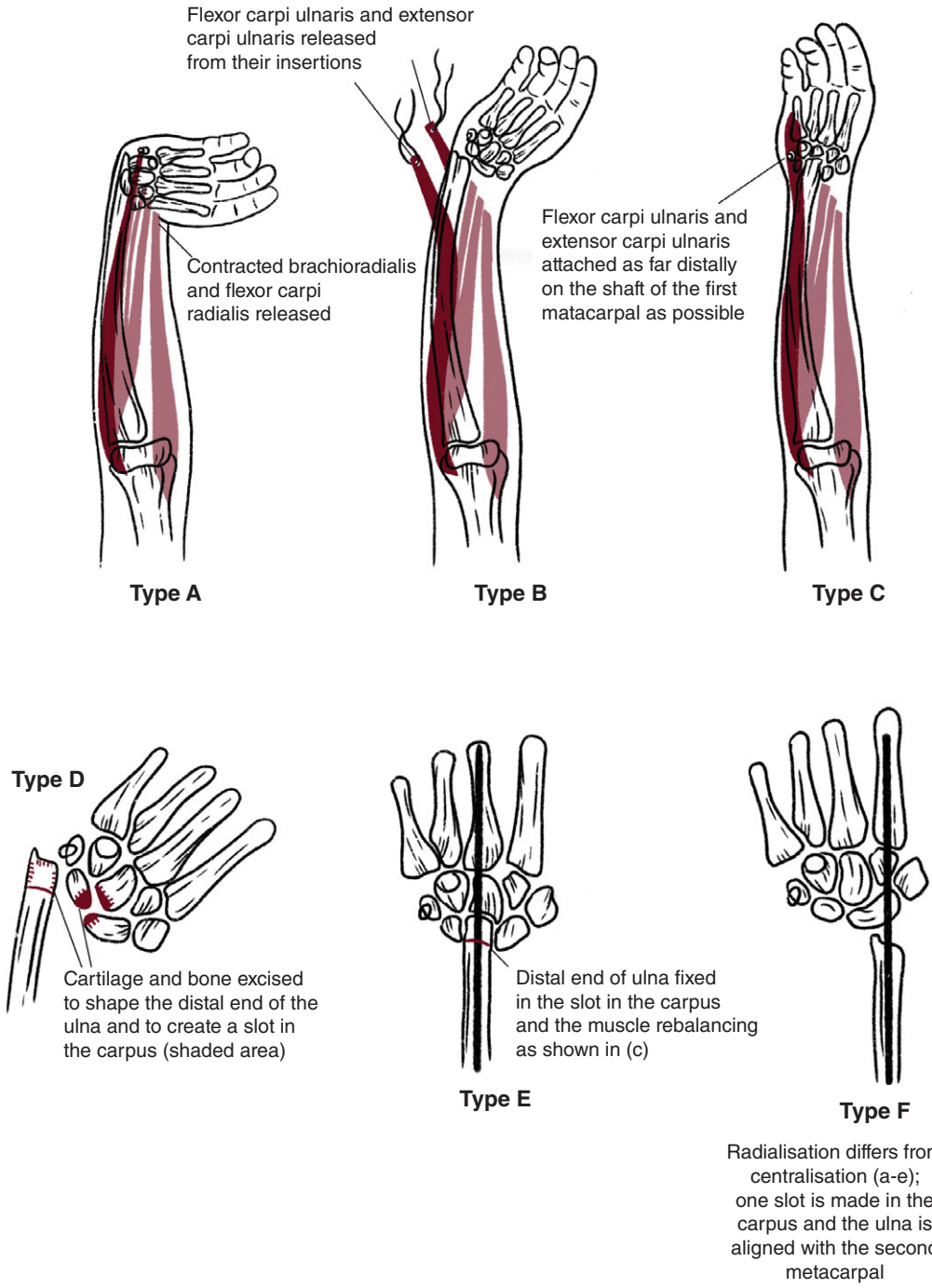


Figure 20.26 Radialisation of the ulna

7. Answer E. **Tibial in-torsion**
Tibial in-torsion is the most likely cause as the patella is pointing forward and the foot pointing inward indicating the twist is below the patella. The lateral border of the foot is straight excluding metatarsus adductus as a cause. The child has a hallux valgus (the big toe pointing outward) and not a hallux varus (the big toe pointing inward). It is impossible to comment on dynamic causes from a photograph (you need a video, clinical examination and EMG studies). Moreover, gracilis and tibialis anterior muscles can cause in-toeing and not biceps femoris.

8. Answer C. **Metatarsus adductus**
The difference between club foot and metatarsus adductus is the hind foot which is normal in the latter and in equinus in the former.

Calcaneovalgus foot is almost always abducted and not adducted, flatfoot is common in children, but these are usually flexible and not rigid. Pes cavus means a high arched foot which is not the case here.

9. Answer E. **Reassure parents and arrange a follow up in 6 months**
Although the parents' concern is legitimate, the clinical and radiological pictures are not that of lymphoma.

Lymphoma causes solid and not cystic lesions; the swelling does not transilluminate. These cysts are benign and do not require biopsy and excision unless they are causing symptoms. Haematologists are not the experts on popliteal cyst, orthopaedic surgeons are.

Some radiologists do sit on the fence when it comes to an MSK swelling as the question of whether the lesion is benign or malignant is based on clinical/histological and radiological information. However, in a proper setting when radiologists are supported by an MDT meeting of experts this can provide a very supportive report.

10. Answer D. **Intramedullary rod stabilisation is an essential part of treatment**
Intramedullary rod stabilisation has become an essential part of the treatment and it has been shown to reduce re-fracture rates and deformity substantively particularly with the new cross-union technique (Figure 20.27).

Figure 20.27 Cross union technique for treating tibia pseudoarthrosis

Change the brace for a well-padded carbon fibre brace; advising parents to encourage him with a different sport (swimming and cycling) are not good long-term options for children that we want to have as normal a life as possible.

A circular frame is a good option but not the best. Children at this age do not tolerate them very well and this can cause serious difficulties if the frame stays on for a protracted time which is usually the case in these children. Pin site infection, pin and wire loosening are common, stiffness and re-fracture rate is higher. It can be used for a short period of time to augment IM nail until union is solid.

11. Answer B. **Increased femoral anteversion**
He is likely to have miserable malalignment syndrome (but not definitely!). Here there is squinting patellae and external tibial torsion plus increased femoral anteversion. The correct answer is increased femoral anteversion because that is the *most likely* clinical finding as he would not be able to sit in the W-position without femoral anteversion.

This can be confirmed using Craig's test, which determines the femoral anteversion. The leg is used as the lever and the axis of the tibia as a reference. The examiner's thumb is placed on the trochanter and the palm of the hand on the buttock. The angle created by the leg to the

imaginary vertical line when the greater trochanter becomes most prominent on rotating the limb from maximum internal rotation to maximum external rotation is the angle of anteversion of the femur. Femoral torsion is described when this is above two standard deviations to the normal. Therefore, there will be excessive internal rotation in femoral torsion and restricted or absent internal rotation in retro torsion of the hip, as in congenital short femora.

12. Answer D. **The boy on the right has abductor muscle weakness**
The picture on the left is normal. The picture on the right shows a positive Trendelenburg test.

The boy on the right does have pes planus, however the photo is not demonstrating that.

13. Answer A. **Flattened lumbar lordosis**
The candidate should be able to pick up that this patient has scoliosis from the front. There is usually an increased lumbar lordosis.

When you show the candidate the photo from the back they will see that options A, B and C are correct (Figure 20.28).

He could have abnormal neurology but based on the photo the *most likely* best answer is A.

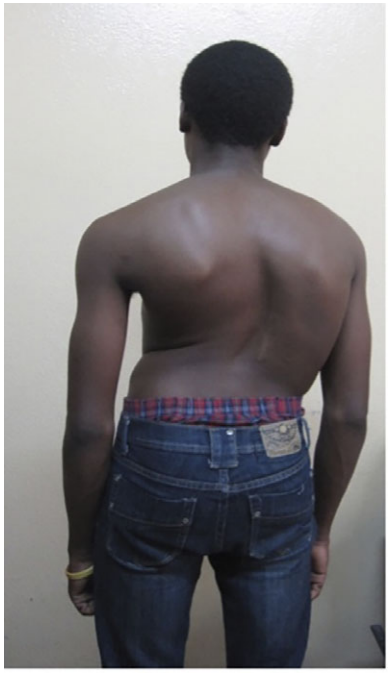


Figure 20.28
Clinical picture from behind

14. Answer A. **Block test is most reliable**
The use of a tape measure in leg length measurement is not helpful in patients with significant foot and ankle pathology where the shortening is coming from below the medial malleolus such as in subtalar arthritis or previous calcaneal fracture. In such cases the use of standing blocks is advised. In turn, blocks are inaccurate for measuring leg length discrepancies in patients with flexed flexion deformities of the lower limb.

15. Answer D. **Tight hamstrings**
This clinical photograph is of an adolescent which reveals an exaggerated lumbar lordosis. On closer inspection there is flattening of the buttocks with hip and knee flexion to compensate for the deformity. The patient has a high-grade spondylolisthesis at L5/S1.

In a high-grade slip, causing a kyphotic lumbosacral junction, the lordosis in the cranial segments will increase to restore balance of the spine in the sagittal plane. The pelvis will help to compensate by retroversion, requiring additional hamstring effort hence the spasm. Pelvic retroversion is limited by tight iliofemoral ligaments and so hip flexion is recruited to allow more retroversion. This requires knee flexion to put the feet back on the floor under the pelvis.

16. Answer C. **Leg length discrepancy**
These photos show bilateral Blount disease – most likely infantile. Also note the LLD.

Lateral thrust would usually be seen during weight bearing.

Short stature suggests the possibility of vitamin D refractory (hypophosphataemia) (distractor) rickets. The short stature is a distractor for a bone dysplasia, such as achondroplasia or metaphyseal dysplasia. This is highly unlikely to be the diagnosis given the clinical picture.

Blue sclera is a random distractor for osteogenesis imperfecta and not associated with infantile Blount. Internal tibial torsion not external.

Blount disease is a paediatric genu varum deformity. Infantile and adolescent forms are two types because of their variable presentation.

Infantile Blount is generally seen in children 2–5 years of age, males > females, bilateral 50% of cases.

Adolescent Blount disease, also known as adolescent genu varum, is more likely to be seen

in children >10 years of age, generally less severe, more likely to be unilateral. Infantile Blount disease is more frequent than adolescent Blount disease and typical of early walkers, Hispanics and Afro-Americans.

17. Answer A. **Absence of reciprocal arm swing**
The normal child begins to walk at 12–14 months of age. Initially, it is normal for the child to walk with a wide-based, externally rotated gait, taking numerous short steps. The gait then undergoes orderly stages of development.

Walking velocity, stride or step length and the duration of the single-limb stance increase with age and the number of steps taken per minute decreases. A mature gait pattern is well established by about 3 years of age, and the gait of a 7-year-old child resembles that of an adult.

The toddler has a broad base gait support, and appears to be high stepped and flat-footed, with arms outstretched for balance. The legs are externally rotated, with a degree of bowing.

Heel strike develops at around 15–18 months with reciprocal arm swing. Running and change of direction occur after the age of 2 years. In the school-age child, the step length increases, and step frequency slows. Adult gait and posture occur around the age of 8 years.

The toddler has a broad base gait for support, and appears to be high stepped and flat-footed, with arms outstretched for balance. The legs are externally rotated, with a degree of bowing.

Heel strike develops at around 15–18 months with reciprocal arm swing. Running and change of direction occur after the age of 2 years. In the school-age child, the step length increases, and step frequency slows. Adult gait and posture occur around the age of 8 years.

- Absence of reciprocal arm swing.
- Increased knee flexion in stance.
- Lack of heel strike – flat foot strike instead.
- Leg externally rotated in swing.
- Stride shorter, speed lower and cadence higher.
- Wider base of support.

18. **Answer C. Lifting the child up from under their arms**
This is a vertical suspension test.

Analysis of preoperative flexibility in scoliosis is needed to classify the curves, determine their structure, and select the fusion levels during preoperative planning.

The flexibility of the curve can be estimated by bending the spine left and right or if the child is an infant by the vertical suspension test.

Option D is for older children.

An infant that is less than a year is not able to walk or stand.

For non-walkers, vertical suspension is the only feasible option to assess flexibility.

The issue of assessing the flexibility of scoliosis curves is essentially one of deciding how much of the spine needs to be corrected and how much will correct itself once the primary structural curve is corrected. In the typical adolescent idiopathic scoliosis, you have a right thoracic curve with a compensatory left lumbar curve. If that lumbar curve remains flexible, then when you correct the thoracic curve, the lumbar curve will automatically correct itself and does not need to be fused.

This question is about experience in scale clinics where there are practical difficulties assessing the flexibility of curves in those patients in whom it is difficult to get them to follow instructions (neuromuscular and infants).

The best answer is to lift the patient under their arms; they are used to it, and it will work.

Options A and D – the infant may not be able to follow instruction.

Option A – this exaggerates curve for easy detection (Adam's forward bend).

Option E – will not work as this is the wrong way up to access flexibility.

There is a potential problem with the question in that in the infant group, you are probably not thinking of fusion, so assessing flexibility/selection of levels is less important.

19. Answer A. **Patient is prone and the knee is gradually flexed and the elevation of the hemipelvis with knee flexion**
Option A is the correct answer, and is the Duncan–Ely test for tight rectus femoris, the examiner feels the tightness of the rectus femoris and assesses the subsequent elevation of the hemipelvis.

Option B does not follow any recognised test patterns.

Option C is measuring the popliteal angle for hamstring tightness (normal <20).

Option D is Ober test for IT band and abductor tightness.

Option E is the modified popliteal angle again for hamstring tightness.

20. Answer D. **In flexible recurrence and after completing the corrective intervention, the foot can be maintained in an ankle foot orthosis and not necessarily in a foot abduction brace/boots and bars**

It is imperative to differentiate between a flexible and rigid recurrence. In a flexible recurrence where the foot alignment is correctable but the foot tends to go into supination in swing phase (dynamic supination) the treatment is usually a tibialis anterior transfer which could be combined with a TA lengthening or tenotomy depending on whether there is an associated equinus deformity. Thereafter the foot could be maintained in an AFO to prevent plantar flexion rather than boots and bars especially as children start getting older and less tolerant of boots and bars, hence making option D the correct answer.

Option B is incorrect because a tenotomy is very likely to be needed after repeat casting.

Option C is incorrect as repeat casting works better in rigid deformities where the casting helps correcting the anatomical deformity rather than the dynamic muscular imbalances (the recurrence is often combined and sometimes short-term casting is needed before tibialis anterior transfers).

Option E is incorrect because whilst this is the standard setup for the foot abduction brace used in most cases, atypical clubfoot is treated with different boots and bars settings where the abduction is maintained at 30–40° rather than 70.

21. Answer A. **A ball and socket ankle deformity can develop due to the mechanical impact of the underlying pathology**

The correct option for this SBA is dependent on understanding the different types of tarsal coalitions and their relative treatments. Recurrent sprains especially in 10–15-year-olds should raise the suspicion of tarsal coalitions. A 'C' sign on a lateral view is highly suggestive of talocalcaneal coalition whereas a prominent anterior process or anteater sign is suggestive of a calcaneonavicular coalition.

Option A is the correct answer where sometimes due to the stiffness of the subtalar joint a ball and socket joint develops. The surgical options are excision of the coalition or a subtalar fusion, there are no solid guidance but it is generally accepted to fuse if the coalition involves more than 50% of the middle facet of the calcaneus.

Option C is excision of a C-N coalition rather than a T-C coalition, through a lateral approach and elevation of EDB.

The amount of pes planus that is usually associated with coalitions does not significantly impact on the choice of excision versus fusion although flatfoot correction surgery might be needed separately, making option D incorrect. Option B is relevant in traumatic lateral instability, and option E pertains to the T-N coalition.

22. Answer D. **The patient is having inadequate eccentric contracture on the tibialis anterior in the first rocker of the stance phase of gait**

Calcaneal gait is due to weakness of the calf muscles leading to the ankle being dorsiflexed in terminal stance with the first rocker and second rocker not affected. Calcaneal gait or deformity can be a significant complication after heel cord lengthening.

The weakness can be due to CP, polio myositis, and also iatrogenic with overlengthening of the calf.

Calcaneus gait is also a known complication of surgical treatment of clubfoot.

The correct answer is D where tibialis anterior is not affected.

23. Answer C. **The patient should be assessed for packaging disorders especially DDH**

The described deformity is vertical talus, and the treatment is reverse Ponsetti to plantarflex and invert the foot followed by soft tissue releases, open reduction and K-wire stabilisation. However, the surgery is usually delayed until 1 year of age. X-rays are important to differentiate between vertical and oblique talus. An oblique

talus could be initially treated with observation and monitoring. Finally, it is associated with DDH and other packaging disorders alongside neuromuscular disorders and spinal dysraphism, making option C the correct answer.

24. Answer A. **Abdominal pain and vomiting after applying the cast should raise concern of a condition that is seen after scoliosis correction surgery**

Knowing how to apply an adequate hip spica cast is essential for a day one general trauma consultant in a DGH.

Superior mesenteric syndrome is seen after scoliosis surgery and occasionally encountered after spica cast application due to excessive lordosis.

Option B is incorrect as the alignment may change but one can always attempt wedging the cast in the first 2 weeks.

Option C is incorrect as this position although helping with traction has been found to be associated with compartment syndrome and hence has fallen out of favour.

Option D is incorrect as the acceptable parameters are: 10° varus, 2.5cm shortening, 20° anterior bow (physiological is about 8°) and 10° posterior bow, and as the tendency is for the femur to slip into varus the cast is applied in mild valgus.

Option E is partially correct but not the best option. A spica is not applied beyond the age of 6 and hence almost all patients are expected to have plenty of growth left when the cast is applied.

25. Answer D. **Surgical intervention is likely to include tibilais posterior transfer to the dorsum of the foot**

This SBA is about a child with Duchenne muscle dystrophy.

Option D is the correct answer as surgical intervention is usually performed for equinovarus foot and for hip abduction and flexion, and includes TA lengthening, Tib post transfer to the dorsum of the foot, IT band lengthening, rectus and sartorius release. Hence option C is incorrect.

Option E is incorrect as absent reflexes are suggestive of spinal muscle dystrophy which differentiates this from Duchenne.

Option B is incorrect as surgeons generally perform soft tissue releases only with the aim to prolong weight bearing as much as possible; in all cases a lateral column lengthening is performed in a plano-valgus foot not an equinovarus foot.

Option A is incorrect as whilst cardiomyopathy is associated with Duchenne and although there are inconclusive data suggesting higher prevalence of malignant hyperthermia in Duchenne, these factors are not absolute contraindications to operating in affected children especially at age 7 years. The older the child the higher the risks, especially with deteriorating respiratory function.

26. Answer A. **Acute correction of a similar deformity secondary to an infection of the distal humerus is different from the acute correction of such deformity due to a fracture**

This is a gunstock deformity and most likely due to a supracondylar fracture that has malunited due to slipping secondary to medial column comminution when fixed with lateral wires. Initial reduction is usually adequate but the fracture slips laterally due to the medial comminution which is therefore best held with cross K-wires. The gunstock deformity does not remodel but is not usually associated with functional compromise and patients and families usually request surgical correction primarily for cosmetic reasons.

Finally, if a varus deformity is due to a medial growth arrest secondary to infection it is not usually associated with the hyper-extension and internal rotation seen in cubitus varus and more importantly the deformity is progressive and the management has to include removal of physeal bridges as opposed to wedge and translation osteotomies used in post fracture malunion cubitus varus. Hence option A is the correct answer.

27. Answer C. **Regarding the left hip an open reduction is likely to be needed for the hip and then depending on stability and movement in the joint a decision could be made regarding the need for a proximal femur osteotomy**

The radiographs demonstrate a dislocated left hip with a subluxed right hip. The intervention for the dislocated left hip varies from reducing

the hip with a varus osteotomy that also entails shortening to bring the femoral head down to the joint and external rotation due to the excessive femoral anteversion. The acetabulum is shallow with the defect being posterior and lateral therefore the need for an acetabular osteotomy in the form of a Dega osteotomy. The other option is excision arthroplasty required if the head has become deformed or arthritic and will not fit smoothly into the acetabulum therefore causing pain. This is the case if the head has been chronically dislocated for a long time or if the head has become arthritic due to bony erosion against the acetabulum. An arthrogram will demonstrate arthritic features and will sway the decision.

Finally, both a femoral osteotomy or an excision arthroplasty includes excision of all or part of the proximal femur (the shortening component) with the lesser trochanter being mobilised and usually excised, hence the psoas is released at the level of the lesser trochanter and surgeons do not need to dig into the groin to release it.

Option C is incorrect (hence the correct answer) as an open reduction is not usually needed with the varus and shortening usually sufficient to reduce the hip and the acetabular osteotomy then improving coverage.

28. Answer B. **If the abnormality is at the centre of the physis then a metaphyseal window might be needed**.
This is a physeal bar formation and it is due to injury to the reserve or proliferative zone. Treatment depends on the expected remaining growth and the size and location of the physeal bar. With growth of more than 2 years and a bar of less than 30% of the physis the bar could be removed and grafted with fat or cement to prevent recurrence. The technique for excision of the bar is dependent on the location where a peripheral bar can be approached directly (laterally or medially) whereas central bars are approached through a metaphyseal window and the cancellous bone is then curetted (hence option B is the correct answer) and the bar is drilled with a high-speed burr but irrigation and alternate burring is used to reduce the chances of thermal damage to the physis.

Growth modulation is not used in such cases and if deformity correction is needed then osteotomies and acute or sequential frame corrections are used.

29. Answer B. **Olecranon fractures are uncommon and when present should be treated with plating rather than TBW**
The patient has osteogenesis imperfecta (OI), the medical treatment is bisphosphonates, the mechanism of which is described in option C (nitrogenous bisphosphonates). Non-union fractures have been reported in up to 25% of fractures and 52% of osteotomies in OI and many stabilisation techniques result in additional surgery due to refracture. Non-union fracture healing and delayed healing in OI increase in frequency as patients go into early adulthood. Even when OI patient fractures do successfully heal, refractures typically go unreported. Abnormal mechanical axis is very significant in OI patients as it leads to a progressive deformity due to microfractures. Olecranon apophysis avulsions are very common in OI and the treatment is TBW rather than plates because plates can cause a stress riser.

Moderate-to-severe OI long bones tend to undergo angular deformation with or without a fracture, even when they harbour IM rods. The tibia tends to develop anterolateral bowing, while the femur anterior/varus angulation and/or retroversion, and the humerus varus angulation and/or internal rotation deformity. If the long bone deformity is so severe that it interferes with limb function or adjacent joint motion, an elective surgery for deformity correction may be indicated to straighten the long bone.

Coxa vara is prevalent that can lead to disadvantaged weaker abductors.

Cho TJ et al. Management of osteogenesis imperfecta: a multidisciplinary comprehensive approach. *Clin Orthop Surg.* 2020;**12**:417–429.

30. **Answer E. Sickle cell dactylitis**
Dactylitis, or hand-foot syndrome, is an episode of vaso-occlusive pain in small bones of the hands and feet that typically develops in children younger than 4 years with sickle cell disease, as at later ages, the haematopoietic tissue in these locations is replaced by fibrous connective tissue and fat.

Vaso-occlusive bone pain often constitutes the onset of sickle cell disease. It presents with pain and oedema and is often accompanied by

mild erythema and low-grade fever. Radiographic examination usually only shows soft-tissue oedema in the early stages and may show bone abnormalities at a later stage. It is not seen after age 5 years because haematopoiesis in the small bones of the hands and feet ceases at this age. Osteomyelitis is the major differential diagnosis. Radiographs show a periodic reaction at the main and little finger metacarpal bones.

Cortical thinning and destruction of the metacarpal appear on radiographs 3–5 weeks after the swelling begins. Leucocytosis or erythema does not accompany the swelling.

31. Answer A. **CRP 25 mg/l**

This SBA deals with septic arthritis.

With Kocher's criteria, one point is given for each of the following four criteria: (1) non-weight bearing on affected side; (2) ESR >40; (3) Fever >38.5°C; (4) WBC count >12,000/μl.

The likelihood of septic arthritis increases with scores from 1–4 by the following percentages:1 (3%); 2 (40%); 3 (93%); 4 (99%).

Recent studies have shown that inability to bear weight, and a CRP >20mg/l is just as effective at diagnosing septic arthritis.

A CRP >20 mg/l was the strongest independent risk factor for septic arthritis (odds ratio 81.9, p <0.001). A multivariable prediction model revealed that only two determinants (weight-bearing status and CRP >20 mg/l) were independent in differentiating septic arthritis from transient synovitis.

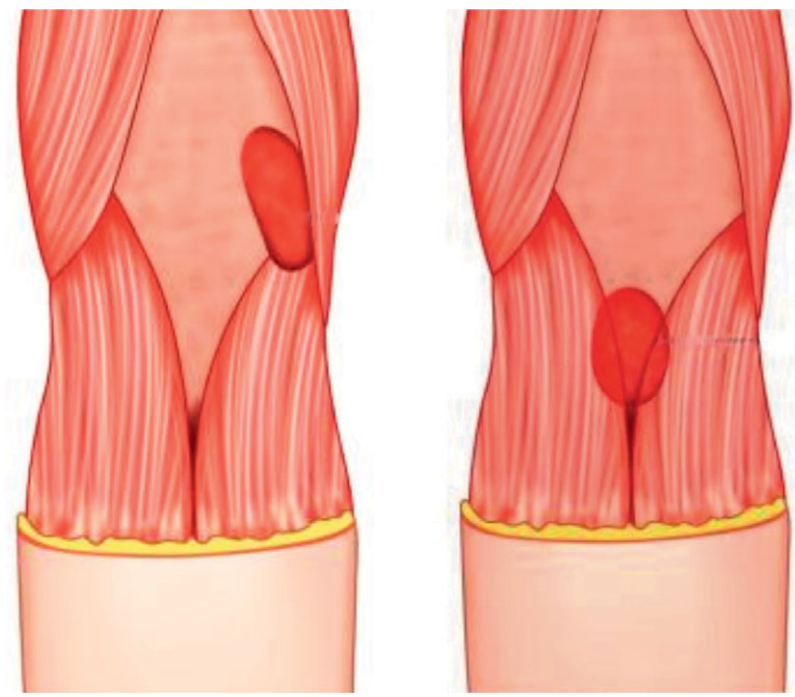
Singhal R et al. The use of CRP within a clinical prediction algorithm for the differentiation of septic arthritis and transient synovitis in children. *J Bone Joint Surg Br.* 2011;**93**:1556–1561.

32. Answer E. **Semimembranosus bursa**

A semimembranosus bursa is located medial to the midline and above the joint line (Figure 20.29 (a)).

A popliteal cyst is due to synovial herniation or rupture between the capsule and oblique popliteal ligament. It is a cystic swelling containing gel-like fluid in the lower midline of the popliteal fossa at the level of joint or just below. It is smooth, soft and cystic, not often transilluminate tender swelling. On flexion the swelling disappears and on extension the swelling increases in size. There may be arthritic changes within the knee.

A semimembranosus bursa is a cystic swelling in the upper medial aspect of the popliteal



(a) (b)

Figure 20.29 Location of the swelling (a) semimembranosus bursa and (b) popliteal cyst

fossa under the semimembranosus tendon. It is said to be due to friction under the tendon causing a bursitis.

It is located between semimembranosus tendon and femoral condyle above the knee joint line. It is common in young adults. It is the most common swelling of the popliteal fossa. It is non-tender, cystic/tensely cystic (firm) swelling located above and on the medial aspect of the popliteal fossa, fluctuant, non-compressible, often transilluminating with a fluid thrill. When it enlarges it comes out of the semimembranosus tendon to become subcutaneous.

The contents of the bursa do not communicate with the knee joint. The swelling becomes tense when the knee is extended. The joint is normal.

A popliteal aneurysm is usually asymptomatic. If patients exhibit chronic symptoms, these are usually secondary to mass effect and compression of adjacent structures, such as the tibial nerve, which causes leg pain or paraesthesias. The popliteal vein also may be compressed, which causes calf swelling. Progressive luminal narrowing of the popliteal artery from thrombus formation may cause an insidious onset of claudication.

33. **Answer A. Further examination could reveal radial head dislocation**

The diagnosis is hereditary multiple exostosis (HME). He has bilateral knee swellings in the photograph.

Radial head dislocation is commonly seen in HME. Osteochondromas found in the forearm, can lead to unbalanced shortening of the ulna, with consequent higher curved radius. That often impairs function with a progressive limitation pronation. Shortening of the ulna, also can cause subluxation or dislocation of the radial head.

Option B is incorrect because at 16 he will have stopped growing.

Option D is a distractor. A subperiosteal haematoma is a possibility but would be unilateral not bilateral.

The condition is AD not recessive.

Hereditary multiple exostoses (HME is characterised by the presence of multiple exostoses (osteochondromas).

An osteochondroma is a benign tumour with a cartilage-capped bony outgrowth, which is broad-based (sessile) or stemmed (pedunculated) and is made up of cortex and a marrow cavity both continuous with the host bone. The pedunculated osteochondromas are always directed away from the growth plate and the joint. In broad-based osteochondromas it can be difficult to differentiate the tumour from the normal underlying bone. The most common location for osteochondromas is at the lateral side of the most active growth plate of a long bone. Osteochondromas develop and increase in number and size during childhood until closure of the growth plates. Osteochondromas can be associated with a reduction in skeletal growth, bony deformity, restricted joint motion, shortened stature, premature osteoarthrosis and compression of peripheral nerves.

MHE is a relatively rare autosomal dominant disorder, mainly caused by loss of function mutations in two genes: exostosin-1 (EXT1) and exostosin-2 (EXT2). Most patients present with an average of 6 exostoses.

Yochum and Rowe (1987) suggest that malignant transformation is noted in 1% of solitary osteochondromas, and in 20% of cases of HME. Flatt (1955) is less specific, inferring that malignant degeneration occurs in 5–25% of cases. Wilner (1982) believes that malignant degeneration occurs in 10–20% of cases, with an average age of 36 years at the time of diagnosis.

Flatt AE. Chondrosarcoma supervening on diaphyseal aclasis. *J Br Surg*. 1955;**43**:85–87.

Yochum TR, Rowe LJ. *Essentials of Skeletal Radiology*, 793–797. Baltimore, MD: Williams and Wilkins; 1987.

Wilner D. *Radiology of Bone Tumors and Allied Disorders*. Philadelphia, PA: W.B. Saunders; 1982.

34. Answer D. **Follow up 1 year**

The most likely diagnosis is adolescent idiopathic scoliosis (AIS). A 3-dimensional spinal deformity with a lateral curvature $>10°$. A Risser grade 5 is ossification fused to iliac crest indicating full maturity. It is highly unlikely corrective scoliotic surgery would be offered following a new patient first-time clinic appointment. Key feature in the assessment of scoliosis is whether a curve is flexible or rigid and whether a curve is structural or compensatory.

MRI is indicated to rule out intraspinal abnormalities and should extend from the posterior fossa to the conus medullaris.

Indications for MRI include:

- Atypical curve patterns (left thoracic curve, apical kyphosis, short dystrophic curve pattern).
- Rapid progression on serial radiographs.
- Asymmetrical abdominal reflexes.
- Structural abnormalities seen on plain radiographs (e.g. hemivertebra/block vertebra.
- Neurological symptoms or severe pain.
- Foot deformities.

The natural history is that before skeletal maturity curves >25° continue to progress and should be monitored. After skeletal maturity thoracic curves >50° progress by 1–2°/year and lumbar curves >40° progress by 1–2°/year. Rate of progression is related to skeletal maturity, as measured by Rissler grading. Rissler 0–1 covers the first two-thirds of pubertal growth and the greatest velocity of skeletal linear growth.

Observation for AIS is the most common approach used for patients with mild deformity (Cobb angle <25°). Depending on the degree of skeletal maturity patients are reviewed every 4–6 months to look for curve progression.

The primary goal of bracing for scoliosis is to halt curve progression. The most widely accepted practice for bracing recommends that patients with curves 25–45° and in the most rapidly growing stage (Risser stage 0 or 1) should be offered a brace on initial evaluation.

Surgery is indicated to treat a significant clinical deformity or to correct a scoliotic deformity likely to progress. Surgery is recommended in adolescents with a curve that has a Cobb angle greater than 45–50°. This is based on studies that have shown that curves >50° tend to progress slowly after maturity. Management should be decided after an MDT.

The patient should not be discharged and should have a follow up at 1 year to determine curve progression.

CT is performed for an evaluation of segmentation abnormalities with 3D reconstructions, though MRIs have largely replaced these scans. CT is also used to evaluate post-operative complications because MRIs may show metallic artefact.

35. **Answer A. Diaphyseal aclasia**

Madelung deformity (MD) of the wrist is characterised by a growth disturbance in the volar-ulnar distal radial physis that results in a volar and ulnar tilted distal radial articular surface, volar translation of the hand and wrist, and a dorsally prominent distal ulna.

Bone dysplasias associated with MD include the following:

- Multiple hereditary exostosis.
- Ollier disease.
- Achondroplasia.
- Multiple epiphyseal dysplasias.
- Mucopolysaccharidoses (e.g. Hurler and Morquio syndromes).

Secondary causes of wrist deformity that may mimic MD include the following:

- Sickle cell disease.
- Infection.
- Tumour.
- Rickets.

Enchondromatosis (Ollier disease) is a benign but debilitating condition in which foci of physeal cartilage are displaced through the metaphysis into the diaphysis, causing weakening of the bone due to expansile, non-ossified lesions. Clinical problems caused by enchondromas include skeletal deformities, limb-length discrepancy, and the potential risk for malignant change to chondrosarcoma. The condition in which multiple enchondromatosis is associated with soft-tissue haemangiomas is referred to as Maffucci syndrome.

Hereditary multiple exostoses (HME) or diaphyseal aclasia is an inherited disorder characterised by the formation of multiple osteochondromas, which are cartilage-capped osseous outgrowths, and the development of associated osseous deformities.

36. Answer C. **Nothing further**

Brodie's abscess is a subacute or chronic variant of osteomyelitis usually involving the metaphysis of long bones. The clinical presentation is often atypical, and the diagnosis can be challenging.

No further treatment is needed as curettage is curative of the condition.

37. Answer D. **Examining the mobility of the calcaneonavicular joint**

The correct answer is D, as rigidity in the Chopart joints in children is usually due to tarsal coalition which will lead to pain and a degree of pes planus but not typically associated with tip toe walking.

Option A: Undetected DDH can lead to a shorter limb leading to unilateral toe walking to compensate, on hip examination DDH could be manifested by limited or asymmetric abduction as well as limited rotational range if movement.

Option B: autism spectrum is well associated with tip toe walking.

Option C: Duchene muscle dystrophy is also associated with toe walking as it develops.

Option E: neuromuscular disorders such as cerebral palsy are associated with tip toe walking, however one has to be careful with surgical management such as gastrocnemius lengthening as it could be associated with unrecoverable weakness in those conditions.

38. Answer D. **The fracture morphology suggests that you should look for bucket handle fractures**

The correct answer is option D; transverse fractures are highly suggestive of NAI. Metaphyseal corner fractures, or bucket handle fractures, are observed in young children, less than 2 years old. It is suggestive of NAI.

Option A is incorrect as at 1 year old the recommended treatment option would be a spica cast however in older children flexible intramedullary nails work best in longitudinally stable factures

Option B is incorrect as rotational deformity does NOT remodel and cannot be accepted.

Option C is not correct as the usual sequalae is overgrowth of the affected side.

Answer E is incorrect as although OI is definitely one of the differential diagnoses it is rare when compared with NAI.

The biomechanics involves the cumulation of multiple microfractures across the metaphysis with an orientation perpendicular to the long axis of the bone. To-and-fro manipulation (shaking) is the force applied, for example holding the child around the trunk while shaking, with the limbs moving back and forth with a resultant whiplash or shear force. The microfractures occur in immature mineralised bone.

This injury occurs usually occur in children under 2 years of age because they are small enough to be shaken and cannot protect their limbs.

39. Answer D. **Because of the pattern of distal tibia physeal closure patients presenting with such fractures are generally older than those presenting with a Tillaux fracture**

The right answer (i.e. the **incorrect** statement) is D. The last part of the physis to close is the anterolateral part leading to Tillaux fractures, hence patients with a Tillaux fracture will be older than patients with a triplanar fracture such as the one in Figure 20.23.

Answer A is generally accepted as correct, the choice of treatment is dependent on injury factors and patient factors, but epiphyseal widening of more than 3mm is generally accepted as an indication to treat with a transepiphyseal screw.

Answer B and C are both true statements, partial tibial growth arrest (medial or lateral) can lead to a varus/valgus deformity, and distal fibula growth arrests can also lead to a valgus deformity.

Chapter 21

Children's Orthopaedics II Structured SBA

Rebecca Critchley and James Fernandes

CHILDREN'S ORTHOPAEDICS II STRUCTURED SBA QUESTIONS

1. You see a 12-year-old girl in your outpatient clinic. Her main complaint is that one leg is bigger than the other and she does not like the fact that it is discoloured (Figure 21.1). Her mum mentions that she had a very subtle red mark on her face when she was born.

Figure 21.1 Clinical picture lower limbs

This condition is usually associated with:
A. Clinodactyly
B. Congenital trigger thumb
C. Camptodactyly
D. Boutonnière deformity
E. Webbing of the toes on the affected side

2. You see a 9-year-old boy in clinic who presents with an unsteady gait and difficulty in playing football, he also complains of clumsiness and lateral foot pain (Figure 21.2). Dad says that his big brother has funny looking feet.

Figure 21.2 Clinical picture demonstrating medial border foot

This condition?
A. Is associated with an intact myelin nerve sheath but Wallerian axonal degeneration
B. Is hereditary motor sensory neuropathy 2 (HMSN2)
C. Peroneus brevis is the driving force of the first ray plantarflexion
D. The chromosome affected encodes peripheral myelin protein 22 (PMP22)
E. This is an autosomal recessive condition but can be associated with sporadic duplications of chromosome 17

3. You are doing a hip scanning clinic with the advanced nurse specialist and have just scanned a 3-week-old baby. Following review of the images, you appropriately diagnose a left sided DDH and place the baby in a Pavlik harness (Figure 21.3).

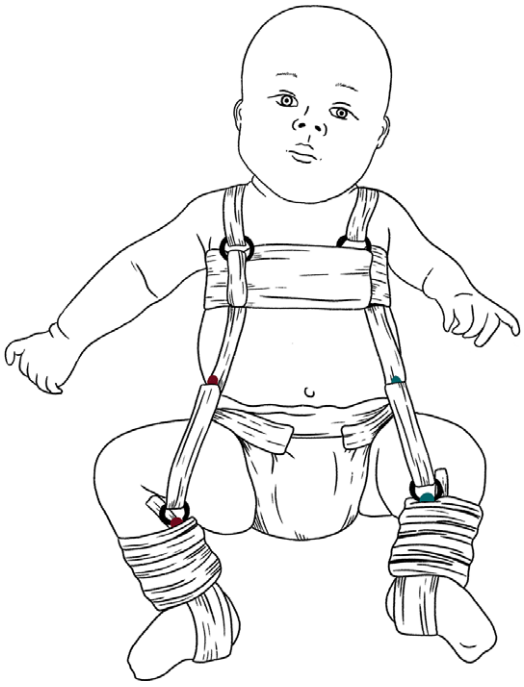


Figure 21.3 Pavlik harness

When assessing the Pavlik harness?

A. The central strap should lie just distal to the nipples
B. The foot stirrups are not sided and can be placed on either foot
C. The foot stirrups should be applied first in order to confirm correct foot sizing
D. The hips should be in 115° of flexion but not more due to the risk of femoral nerve palsy
E. The line of pull of the anterior straps should follow the anterior axillary line on each side

4. Dad brings the baby back to clinic a week later with a decreased movement in their right leg.

The most appropriate course of action would be to:

A. Remove the harness on both sides to reduce the risk of progressive avascular necrosis
B. Remove the harness on the right (affected) leg and await resolution
C. Repeat the ultrasound scan to check that the hip is not dislocated
D. Reposition the harness taking care to place the hips in Ramsey's safe zone
E. Review the patient for compartment syndrome if the strap is too tight

5. **Concerning development of the hip.**

A. At 9 weeks of gestation, a cleft develops in the precartilaginous cells
B. At 9 weeks of gestation, a cleft develops in the precartilaginous cells. This cleft becomes the labrum
C. By 3 months of age the proximal femoral ossification centre appears
D. By the 11th week of gestation, the hip is fully formed although not fully developed
E. The acetabulum and femoral head develop from a common myeloid progenitor cell

6. You see an 8-year-old boy in clinic who presents with a symmetrical scapulae and complains that he struggles to look up (Figure 21.4).

Figure 21.4 Clinical picture

Which of the following best describe the condition?

A. It can be associated with Arnold-Chiari malformation, diastematomyelia and renal aplasia
B. It is paramount to obtain a full spinal X-ray and MRI to rule out scoliosis and tethering of the cord distally
C. The patient should abstain from contact sports if C2 is involved or if long fusions are present

Figure 21.5 (a) Anteroposterior (AP) and (b) lateral radiographs knee

D. This condition can occur due to incarcerated, block or bony bar cervical spine vertebrae
E. This condition is known as Klippel–Feil syndrome and is associated with a Sprengel deformity, as seen here

7. You review a 14-year-old girl in the ED, she was playing football when she hyperextended her knee and rotated it. She developed an effusion and was unable to continue playing the match due to pain. On examination, she is holding her knee in flexion due to pain. She is unable to weight bear. Her radiographs are shown in Figure 21.5.

The most appropriate next step is:

A. A block to flexion beyond 90° is an indication for operative intervention
B. The patient can be reassured and sent home with RICE advice
C. The patient can be treated conservatively if the fracture reduces in an above knee extension cast. Full weight bearing
D. This injury occurs due to incomplete ossification of the intercondylar eminence. This makes the bone more likely to fail than the ligament
E. This is a type 4 injury and needs operative intervention either arthroscopic or open

8. **Regarding the radiograph in Figure 21.6.**

A. Ossification goes from anterior to posterior with the final stage 4 being full fusion

Figure 21.6 Anteroposterior (AP) radiograph pelvis skeletally immature patient

B. Ossification goes from posterior to anterior with the final stage 5 being full fusion
C. Risser 0 and 5 cannot be differentiated as there is no ossification centre seen on X-ray
D. Risser 1 usually appears around age 11 in girls and 13 in boys
E. Risser's sign is based on the iliac crest being divided into 5 quadrants

9. As the paediatric orthopaedic registrar, you are called to see a patient with left thigh swelling. Of note, it was a normal vagina delivery (NVD) but breech presentation.

You review the radiograph (Figure 21.7).

A. The patient has a partially dislocated left hip
B. These X-ray findings are in keeping with osteogenesis imperfecta given the sclerotic

Figure 21.7 Anteroposterior (AP) radiograph pelvis skeletally immature patient.

looking bone and suspicion of Erlenmeyer shaped distal femora
C. This is an age-appropriate X-ray with normal findings
D. This patient can be expected to develop genu varum
E. This patient needs a referral to haematology, genetics and paediatrics

10. You are the on-call orthopaedic registrar and see an 8-year-old child in the ED. They are normally fit and well and fell off the monkey bars at school. They are systemically well and present with hip pain.
At what age does the triradiate cartilage fuse?
A. 18 years
B. 15 years
C. 9 years
D. 7 years
E. 1 year

11. You are asked to see a 7-year-old child in the ED with a painful, swollen sole of their foot. The child jumped on something sharp 5 days ago when playing in the basement. The child was wearing socks and trainers at the time.
Regarding the injury:
A. I would expect the bacterial load from any infection to be less, given the protection offered by the socks and trainers
B. I would have a low threshold to wash the wound out given the risk of *Pseudomonas aeruginosa*
C. If the injury occurred outside there is a risk of *Eikenella corrodens* infection
D. Start the patient on broad-spectrum antibiotics and arrange outpatient clinic appointment for a week
E. The infection could have been cause by an encapsulated, Gram-positive, strict anaerobic, rod-shaped bacterium

12. You attend the joint genetics, paediatrics and orthopaedic specialist clinic.
You see a 14-year-old boy with rhizomelic short stature, lumbar stenosis and frontal bossing. He attends with his dad and presents with back pain.
A. This condition is caused by the absence of FGFR3 gene
B. The abnormal mutation encodes for fibrin growth factor receptor 3 gene
C. This disorder affects the proliferative zone of the physis
D. This disorder affects the reserve zone of the physis
E. This most common skeletal dysplasia is autosomal recessive but can be x-linked autosomal dominant

13. You are called to see a limping child in the ED with new-onset unilateral positive foot progression angle. The child is systemically well and bloods are normal. They deny any sinister symptoms and have had no recent trauma.
A. In the first instance you would get a foot and ankle X-ray
B. The physeal layer involved will be the maturation zone
C. This may be a normal variant
D. You predict the child will be a boy, obese and around 13 years old
E. You would expect Kocher's criteria to be 4

14. You see a 6-year-old girl in the ED, she is normally fit and well. She fell off the monkey bars at school. She presents with pain and reluctance to move the lower right leg (Figure 21.8).

Figure 21.8 Anteroposterior (AP) radiograph tibia

Which of the following statements applies?

A. Children can often develop a varus deformity following this fracture (Cozen's phenomenon)
B. If the child develops a valgus deformity (Cozen's phenomenon) then a varus producing osteotomy is normally performed prior to completion of growth
C. The valgus deformity normally corrects itself by 1–2 years
D. These are classified as toddler fractures in the young
E. These fractures do not result in deformity due to the excellent metaphyseal blood supply

15. A GP has referred a 3-month-old baby with clicky hips and asymmetrical skin creases. She was born full-term by caesarean section as she was breech. Mum did not take folic acid prior to pregnancy.

The next most appropriate course of action would be?

A. Examine the patient to confirm there are no signs of spinal dysraphism
B. List her for arthrogram plus closed reduction and application of spica cast
C. Perform US scan in clinic and place in a Pavlik Harness if indicated
D. Perform an X-ray of the pelvis to rule out DDH
E. Request an MRI scan to rule out spina bifida

16. You see a 9-month-old girl in ED. She is pyrexic, lethargic and tachycardic. Her CRP is 72 and WBC 24. She is normally fit and well and her immunisations are up to date. The only thing of note is that she has dry scabs from chickenpox last week.

What organism must you rule out?

A. Group A streptococcal infection
B. Group B streptococcus
C. *Haemophilus influenzae*
D. *Neisseria gonorrhoeae*
E. *Staphylococcus aureus*

17. During your on call you were asked to review a baby in ED. The baby is septic and appears to have a painful left hip.

Which of the following applies?

A. If the child is fully immunised at 1 year of age the organism could be *Haemophilus influenzae* as this can only be ruled out following later immunisations
B. If the child is unimmunised at 1 year of age the likely diagnosis would be *Haemophilus influenzae*
C. If the child recently had chickenpox, there is a high chance that they could have group B Streptococcal infection
D. In a 10-day-old, following aspiration the organism cultured is unlikely to be group B *Streptococcus*
E. In a 10-day-old, following aspiration the organism most likely to be cultured is *Staphylococcus aureus*

18. You see a 5-year-old boy in the ED. He fell off his garden slide earlier today. Radiographs are shown in Figure 21.9.

Regarding the injury:

A. Crossed wires are biomechanically stronger but more likely to cause a neurological injury therefore an open approach to the medial side should be performed
B. Due to significant instability the fracture should be treated with ORIF if the child is fit for anaesthetic

Figure 21.9 Anteroposterior (AP) and lateral radiographs elbow

C. Due to the age of the child and unstable nature of the facture it should not be treated with traction
D. He will almost certainly have a PIN palsy
E. Lateral K-wires are biomechanically stronger to torsional stress and are less likely to cause a neurological injury

19. **You are asked to see a 3-day-old baby boy on PICU. He underwent a repair of open myelomeningocele 3 days ago. His knees are hyperextended (toes to nose) and he has severe bilateral CTEV.**
A. He should have an ultrasound scan of his hips as soon as possible to confirm if he has dislocated hips
B. Long leg casts can be applied using the Ponseti technique however his parents should be warned that these are challenging feet due to his underlying condition
C. No treatment should be commenced until he has had his first neurosurgical wound check at 2 weeks given the tenuous nature of the myelomeningocele closure
D. The first thing that should be commenced is stretching techniques by the paediatric physiotherapist in order to bend the knees so Ponseti casting can be commenced
E. Treatment should start from the feet up

20. **You operate on a 3-year-old with a delayed presentation of congenital dislocated patella. She is otherwise a fit and well, happy little girl.**
A. It is often associated with internal tibial torsion and thickened tight lateral structures
B. Patients often present with genu varum
C. The patella is often hypoplastic and sits superiorly due to tight quadriceps, therefore operative intervention is indicated
D. This is a common cause of hyperextended knees in patients with spina bifida
E. This is a rare condition of unknown aetiology, it is rarely associated with other conditions

21. A 2-year-old boy is brought to clinic as his parents are concerned with the appearance of his thumb (Figure 21.10). He is otherwise fit and well and has no other issues with his hand or feet. There is no family history of note.

Figure 21.10 Clinical picture hand

Which of the following statements is correct?
A. Around 40% of patients have this as a bilateral condition
B. Most patients improve by 2 years old therefore operative intervention prior to this is not recommended

C. Operative intervention involves a small incision and division of the oblique pulley
D. There is usually a family history
E. This is often associated with a Notta's nodule, which is just distal to the A1 pulley

22. **An 11-year-old boy is reviewed in clinic, he is a bilateral toe walker. He has a background of eczema and mild autism. He is struggling with PE due to his unsteady gait and would like something done. His creatine kinase is normal.**
A. He should start serial casting in the first instance
B. He should be observed until skeletal maturity and if still toe walking at this point he should undergo a tendo-Achilles lengthening procedure
C. He should undergo a tendo-Achilles lengthening procedure at the earliest opportunity
D. Since this is a new presentation of toe walking the patient should be investigated with MRI whole spine to confirm no spinal stenosis
E. This presentation could be associated with a chromosomal duplication, encoding for PMP22

23. You are asked to see a 5-year-old in the ED who has fallen onto his elbow. He is normally fit and well. He was playing with his friends when he fell off his scooter, banging his left elbow on the concrete. He is tender over his lateral epicondyle. His radiographs are shown in Figure 21.11.

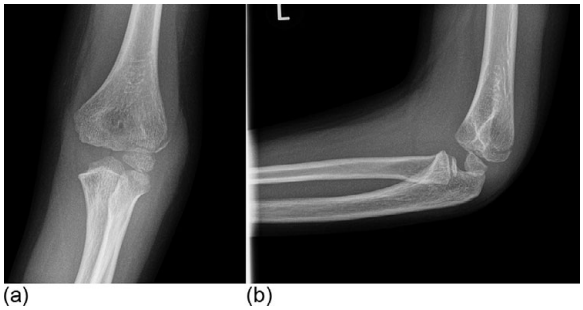


Figure 21.11 (a) Anteroposterior (AP) and (b) lateral radiographs left elbow

Concerning the injury?
A. The fracture normally extends distally and posteriorly across the physis and epiphysis into the joint
B. The lateral epicondyle fuses between 9–11 years old
C. The major blood supply to the distal humerus is from the posterior anastomotic vessels
D. These injuries are often associated with a posteromedial dislocation of the elbow
E. These injuries have a lower risk of AVN, malunion or non-union compared with other elbow injuries

24. You see a 7-month-old baby in your orthopaedic clinic. She and her twin sister are fit and well and are developing appropriately. Dad contacted the health visitor as he noticed difficulty when changing her nappy. Radiographs are shown in Figure 21.12.

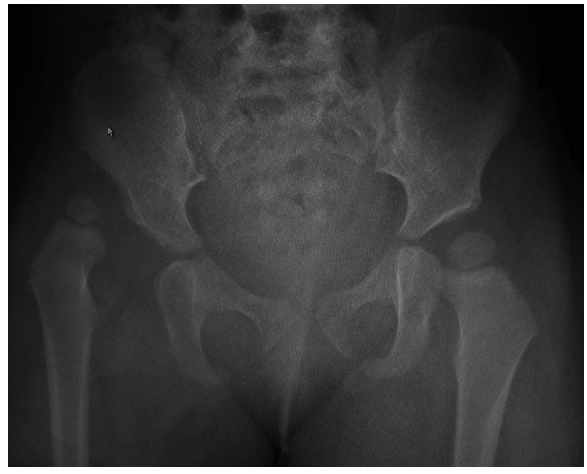


Figure 21.12 Anteroposterior (AP) radiograph pelvis

Concerning the radiographic features seen?
A. A centre edge angle of Wiberg of $>15°$ is normal
B. Hilgenreiner's line is perpendicular to Perkin's line through a point at the lateral margin of the acetabulum. The femoral head ossification centre should sit medial to this line
C. Perkin's line is a horizontal line passing between both triradiate cartilages. The femoral head ossification centre should sit inferior to this line
D. The acetabular index (AI) is the angle formed from a point on the lateral triradiate cartilage to a point on lateral margin of acetabulum and by Perkin's line
E. The AI should be $<25°$ in patients greater than 6 months old

25. You are on night shift and a 14-month-old, normally fit and well boy is transferred from the local DGH. He presents with pyrexia (38–40°), teething and snuffles for the past 9 days. He is very lethargic and looks unwell. CRP 107, WBC 23. He is reluctant to move his right arm and has a pseudo paralysis.
Radiographs are shown in Figure 21.13.

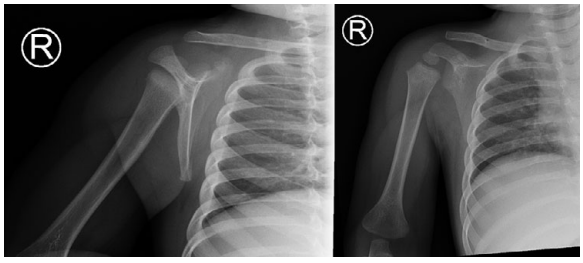


Figure 21.13 Anteroposterior (AP) and lateral radiographs shoulder

A. Given the 9-day history of coryzal type symptoms this is most likely to be transient synovitis
B. If this is a streptococcal infection, confirmation of effusion must be made prior to any GA, given the high risk in these patients
C. IV antibiotics should be given after aspiration
D. NAI must be ruled out as the right shoulder does not appear to be enlocated
E. The well delineated lytic lesion on the clavicle is most likely the first signs of a Brodie's abscess

26. You receive a call from the paediatric registrar asking you to review a 1-day-old baby boy. He has just performed the Newborn Infant Physical Examination (NIPE) on the postnatal ward and is concerned regarding his feet. He found no other causes for concern and the baby is fit and well otherwise. He had a planned C-section (Figure 21.14).
Regarding the condition:
A. The boots and bars must be worn for 23 hours a day for the first 12 weeks then nights and naps until age 3
B. The lateral head of the talus acts as the fulcrum around which the foot rotates during the Ponseti technique
C. The majority of patients with CTEV have other abnormalities
D. The neck of the talus is medially and dorsiflexed position

Figure 21.14 Clinical picture lower limbs

E. The sequence of Ponseti correction is Cavus, Abduction of the forefoot, Varus and Equnius (CAVE)

27. You see a 13-year-old girl in clinic who presents with medial knee pain. She is 94kg but otherwise fit and well. On examination she has an intermalleolar distance of 15cm.
You diagnose her with genu valgum.
A. Growth rate of the knee is 15 mm/year. 9mm at the proximal tibia and 6mm at the distal femur.
B. Patients with a Cozen deformity should be treated with eight plates
C. The intermalleolar distance should be <8 cm after 7 years of age
D. The Hueter–Volkmann Law states that growth is increased by mechanical compression and decreased by tension
E. This procedure should be considered in patients in 10–15° of valgus

28. You attend the genetics clinic with your consultant. You are asked to see a 7-year-old right hand-dominant girl who presents with difficulty tying her shoelaces. She denies any pain. Her clinical picture is shown in Figure 21.15.
Concerning her right hand:
A. This is associated with increased fibroblast growth factor function as a result of a sonic hedgehog gene mutation
B. It is commonly associated with Wilms tumour and therefore patients should have an USS of the abdomen
C. Movement of the elbow will dictate the management of these deformities

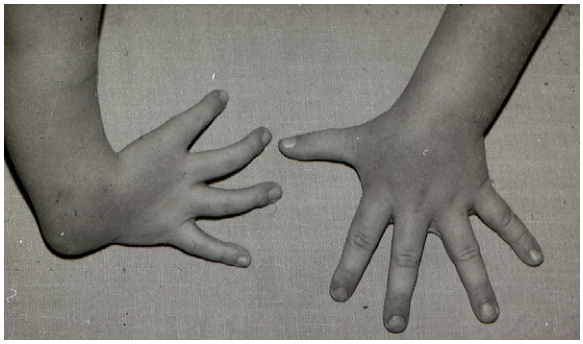


Figure 21.15 Clinical picture bilateral hands

D. The limb bud develops after 9 weeks of gestation
E. This is a genetic condition that affects a gene that acts on the AER (Apical Ectodermal Ridge) of the limb bud

29. You are called by the ED doctor for advice regarding a 15-year-old patient presenting with elbow pain following a fall. She is concerned that he has fracture dislocation of his elbow. Radiographs are shown in Figure 21.16.

Regarding the condition:

A. Patients often have coxa valgus and codfish vertebrae
B. These patients can present with osteomyelitis of the mandible
C. This condition is associated with cranial nerve palsies with the facial nerve being most commonly affected
D. This is an autosomal recessive disorder with 75% gene penetrance
E. This patient's underlying condition results in defective osteoblasts

30. You are called to see a 7-year-old girl in the ED. Her mum has brought her as she is concerned that she has a 'bowed leg'. Her radiographs are shown in Figure 21.17.

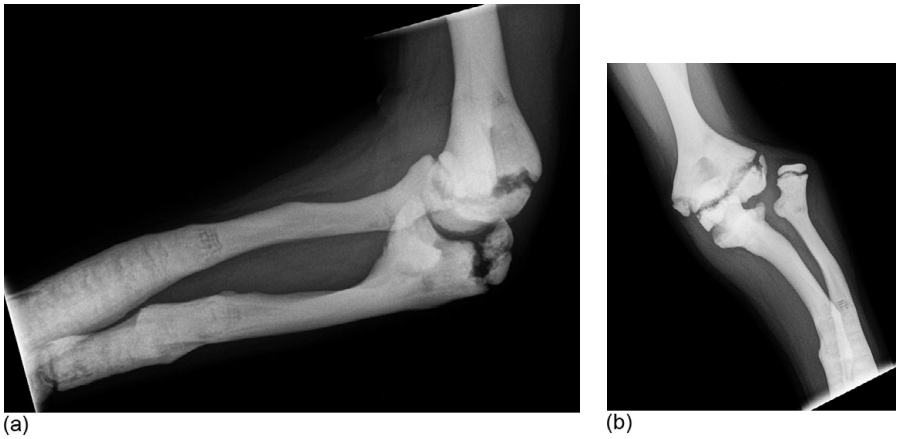
Her bow legs?

A. It is an autosomal dominant condition
B. Pseudoarthrosis of the tibia results in the deformity
C. The most common cause is fibular hemimelia
D. This condition is associated with neurofibromatosis type 1
E. This is most commonly physiological

31. You are in a new patient clinic and obtain imaging for a 2-year-old girl (Figure 21.18). She presents with one leg shorter than the other. She has no learning difficulties.

Regarding her condition:

A. Amputation of the foot should be based on the number of toes present
B. It is commonly associated with posteromedial bowing of the tibia
C. The amount of fibula present dictates treatment
D. This condition is associated with Fibroblast Growth Factor 10 coding gene
E. This condition is often associated with other orthopaedic issues including a ball and socket ankle, ACL insufficiency, PFFD and CTEV



(a) (b)

Figure 21.16 Anteroposterior (AP) and lateral radiographs elbow

Figure 21.17 (a) Anteroposterior (AP) and (b) lateral radiographs tibia

Figure 21.18 Radiograph lower legs

32. You review a 9-year-old in clinic with a wrist deformity. She is fit and well. She is a keen gymnast and presents due to discomfort and the fact she does not like the appearance of her wrist. You get the following X-rays (Figure 21.19).

Regarding her wrist deformity?

A. It is an autosomal recessive condition
B. It is associated with the Wingless and Int-1 (Wnt1) gene
C. Patients commonly present with altered sensation in the distribution of the superficial radial nerve due to the increased radial inclination
D. Tethering of Vickers ligament is often implicated in the pathology of this condition
E. This patient should have a workup for giant cell tumour and onward referral to the sarcoma service

Figure 21.19 Anteroposterior (AP) and lateral radiographs wrist

33. You see a 12-year-old fit and well boy of Asian origin who complains of left knee pain for 1 year. He is developmentally normal and there is no family history of note. After examining him, you get a knee X-ray (Figure 21.20).

Your management plan would be.

A. Arthroscopic stabilisation
B. MRI scan, vitamin D levels and commence vitamin D

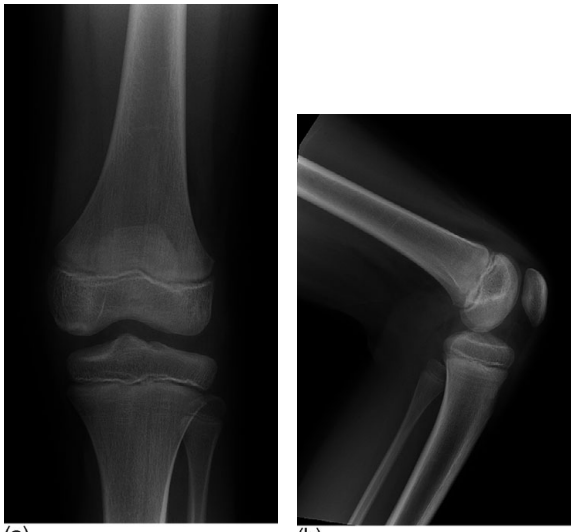


Figure 21.20 (a) Anteroposterior (AP) and (b) lateral radiographs knee

C. MRI scan. Restricted weight bearing and bracing
D. Open surgical stabilisation
E. Refer to physiotherapy for ankle proprioception exercises

34. You are performing the following procedure on an 18-month-old who presented with waddling gait and leg length discrepancy.

Based on the imaging shown in Figure 21.21.

A. Image B show a post reduction image, confirmed by the femoral head pointing to the acetabulum
B. This patient has an attenuated ligamentum terres but the labrum is not inverted
C. This patient should go on to a closed reduction and application of spica followed by a CT under sedation or GA
D. When performing this procedure blocks to reduction are an inverted labrum, inverted limbus, transverse acetabular ligament, hip capsule, pulvinar and ligamentum teres and iliopsoas
E. You suggest a pelvic osteotomy for this patient +/− femoral osteotomy if the hip is not reducible

35. You see a high-performing netball player in clinic following an injury. The MRI scan confirms your suspected diagnosis. She is 15 years old and has been having intense physio. She is keen to proceed with operative intervention. She

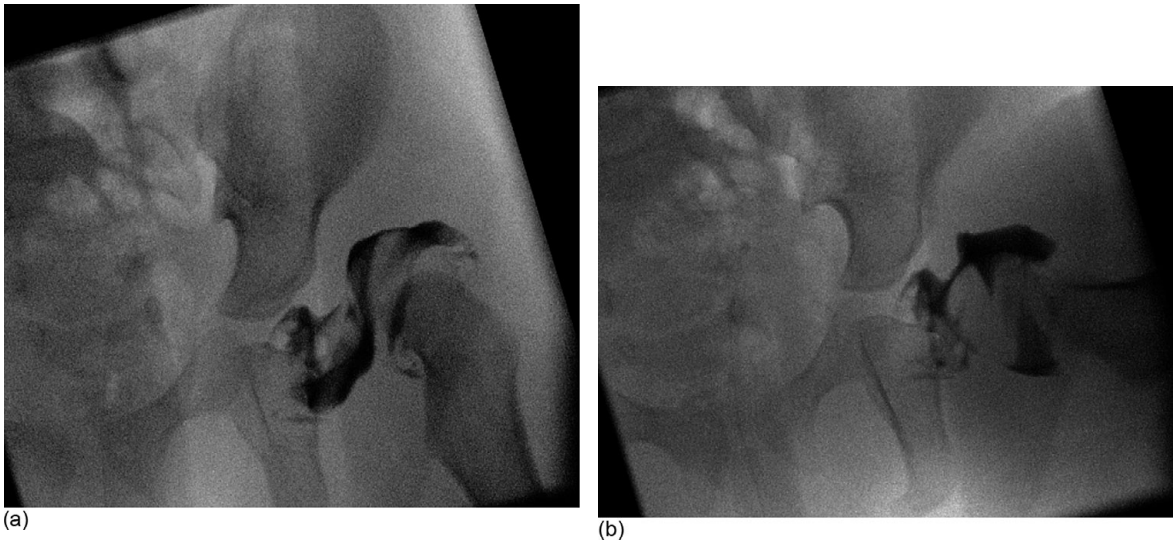


Figure 21.21 Arthrogram hip

complains of medial sided knee pain and is keen to have something done due to the pain.

What would you recommend?

A. ACL reconstruction
B. ACL repair
C. Arthroscopic trimming of meniscus
D. Bracing and restricted weight bearing
E. Bracing KAFO

36. You review an obese 11-year-old girl in your general paediatric clinic with genu valgum, her intermalleolar distance is 14cm.

You would recommend:

A. Excision of physeal bar and graft interposition
B. Hemiepiphysiodesis
C. Observation
D. Realignment osteotomy
E. This is most likely a discoid meniscus so recommend saucerisation of the meniscus

CHILDREN'S ORTHOPAEDICS II STRUCTURED SBA ANSWERS

1. Answer A. **Clinodactyly**
The clinical picture shows Klippel–Trenaunay syndrome (KTS).

KTS is characterised by a triad of port-wine stain (capillary haemangioma), soft tissue or bony overgrowth of an extremity and complex vascular malformation. Two of these need to be present to make a diagnosis.

Hypertrophy of affected extremity is common due to underlying soft tissue or adipose tissue hyperplasia and lymphoedema. Rarely, it may be associated with bony hypertrophy that can lead to a limb-length discrepancy. Neurofibromatosis 1 can be associated with hemi-hypertrophy, however it is not normally associated with vascular abnormalities.

Klippel–Trenaunay syndrome is associated with finger and toe anomalies (clinodactyly, polydactyly, syndactyly) in 25% of cases.

It is not known to be associated with congenital trigger thumb.

Patients with KTS often have symptoms spanning multiple medical subspecialties, requiring a multidisciplinary approach to care. Associated lymphoedema in the affected extremities places patients at risk of skin breakdown and ulcers. Thromboembolic diseases may develop due to altered blood flow and clotting abnormalities.

Schoch JJ et al. Orthopaedic diagnoses in patients with Klippel–Trenaunay syndrome. *J Child Orthop.* 2019;**13**:457–462.

2. Answer D. **The chromosome affected encodes peripheral myelin protein 22 (PMP22)**
This is a clinical photograph of a patient with hereditary motor sensory neuropathy (HMSN) type 1 or Charcot-Marie-Tooth disease (CMT1).

HMSN are a group of clinically and genetically heterogeneous disorders primarily affecting the peripheral nervous system (PNS) with secondary muscle wasting and weakness. The diagnosis is based on the presence of lower motor neuron signs and evidence of sensory involvement.

HMSN 1/CMT1, the most common subtype (74% of cases), is characterised by slow conduction velocities and diffuse demyelination. HMSN 2/CMT2 is the axonal form. HMSN 3 is now more commonly known as Dejerine–Sottas neuropathy and is characterised by an early disease onset and severe 'hypertrophic' demyelination.

With CMT1, onset is usually in the first decade unlike type 2 that is usually milder and presents in the second decade or later.

Answer A describes HSMN 2. This is an autosomal dominant condition usually causing a duplication of chromosome 17. Peroneus longus is the driving force for the first ray plantarflexion.

The functional peroneus longus serves to plantar flex the first ray while the denervated anterior tibialis fails to provide any counterbalancing dorsiflexion. The first metatarsal head is depressed and a compensatory hindfoot cavus results.

The foot deformities in CMT do not result from absolute weakness of the motor units powering the foot but from their relative imbalance. Initiation of the deformity likely results from an imbalance of the failing foot intrinsics and the preserved extrinsics.

The reasons for the unusual patterns of motor weakness in CMT remain poorly understood. A specific pattern of extrinsic motor weakness is common in CMT in which the anterior and lateral compartment musculature is selectively affected. The posterior compartment involvement is seen very late.

The disease almost always affects the peroneus brevis but spares the peroneus longus. Tibialis posterior remains strong.

In the anterior compartment musculature, the extensor hallucis muscle can be spared while the anterior tibialis is affected. This occurs despite the more distal location of the extensor hallucis longus (EHL) and their shared peroneal innervation.

3. Answer E. **The line of pull of the anterior straps should follow the anterior axillary line on each side**
The central strap should be at the level of the nipples. If the foot stirrups are applied first the baby will kick them off! The foot stirrups are sided. The hips should be flexed between 90–110°. 115° would be too much flexion. A Pavlik harness prevents hip extension and adduction, which can lead to redislocation. The Pavlik

harness allows flexion and abduction which lead to reduction and stabilisation.

The posterior abduction strap should be at the level of the child's scapula and adjusted to allow comfortable abduction within the safe zone. The posterior strap acts as a check rein to prevent the hip from adducting to the point of redislocation.

Inferior dislocations may occur with prolonged excessive flexion. Hyperflexion may also induce femoral nerve compression neuropathy. Brachial plexus palsy may occur from compression by the shoulder straps and knee subluxations may occur from improperly positioned straps. Skin breakdown may occur in groin creases and in the popliteal fossa if these areas are not kept meticulously clean and dry.

4. Answer B. **Remove the harness on the right (affected) leg and await resolution**
This baby has a femoral nerve palsy. This is more common in older and larger babies. It affects 2.5% of patients treated in a Pavlik harness. The parents usually notice that the baby is not kicking its leg. The affected limb should be taken out of the harness until symptoms have resolved. Treatment can resume after resolution with decreased hip flexion. There is a higher rate of failure in these patients.

Murnaghan et al. (2011) found a clear association between the number of days that a femoral nerve palsy persisted and the probability of success of Pavlik harness treatment.

They found that if the femoral nerve palsy persisted beyond 3 days, the probability of success was only 30%. They recommended the treating surgeon to recognise femoral nerve palsies early and reinstitute treatment quickly following resolution of the palsy. The harness should only be adjusted or suspended, not completely abandoned. Follow up of a femoral nerve palsy should be limited to a few days, in order that treatment can be recommenced as soon as possible.

Various theories have been suggested to explain the cause of FNP, the most accepted is that forced hip flexion greater than 90° produces a possible entrapment of the femoral nerve under the inguinal ligament.

Ghanem et al. (2023) reported that the most significant risk factors for femoral nerve palsy were DDH severity (Tönnis grade) and hip flexion angle in the harness (>90°). The femoral nerve palsy was found to resolve spontaneously before completion of treatment and did not require any strap release other than the one required to bring the thighs to 90° flexion. The results of the study did not support harness abandonment if a femoral nerve palsy occurs during the course of treatment.

Ghanem I, Karam G, Ghanem D, Saliba I. Femoral nerve palsy during Pavlik harness treatment for developmental dysplasia of the hip is not an indication for harness abandonment. *J Child Orthop.* 2023;**17**:205–211.

Murnaghan ML, Browne RH, Sucato DJ, Birch J. Femoral nerve palsy in Pavlik harness treatment for developmental dysplasia of the hip. *J Bone Joint Surg Am.* 2011;**93**:493–499.

5. Answer D. **By the 11th week of gestation, the hip is fully formed although not fully developed**
The acetabulum and femoral head develop from the same primitive mesenchymal cells.

At 7 weeks of gestation, a cleft develops in the precartilaginous cells.

This cleft becomes the acetabulum and femoral head.

Between 4–7 months of age the proximal femoral ossification centre appears.

6. Answer C. **The patient should abstain from contact sports if C2 is involved or if long fusions are present**
This is Klippel–Feil syndrome (KFS). The syndrome consists of a triad of a low posterior hairline, short neck and limited cervical range of motion.

It is caused by an abnormal segmentation or failure of formation of cervical vertebrae. Studies have suggested vascular disruption, global foetal insult and primary neural tube complications, in addition to genetic mutations, as potential causes of the cervical spine segmentation failure.

Paediatric patients with KFS should be evaluated for associated congenital conditions such as renal and cardiac anomalies. Patients are normally treated with observation unless they become symptomatic.

Scoliosis is the most common musculoskeletal finding.

Sprengel deformity (SD) is defined as elevation or malposition of the scapula caused by abnormal descent of the scapula during embryogenesis. The inferior pole of the scapula rotates medially, resulting in a downward-facing glenoid cavity. Upward rotation of the superomedial angle of the scapula causes neck fullness, and scapular proximity determines severity. SD is found in approximately 25% of KFS cases.

KFS can contribute to myelopathy because of hypermobility of the non-fused cervical segments, leading to traumatic instability, disc herniation and spinal cord compression.

Patients with KFS are at risk for cervical spine injury after minor trauma because of disrupted load biomechanics and subsequent hypermobility and instability of the adjacent segments.

There is no clear consensus in the literature regarding the criteria for or against participation in contact sports by patients with KFS. All studies agreed that instability of the upper (O-C2) cervical spine as well as craniocervical abnormalities are absolute contraindications for contact.

For stable fusions, especially those caudal to C3, patients can compete without restrictions. Because of the high-energy nature of contact sports, clinicians should perform flexion-extension imaging studies as well as careful neurological and musculoskeletal examinations to assess for hypermobility, instability and neurological deficits before clearing KFS patients for participation.

Jae-Min Park A, Nelson SE, Mesfin A. Klippel-Feil syndrome: clinical presentation and management. *J Bone Joint Surg. Rev.* 2022;**10**(2).

7. Answer D. **This injury occurs due to incomplete ossification of the intercondylar eminence. This makes the bone more likely to fail than the ligament**

Fractures of the partially ossified tibial eminence occur after forced knee flexion with simultaneous tibia external rotation, or hyperextension, such as anterior cruciate ligament (ACL) rupture mechanism of injury. The incomplete ossification makes the bone more likely to fail than the ligament.

They are typically classified, using plain radiographs, with the Meyers and McKeever classification. This is based on displacement and morphology of the fracture fragment. Fractures were originally categorised into 3 types: type I fractures are non-displaced; type II fractures are displaced anteriorly with an intact posterior cortical hinge; and type III fractures are completely displaced.

Whether McKeever type II fractures should be treated operatively or non-operatively remains controversial. There is a substantial variation among paediatric orthopaedic surgeons when treating type II tibial spine fractures.

The degree of fracture displacement is the major factor affecting the surgeons' decision to operate. Relative indications for arthroscopic reduction and internal fixation depend on the patient attributes, including age, sex, injury mechanism and athletic level.

The patient can be treated conservatively if the fracture can be reduced. This should be confirmed on imaging. The cast should be in 0° of flexion and be closely followed up. They should be in a cast for 3–4 weeks non-weight bearing. A block to extension is an indication for operative intervention.

Prompt treatment decision making is imperative. If not treated correctly, patients with these injuries have an increased risk of arthrofibrosis, residual laxity, fracture non-union or malunion, quadriceps atrophy, retropatellar pain and tibial physis disruptions.

Adams AJ et al. Pediatric Type II tibial spine fractures: addressing the treatment controversy with a mixed-effects model. *Orthop J Sports Med.* 2019;**7**:2325967119866162.

8. Answer C. **Risser 0 and 5 cannot be differentiated as there is no ossification centre seen on X-ray**

Risser's sign goes from 0–5 (Figure 21.22). The iliac crest is divided into 4 quadrants and the final Risser 5 is the ossification of the whole of the iliac crest. Ossification goes from anterior to posterior. Risser 0 and 5 look similar on radiographs due to the lack of ossification centres. To differentiate look at the long bone physes, if these are closed it will be Risser 5. Risser 1 usually

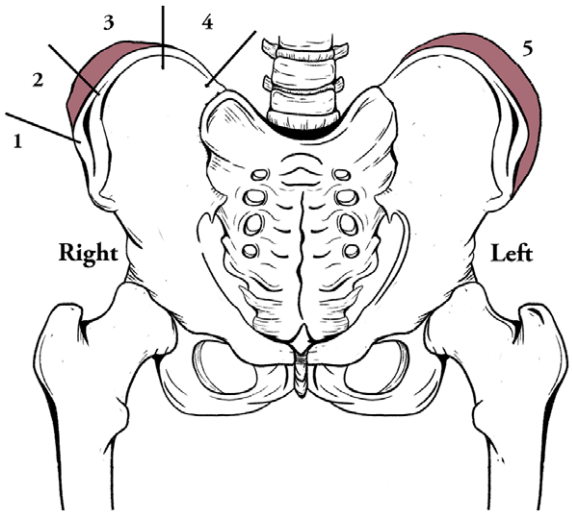


Figure 21.22 Risser grade. Risser 0 – no ossification centre at the level of iliac crest apophysis. Risser 1 – approximately 25% apophysis of the iliac crest. Risser 2 – approximately 25–50% apophysis of the iliac crest. Risser 3 – approximately 50–75% apophysis of the iliac crest. Risser 4 – approximately 75% apophysis of the iliac crest. Risser 5 – complete ossification and fusion of the iliac crest apophysis

appears at around 13.8 years in girls and 15.2 years in boys.

The axial skeleton matures a few years later than the limbs, and for scoliosis, the Risser sign is a useful method of bone age determination. Risser's sign is a measure the growth left in the spine – this can help to determine the potential for progression of scoliosis.

9. Answer E. **This patient needs a referral to haematology, genetics and paediatrics**
The X-ray is in keeping with a diagnosis of osteopetrosis given the increased bone density, loss of medullary canal diameter/cortical thickening and Erlenmeyer flask deformity of the distal femurs.

Osteopetrosis is a rare genetic disorder characterised by defective osteoclast function or development and impaired bone resorption that results in generalised sclerosis of bones with a reduction of marrow spaces. Osteopetrosis is categorised into three types based on inheritance: (1) an autosomal recessive (infantile malignant) form; (2) autosomal dominant (adult) form; and (3) X-linked form.

The autosomal recessive form of osteopetrosis is further subdivided into osteoclast-rich and osteoclast-poor forms based on the number of osteoclasts present. These forms correspond to defects in osteoclast function (osteoclast-rich) or osteoclast development (osteoclast-poor) and are associated with distinct mutations. Autosomal recessive osteopetrosis (ARO) is associated with early onset and a poor prognosis, whereas autosomal dominant osteopetrosis (ADO) manifests in later childhood and is typically discovered as an incidental radiographic finding.

ARO has a diminished life expectancy, with most untreated children dying in the first decade as a complication of bone marrow suppression. Life expectancy in the adult-onset forms is normal.

ARO is characterised by fractures, short stature, compressive neuropathies, hypocalcaemia with tetanic seizures, and life-threatening pancytopaenia. The condition requires rapid diagnosis and clinical intervention, as haematopoietic stem cell transplantation performed early in life offers the best chance of long-term survival.

Stark Z, Savarirayan R. Osteopetrosis. *Orphanet J Rare Dis.* 2009;**4**:5.

10. Answer B. **15 years**
The triradiate cartilage is located between the ilium, pubis and ischium. Its branches are arranged like a Y-shape, namely the iliopubic arm, iliosciatic arm and ischiopubic arm. The triradiate cartilage is the main structure that determines the development of the acetabulum. Triradiate cartilage injury (TCI) often occurs in high-energy pelvic injury. TCI should be suspected when there is widening or narrowing of the triradiate cartilage gap, small bone fragments at the iliac, pubic and ischial metaphysis, and changes in the relationship between the ilium, ischium and pubic bones. More than 50% of TCIs are missed on the initial assessment. If there is any doubt MRI of the hip joint is recommended to confirm the diagnosis.

Dong Y et al. Retrospective analysis of traumatic triradiate cartilage injury in children. *BMC Musculoskelet Disord.* 2021;**22**:674.

11. Answer B. **I would have a low threshold to wash the wound out given the risk of *Pseudomonas aeruginosa***
This SBA is important as plantar puncture wounds are difficult to assess, can be deceptive,

prone to infection and complications. Given the fact that the patient had socks and trainers on there is an increased risk of *Pseudomonas aeruginosa* infection. *Pseudomonas aeruginosa* is a Gram-negative, aerobic, rod-shaped encapsulated bacterium. Although *Staphylococcus aureus* and *Streptococcus* are the most likely organisms to be responsible for a plantar infection, *Pseudomonas aeruginosa* thrives in rubber and plastic therefore a penetrating injury that occurs through a shoe's sole and foam lining can implant a *Pseudomonas aeruginosa* from the shoe into the patient's plantar tissues. *Pseudomonas aeruginosa* is associated with deep space infection, osteochondritis and osteomyelitis.

Eikenella corrodens infection can be associated with human bites.

12. Answer C. **This disorder affects the proliferative zone of the physis**

The patient has achondroplasia, the most common skeletal dysplasia. It is autosomal dominant. The abnormal mutation encodes for fibroblast growth factor receptor 3 (FGFR3) gene not fibrin growth factor receptor 3 gene.

This is a level 1 SBA masquerading as a level 2 SBA. The candidate needs to recognise that rhizomelic short stature, lumbar stenosis and frontal bossing is typical of achondroplasia. The second part of the SBA goes on to test factual knowledge of the condition.

13. Answer D. **You predict the child will be a boy, obese and around 13 years old**

This patient has a SUFE until proven otherwise. This condition is more common in boys. Patients are normally obese unless they have an underlying endocrine disorder. Despite this, even in slim children with no underlying endocrine disorder, a presentation like this warrants X-rays to exclude SUFE.

Patients often complain of a non-radiating, dull, aching pain in the hip, groin, thigh or knee, and no history of preceding trauma. The pain is increased by physical activity and may be acute, chronic or intermittent. Patients with acute or acute on chronic pain with significant pain, loss of motion in the affected hip, and/or difficulty ambulating should be made non-weightbearing while establishing the diagnosis and remain non-weightbearing until definitive treatment.

SUFE normally occurs during a period of increased growth and hormonal change. New onset unilateral alteration in gait is highly unlikely to be a normal variant. The physis layer involved will be the hypertrophic zone where the slip occurs.

Clinical examination would likely reveal a limited range of motion of the hip, shortening, and commonly, inability to bear weight. Internal rotation is decreased in nearly all hips with SUFE and is often painful. Active motion of the hip is severely limited by muscle spasm, and the patient complains of intense pain with any attempt at passive motion. Passive flexion of the hip from extension may cause abduction and external rotation (highly suggestive of SUFE).

With a chronic SUFE, the gait may be antalgic and there may be a Trendelenburg component. The affected leg is usually held in an externally rotated position and may be shorter. Disuse atrophy of the upper thigh and gluteal muscle may be present in moderate or severe slips but may be difficult to appreciate in a patient with obesity.

The Kocher criteria is used as a predictor for septic arthritis.

Kocher MS et al. Delay in diagnosis of slipped capital femoral epiphysis. *Pediatrics* 2004;**113**:e322–5.

14. Answer C. **The valgus deformity normally corrects itself by 1–2 years**

Fractures of the proximal tibial metaphysis usually present in children between 3–6 years following a laterally applied force to an extended knee with resulting failure of the medial metaphysis in tension. The fracture may be complete or incomplete (greenstick fractures) with opening of the medial cortex. These fractures often may appear benign, as commonly they are undisplaced and non-angulated. However, there may be a progressive increase in valgus angulation during fracture healing and even after immobilisation treatment has ceased (Cozen deformity/phenomenon).

In general the angular deformity usually corrects between 1–2 years after the injury.

If spontaneous correction of the deformity is not observed, guided growth, by tethering the proximal medial tibial physis with an extra-periosteal, non-locking plate (e.g. 8 or O plate) and two screws is recommended.

Candidates can sometimes be asked about causative theories:

Malreduction of the initial fracture.

Soft tissue interposition.

Medial tibial overgrowth secondary to fracture induced hyperaemia or due to release of the medial mechanical periosteal restraint.

Discrepancy in tibia/fibular growth with subsequent tethering of lateral tibia growth by the fibula or loss of tethering effect of the pes anserius.

Eccentric callus formation.

This question could also lead on to discussion of the Hueter-Volkmann law – growth on the compression side is decreased and it is increased on the tension side.

Gowtam SV, Garud AB, Sharma R, Nikam M. Cozen's phenomenon of proximal tibia. *Int J Orthop Sci.* 2021;**7**:339–342.

15. Answer C. **Perform US scan in clinic and place in a Pavlik Harness if indicated**

Knowledge of the normal growth and development of the hip joint is essential to the understanding of DDH. The femoral epiphysis usually ossifies between 4 and 7 months of age. This bony centrum and its cartilaginous anlage continue to enlarge until adult life, at which time only a thin layer of articular cartilage remains.

The changes seen on the femoral side in untreated DDH include excessive anteversion and shape changes in the cartilaginous anlagen. As in normal development of the proximal femur, the shape and growth of the untreated proximal femur in DDH is affected by muscle pull, the forces transmitted across the hip joint in its subluxated or dislocated position and by weight bearing, normal joint nutrition, circulation and muscle tone.

Weinstein SL, Dolan LA. Proximal femoral growth disturbance in developmental dysplasia of the hip: what do we know? *J Child Orthop.* 2018;**12**:331–341.

16. Answer A. **Group A streptococcal infection**

Group A streptococcal infection can occur following chicken pox infection. A high index of suspicion is required given the potential severity of the developing sepsis.

Children who have had chickenpox recently are more likely to develop serious forms of Group A Streptococcal infection, although this remains very uncommon. The chickenpox rash can make it easier for Group A Strep to enter the body, which can lead to invasive infection such as necrotising fasciitis. If a child has chickenpox – or has had it in the last 2 weeks – parents should remain vigilant for symptoms such as a persistent high fever, cellulitis (skin infection) and arthritis (joint pain and swelling).

Clark P, Davidson D, Letts M, Lawton L, Jawadi A. Necrotizing fasciitis secondary to chickenpox infection in children. *Can J Surg.* 2003;**46**:9–14.

Xavier R, Abraham B, Cherian VJ, Joseph JI. Early diagnosis of post-varicella necrotising fasciitis: a medical and surgical emergency. *Afr J Paediatr Surg.* 2016; **13**:44–46.

17. Answer B. **If the child is unimmunised at 1 year of age the likely diagnosis would be *Haemophilus influenzae***

A fully immunised 1-year old should be fully protected from *Haemophilus influenzae*. In a 10-day-old the most likely pathogen would be Group B Streptococcus. If they have recently had chickenpox, there is a high chance that they could have a Group A Streptococcal infection not Group B.

Haemophilus influenzae type b causes pneumonia, septicaemia, meningitis, epiglottitis, septic arthritis, cellulitis, otitis media and purulent pericarditis, as well as less common invasive infections such as endocarditis, osteomyelitis and peritonitis.

Routine immunisation has resulted in a remarkable decline in serious *Haemophilus influenzae* type b (Hib) disease and has practically eliminated Hib meningitis among vaccinated infants and young children.

The highest incidence of invasive Hib in unimmunised populations is in the 6–24 months age group. This is explained by the passive protection from maternal antibodies during the first months of life and the improving natural immunity after 2 years of age.

The WHO recommends that Hib conjugate vaccine should be included in all routine childhood immunisation programmes with a three-

dose primary series given at the same time as diphtheria, tetanus and pertussis vaccines. A booster in the second year of life increases protection.

Following Group B Streptococcus, *Staphylococcus aureus* is typically the second most common cause of septic arthritis in neonates.

18. Answer A. **Crossed wires are biomechanically stronger but more likely to cause a neurological injury therefore an open approach to the medial side should be performed**
AIN palsy is more common. This fracture can be treated with K-wire fixation or traction. Crossed K-wires are biomechanically stronger to torsional stress.

There are several options for K-wire fixation of displaced supracondylar fractures. Zionts et al. (1994) measured the biomechanical stability of different fixations of adult human cadaver models. They found the greatest resistance to rotation occurred with medial–lateral cross pinning. The second most stable pattern was fixation utilising three lateral diverging pins. The least stable was fixation with two lateral pins, which crossed at the fracture site. While medial–lateral cross pinning has the greatest resistance, the disadvantage is the risk of ulnar nerve injury.

Sadiq et al. (2007) reported on 20 cases of severely displaced grade III supracondylar fractures of the humerus in children. There was marked swelling and distorted local anatomy in all these fractures, which were managed conservatively with straight-arm lateral traction. The patients were treated in skin traction for 2 weeks, following which they commenced physiotherapy. They concluded that straight-arm lateral traction was an effective and successful method of treating displaced grade III supracondylar fractures of the humerus.

Sadiq MZ, Syed T, Travlos J. Management of grade III supracondylar fracture of the humerus by straight-arm lateral traction. *Int Orthop.* 2007;**31**:155–158.

Zionts LE, McKellop HA, Hathaway R. Torsional strength of pin configurations used to fix supracondylar fractures of the humerus in children. *J Bone Joint Surg Am.* 1994;**76**:253–256.

19. Answer D. **The first thing that should be commenced is stretching techniques by the paediatric physiotherapist in order to bend the knees so Ponseti casting can be commenced**
These are challenging feet due to his underlying diagnosis of spina bifida. He should commence stretching techniques and casts/splints by the paediatric physiotherapist to bend the knees. Once the knees are bent, his feet can be treated using the Ponseti technique. He should have an ultrasound scan of his hips once his lower limbs are in a better position. An ultrasound scan would be too difficult with the hips in the current position.

CTEV occurs in 30–50% of patients with spina bifida. In spina bifida, the Ponseti method leads to reliable initial correction and is useful to decrease extensive soft tissue release. Arkin et al. (2018) reported the midterm results of using the Ponseti method for clubfoot in spina bifida with a successful outcome in 42.3% of cases.

Abraham et al. (2012) recommends using the Ponseti method as the primary approach in the initial treatment of non-idiopathic clubfoot as they reported a reduced risk of future invasive surgery and shortened anaesthesia and surgery times when surgical treatment was needed. There is no need to wait for a neurosurgical review to apply the casts if the wound is healed.

Abraham J, Wall JC Jr, Diab M, Beaver C. Ponseti casting vs. soft tissue release for the initial treatment of non-idiopathic clubfoot. *Front Surg.* 2021;**8**:668334.

Arkin C, Ihnow S, Dias L, Swaroop VT. Midterm results of the Ponseti method for treatment of clubfoot in patients with spina bifida. *J Pediatr Orthop.* 2018;**38**:e588–e592.

20. Answer C. **The patella is often hypoplastic and sits superiorly due to tight quadriceps, therefore operative intervention is indicated.**
Congenital patellar dislocation (CPD) is a rare deformity in children that involves a laterally displaced patella. While potentially identified in early childhood using diagnostic imaging techniques, it is often misdiagnosed at birth, creating pain and mobility issues as the child grows.

Dislocation of the patella is permanent and manually irreducible, often manifesting with flexion contracture of the knee, genu valgum,

external tibial torsion, thickened tight lateral structures and foot deformity.

This is a rare condition often associated with other conditions such as arthrogryposis, nail-patella syndrome, Larsen's syndrome etc.

Nguyen H et al. Presentation and repair of serial misdiagnosed congenital patellar dislocation. *Cureus* 2021;**13**:e20082.

21. Answer B. **Most patients improve by 2 years old therefore operative intervention prior to this is not recommended**

Trigger thumb is bilateral in approximately 25% of patients. It is not normally associated with a family history. Operative intervention involves a small incision and division of the A1 pulley. Notta's node is just proximal to the A1 pulley at the metacarpal head.

Surgical timing for paediatric trigger thumb treatment is controversial for numerous reasons including the potential for spontaneous resolution, the possibility of bilateral involvement, and anaesthetic concerns regarding the developing brain. Most patients improve by age 2. Hence, a reasonable approach is to delay the surgical procedure until then. By age 2, if a child's trigger thumb has not resolved, it's less likely to improve spontaneously.

The term congenital trigger thumb is a misnomer, as multiple studies have not identified the condition at birth, although parents may anecdotally report the deformity from birth.

Paediatric trigger thumb does not usually present with triggering, but rather with the thumb interphalangeal (IP) joint locked in flexion and palpable thickening of the flexor pollicis longus (FPL) tendon at the base of the thumb, known as a Notta's nodule.

Nguyen JL, Ho CA. Congenital disorders of the pediatric thumb. *J Bone Joint Surg Rev.* 2022;**10**.

22. Answer A. **He should start serial casting in the first instance**

The first line of treatment in idiopathic toe walkers is serial casting.

Toe walking has multiple aetiologies, ranging from idiosyncratic habit to profound neuromuscular disease. The most observed type of toe walking is idiopathic bilateral toe walking (IBTW), which is a diagnosis of exclusion. It is often associated with autism. Toe walking that results from a definable cause (most often neurological or muscular disease) is broadly labelled non-idiopathic toe walking (non-ITW).

Idiopathic toe walking (ITW) is an abnormal gait pattern whereby the child walks on the balls of their feet, skipping the heel strike during the initial stance phase that occurs in a normal gait. ITW can be associated with contracture of the Achilles tendon, resulting in limited range of motion of the ankle; however, many children with ITW have no contracture.

Treatment depends on the patient's age, the severity of the gait abnormality, and the underlying diagnosis.

Non-surgical treatment options reported for ITW include bracing, botulinum toxin (Botox; Allergan) injections, serial casting and physiotherapy (PT).

Surgical treatment of ITW includes gastrocnemius lengthening.

Zone 1 Baumann – Lengthening of the gastrocnemius aponeurosis.

Zone 1 Strayer – Lengthening of the gastrocnemius aponeurosis at the junction of the coalescence of soleus and gastrocnemius.

Zone 2 – Vulpius/Baker – Vulpius – inverted V-shaped and Baker 'tongue in groove' incision lengthening of the gastrocnemius aponeurosis and soleus fascia.

Zone 3 – White/Hoke – Percutaneous or open tendo-achilles lengthening (TAL). White – double hemisection, Hoke – triple hemisection.

While non-operative treatments avoid surgical and anaesthetic risks, their effectiveness in published studies is poor, and the longevity of a normal gait following these treatments is not well documented. Despite this it is the first-line treatment of choice in most units. If serial casting fails, surgery may be undertaken. Surgical lengthening of the gastrocnemius, however, results in the most consistent and successful outcomes with excellent results with limited morbidity reported for zone-3 lengthening, and the simplicity and effectiveness of percutaneous TAL, have made this the preferred treatment option for some authors.

In all new presentations of tip toe walking, creatine kinase (CK) should be performed to rule out muscular dystrophy and an MRI scan of the brain and spinal cord to rule out any underlying

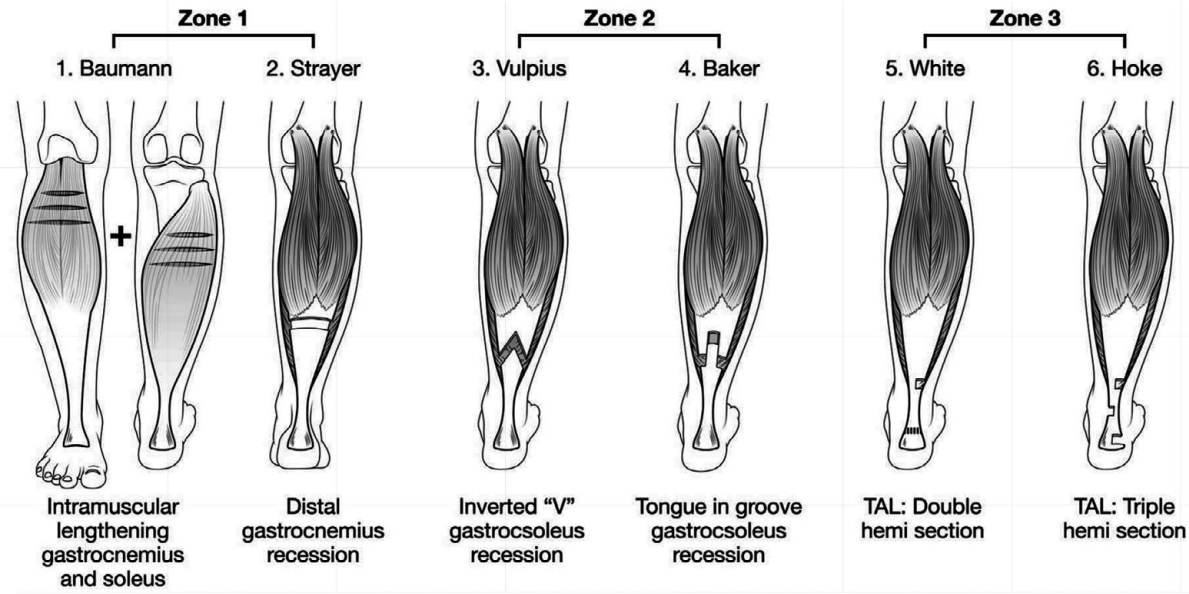


Figure 21.23 Surgical techniques for gastrocsoleus lengthening (GSL) based on the Zonal classification of the gastrocsoleus muscle-tendon unit (Ma et al. 2021) (Creative commons licence)

neurological causes such as cyst, syrinx or diastematomyelia. Spinal stenosis would be unlikely in this age group unless they have rhizomelic short stature.

Freiman HD, Mensah C, Codrington J, Frick SL. Idiopathic toe-walking in children and adolescents: diagnosis, natural history, and treatment options. *J Bone Joint Surg Rev.* 2022;**10**(2).

Tinney A, Khot A, Eiznberg, Wolfe R, Graham HK. Gastrocsoleus recession technique: an anatomical and biomechanical study in human cadavers. *Bone Joint J* 2014;**96-B**:778–782.

Ma N et al. Three-dimensional gait analysis in children undergoing gastrocsoleus lengthening for equinus secondary to cerebral palsy. *Medicina (Kaunas)* 2021;**57**:98.

23. Answer C. **The major blood supply to the distal humerus is from the posterior anastomotic vessels** Lateral epicondyle fractures are the second most commonly encountered elbow fractures in the paediatric population. These fractures are intra-articular and are prone to displacement owing to the attachment of the forearm extensor muscles on the lateral condyle. Fracture displacement is defined as the maximum distance between the proximal fragment and distal fragment in any of the radiographic views

Elbow Ossification Centers

Capitellum: 1 Y

Radial head: 3 Y

Int. epicondyle: 5 Y

Trochea: 7 Y

Olecranon: 9 Y

Ext. epicondyle: 11 Y

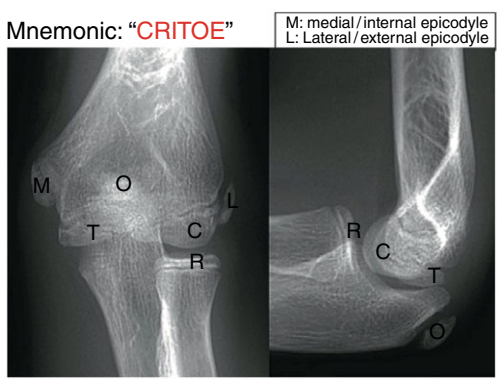


Figure 21.24 Elbow ossification centres. Reproduced with permission from Jack CF Chong. https://www.emnote.org/emnotes/ossification-centers-of-the-elbow

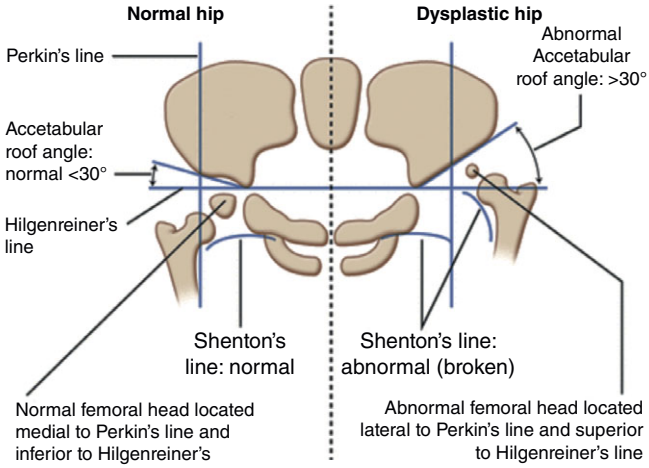


Figure 21.25 Demonstration of the radiographic parameters seen in the normal and dislocated hip. Reproduced with permission from Musculoskeletal Key. https://musculoskeletalkey.com/developmental-dysplasia-of-the-hip/#Fig4

These injuries have a higher risk of avascular necrosis (AVN), malunion or non-union compared with other elbow injuries. Clinical sequelae can include elbow stiffness and tardy ulnar nerve palsy. They are rarely associated with a posteromedial dislocation of the elbow.

The lateral epicondyle ossifies at 11 years old and fuses between 12–14 years old. The fracture normally extends distally and anteriorly across the physis and epiphysis into the joint.

For fixation an anterior approach is recommended to avoid the posterior vascular pedicle to the fracture fragment. This is important for minimising the risk of AVN of the fragment. There is some debate as to whether AVN occurs because of stripping of soft tissues from the lateral condyle fragment rather than because of the specific approach used.

24. Answer E. **The AI should be <25° in patients greater than 6 months old**
In infants treated for DDH, radiographs become essential to monitor further development of the infant hips beyond the age of 6–12 months. The acetabular index (AI) is the angle formed from a point on the lateral triradiate cartilage to a point on lateral margin of acetabulum and by Hilgenreiner's line. The centre edge angle of Wiberg should be greater than 20° (Figure 21.25).

Hilgenreiner's line is a horizontal line passing between both triradiate cartilages. Think Hilgenreiner's 'H' for horizontal. The femoral head ossification centre should sit inferior to this line.

Perkin's line is perpendicular to Hilgenreiner's line it passes through a point at the lateral margin of the acetabulum. Think 'P' perpendicular. The femoral head ossification centre should sit medial to this line.

25. Answer B. **If this is a Streptococcal infection, confirmation of effusion must be made prior to any GA, given the high risk in these patients**
Streptococcal infections are toxin producing so often there is no fluid to aspirate. Patients taken to theatre can decompensate and arrest therefore confirmation of an effusion must be made prior to any anaesthetic. The shoulder is in joint. Given the raised CRP and WBC this patient should be treated as a septic arthritis and given

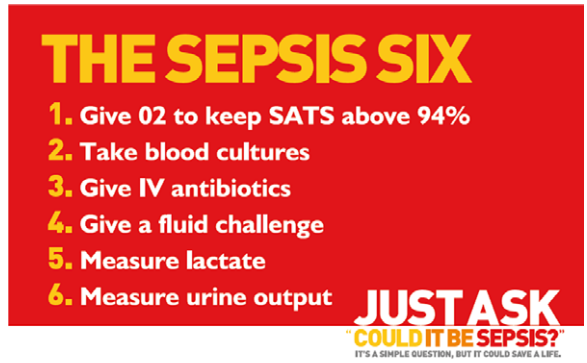


Figure 21.26 The Sepsis Six, reproduced with permission from The UK Sepsis Trust. https://sepsistrust.org

antibiotics immediately according to Sepsis Six guidelines.

26. Answer B. **The lateral head of the talus acts as the fulcrum around which the foot rotates during the Ponseti technique**
In 80% of patients, CTEV is an isolated deformity.

The Ponseti method involves an exact and precise sequence of weekly gentle manipulation, with the lateral head of the talus as the fulcrum. The sequence of correction is Cavus, Adduction not Abduction of the forefoot, Varus and Equnius (CAVE).

The neck of the talus is in a medially and plantar flexed position and not dorsiflexed position.

According to the official Ponseti technique the boots and bars must be worn for 23 hours a day for the first 12 weeks then nights and naps until age 4–5.

The following steps are performed with the Ponseti technique (Ponseti and Smoley 2009; Dietz and Noonan 2016).

1. Identify the head of the talus by palpation.
2 Supinate the forefoot to eliminate the cavus deformity and create a normal-appearing arch.
3 Abduct the forefoot with the vector of force parallel to the sole of the foot while using the lateral head of the talus as the fulcrum and maintaining the reduction of the cavus deformity.
4 This manipulation is followed by the application of an above-the-knee cast with the foot in the corrected position.

The manipulation and casting steps are repeated every 5–7 days until the foot is abducted approximately 50° from the frontal plane of the tibia.

In most patients (60–90%), a percutaneous tenotomy of the Achilles tendon is necessary to correct the residual ankle equinus after gaining full abduction of the foot with the manipulations.

The Newborn Infant Physical Examination (NIPE) should be performed on all newborn babies within 72 hours of birth.

https://global-help.org/products/clubfoot_ponseti_management/

Ponseti IV, Smoley EN. The classic: congenital club foot: the results of treatment. 1963. *Clin Orthop Relat Res.* 2009;**467**:1133–1145.

Dietz FR, Noonan K. Treatment of clubfoot using the Ponseti method. *J Bone Joint Surg Essent Surg Tech.* 2016;**6**:e28.

https://www.nhs.uk/conditions/baby/newborn-screening/physical-examination/

27. Answer C. **The intermalleolar distance should be <8 cm after 7 years of age**
This procedure should be considered in patients in 15–20° of valgus. Growth rate of the knee is 15 mm/year. 9 mm at the distal femur and 6 mm at the proximal tibia.

Hueter–Volkmann Law suggests that growth is decreased by mechanical compression and increased by tension. Patients with a Cozen deformity normally remodel.

Genu valgum can be corrected surgically either by osteotomy and internal fixation or gradual correction by external fixator or by growth modulation. Growth modulation means modifying/manipulating the normal growth patterns. It facilitates correction of angular deformities by selectively reversible tethering a portion of the physis to correct limb alignment.

Growth modulation in genu valgum is done by hemiepiphysiodesis using implants such as 8 or O plates, tension band, staples or transphyseal screws. Hardware removal is required after correction has been achieved.

In 2007, Stevens introduced a technique (8-plate) of temporary hemiepiphysiodesis, using a different construct then staples, but based on Blount's principles. It comprised of a non-locking extraperiosteal tension plates with two screws for angular correction. It is technically simple and highly efficient, allowing gradual correction with minimal complications and is removable. The 8-plate acts as a focal hinge at the perimeter of the physis with a longer lever arm, so as the physis grows, the screws toggle in the plate and pivot in the bone bringing about gradual correction and that does not produce compression at the physis, thus preserving the growth potential (Vaishya et al. 2018).

Figure 21.27 8-plate hemiepiphysiodesis

Stevens PM. Guided growth for angular correction: a preliminary series using a tension band plate. *J Pediatr Orthop.* 2007;**27**:253–259.

Vaishya R, Shah M, Agarwal AK, Vijay V. Growth modulation by hemiepiphysiodesis using eight-plate in genu valgum in paediatric population. *J Clin Orthop Trauma.* 2018;**9**:327–333.

28. Answer C. **Movement of the elbow will dictate the management of these deformities**

The condition is radial longitudinal deficiency (RLD). This is the commonest longitudinal deficiency in the upper limb and is represented by dysplasia and hypoplasia of varying degree involving the radial sided structures of the limb.

Movement at the elbow is integral to the treatment. It is extremely important to restore passive range of motion at the elbow with serial casting and splinting before any surgical procedure is undertaken. It has been reported that range of motion does not improve after centralisation.

Contraindications for surgical intervention are mild (type I) deformity in children and elbow extension contractures that prevent the hand from reaching the mouth if the deformity at the wrist is corrected. Surgery is also contraindicated for adults who have adjusted to their deformity.

Sonic Hedgehog gene affects the ZPA (zone of polarising activity).

This deformity is associated with several syndromes including thrombocytopenia, absent radius (TAR), Fanconi anaemia, Holt–Oram syndrome, VACTERL (vertebral, aal atresia, cardiac defects, tracheoesophageal abnormalities, renal and radial abnormalities, limb abnormalities) and VATER syndrome but not Wilms' tumour.

The limb bud develops at 4–8 weeks of gestation.

Bhat AK, Acharya AM. Current concepts in the management of radial longitudinal deficiency. *J Clin Orthop Trauma.* 2020;**11**:597–605.

29. Answer B. **These patients can present with osteomyelitis of the mandible**

This SBA is dependent on a candidate recognising that the radiographs demonstrate osteopetrosis.

The primary underlying defect in all types of osteopetrosis is failure of the osteoclasts to reabsorb bone. Several heterogeneous molecular or genetic defects can result in impaired osteoclastic function.

The specific genetic defect is due to defective carbonic anhydrase II. This results in an inability of the osteoclasts to acidify the Howship's lacunae.

These patients can present with osteomyelitis of the mandible due to dental abscesses.

Patients often have coxa vara due to fractures and malunion and rugger jersey vertebrae. The distal femora and proximal humeri often look like 'Erlenmeyer flasks'.

There are three types – malignant, intermediate and benign. The latter is autosomal dominant and the former two autosomal recessive. There is 75% gene penetrance.

This condition is associated with cranial nerve palsies; however, the optic nerve is most affected and the facial nerve the least affected.

With osteopetrosis malignant (autosomal recessive osteopetrosis (ARO)) the main pathological features are present at birth or become evident during the neonatal period (Sobacchi et al. 2013). Patients have a generalised increase in BMD that results in macrocephaly despite overall growth retardation, frontal bossing, exophthalmos (eye protrusion) and micrognathia (an abnormally small jaw), leading to characteristic facies. In addition, patients with ARO have a small thorax and hypertelorism (increased distance between the eyes). The increased BMD is detectable on radiographs as a 'bone-in-bone' appearance, mainly in the iliac wings, and Erlenmeyer flask deformity of the distal femoral and humeral metaphyses. These sclerotic changes also cause neurological defects – probably through calvarial thickening, increased intracranial pressure and inadequate formation of the cranial foramina through which nerves, spinal cord and major blood vessels pass. As a result,

patients with ARO often develop hydrocephalus and Chiari I malformation.

Sobacchi C, Schulz A, Coxon FP, Villa A, Helfrich MH. Osteopetrosis: genetics, treatment and new insights into osteoclast function. *Nat Rev Endocrinol.* 2013;**9**:522–536.

30. Answer C. **The most common cause is fibular hemimelia**

There are multiple aetiologies for tibial bowing. The radiographic appearance shows anteromedial bowing most likely caused by fibula hemimelia. The apex of the deformity is directed anteromedially. The bowing presents uniformly in the distal portion of the central third of the tibia. The epiphyseal ossification centers appear reduced, particularly at the lateral and posterior aspect.

Fibular hemimelia is a congenital lower limb anomaly characterised by partial or complete absence of the fibula and includes a spectrum ranging from mild fibular hypoplasia to complete fibular aplasia.

The anteromedial bowing is not physiological unlike posteromedial bowing. Anterolateral bowing is associated with neurofibromatosis and a congenital pseudoarthrosis. No genetic inheritance is associated with this condition.

Blakey C, Fernandes, JA. Tibial bowing. *Orthop Traum.* 2016;**30**:518–524.

31. Answer E. **This condition is often associated with other orthopaedic issues including a ball and socket ankle, ACL insufficiency, PFFD and CTEV**

Fibula hemimelia has several orthopaedic manifestations. From the hips down, DDH (development dysplasia of the hip), PFFD (proximal femoral focal deficiency), coxa vara, cruciate ligament deficiency, genu valgum due to lateral femoral condyle dysplasia, ankle instability and ball and socket ankle joint, tarsal coalition (50%), absent lateral rays and CTEV (congenital talipes equinovarus). This condition is associated with Sonic Hedgehog gene but there is no inheritance pattern. It is associated with anteromedial bowing. Consideration of amputation should be based on function of the foot. Treatment is determined by the length of the limb and the stability of the foot and ankle. The length of the fibula does not dictate treatment.

32. Answer D. **Tethering of Vickers ligament is often implicated in the pathology of this condition**

AP radiograph of the wrist shows a positive ulnar variance and a V-shaped proximal carpal row while the lateral radiograph shows palmar carpal subluxation. This patient has a Madelung's deformity and is hypothesised to be associated with a tethering of Vickers ligament. This is a fibrous band extending from the lunate to the distal radius, resulting in partial growth arrest of the distal physis. This can be confirmed on MRI scan. The condition is also associated with Léri–Weill dyschondrosteosis, which is a genetic disorder caused by mutation in the SHOX (short-statute homeobox-containing) gene. It is an autosomal dominant condition characterised by Madelung's deformity, short lower limbs and short stature.

Madelung's deformity is more common in female gymnasts if not associated with this mutation.

The median nerve is the most affected nerve.

33. Answer B. **MRI scan, vitamin D levels and commence vitamin D**

This patient has osteochondritis dissecans of his left knee. It most commonly affects the lateral aspect of the medial femoral condyle. It can also occur in the talus and capitellum of the humerus. It has no known cause, but repetitive stress on the joint, low vitamin D and a genetic predisposition are often linked to this condition.

An MRI scan will define the lesion giving an indication of size and stability. The patient should be restricted weight bearing with a brace. This lesion looks stable on the X-ray so the first line of treatment would be conservative.

The most important prognostic factor involves the skeletal age of the patient at the time of onset of symptoms. More than half of paediatric osteochondritis dissecans cases treated conservatively will demonstrate healing within 6–18 months, while adults with osteochondritis dissecans of the knee frequently require surgery.

Osteochondritis dissecans of the knee may be completely asymptomatic. It is important to examine the knee to rule out other causes of knee pain. Inspection of knee alignment may reveal genu varus, associated with a lesion at the medial femoral condyle, or genu valgus, more common with osteochondritis dissecans of the lateral

femoral condyle. Palpation may reveal effusion or bony tenderness along the femoral condyles with varying degrees of knee flexion. The patient's range of motion may be limited secondary to pain, swelling or a loose body compared with the contralateral knee.

The X-rays also have some features, which suggest mild rachitis so the patient should have blood tests for bone biochemistry including vitamin D levels and commence vitamin D supplements.

Mohr B, Baldea JD. Knee Osteochondritis Dissecans. Treasure Island, FL: StatPearls Publishing; 2023.

34. Answer E. **You suggest a pelvic osteotomy for this patient +/− femoral osteotomy if the hip is not reducible**

The treatment of choice would be a pelvic osteotomy (most likely Dega) following open reduction of the hip and femoral osteotomy depending on hip stability.

This patient has an attenuated ligamentum terres and the labrum is inverted. When performing this procedure, blocks to reduction are an inverted labrum, inverted limbus, transverse acetabular ligament, hip capsule, pulvinar and ligamentum terres but not iliopsoas. The iliopsoas causes an hourglass deformity of the capsule by constricting it, but it is not classically described as a block to reduction. A closed reduction would not be the treatment of choice in this child. Following closed reduction and spica application an MRI should be performed under sedation and not a CT scan due to the amount of radiation.

35. Answer A. **ACL reconstruction**

ACL ruptures are very common in female netball players and there are several reasons for this; females generally have increased laxity compared with their male counterpart. In general, when females land, their knee is in valgus and extension. They have stronger quadriceps compared with hamstrings and decreased core stability.

The natural history of the ACL deficient knee in children generally results in recurrent instability and progressive intra-articular injury. Most children attempting to return to high-risk activities with an ACL deficiency suffer from knee instability and functional decline.

Numerous techniques have been described for the treatment of paediatric ACL injuries. Good functional results have been obtained with physeal-sparing, partial transphyseal and complete transphyseal procedures. Adolescents who are nearing the end of their growth can be managed as an adult with a transphyseal ACL reconstruction and minimal risk of growth disturbance.

McConkey MO, Bonasia DE, Amendola A. Pediatric anterior cruciate ligament reconstruction. *Curr Rev Musculoskelet Med.* 2011;**4**:37–44.

36. Answer B. **Hemiepiphysiodesis**

This patient has an increased intermalleolar distance. Given her age, hemiepiphysiodesis would be recommended. This should be performed as soon as possible in order to allow time for correction.

Idiopathic genu valgum is a frequently diagnosed growth disorder in adolescence, albeit with strong variations regarding degree, cause and therapeutic relevance. Particularly in the growth phase from 2–11 years of age, a minor valgus deformity of 5–10° is regarded as physiological and may persist beyond this depending on body habitus.

Non-operative treatment options for genu valgum include observation in case of spontaneous correction, bracing, non-steroidal anti-inflammatory drugs, and/or lifestyle restrictions. The efficacy of these treatment modalities remains unknown. If a tibiofemoral angle of more than 15° or an inter-malleolar distance of 10 cm persists after age 10, it is likely that spontaneous correction will not occur and operative treatment will be necessary

Options for operative treatment include hemiepiphysiodesis with plate, hemiepiphyseal stapling and corrective osteotomy.

Hemiepiphyseal stapling is a good option because it is minimally invasive, does not ablate the growth plate as in permanent epiphysiodesis, and is theoretically reversible in the possible event of overcorrection. An 8-plate hemiepiphysiodesis is probably the preferred method for correcting angular deformities of the knee in skeletally immature patients. This option was not given in the SBA.

Chapter 22

Children's Orthopaedics III Structured SBA

Maire-Clare Killen and Ling Hong Lee

CHILDREN'S ORTHOPAEDICS III STRUCTURED SBA QUESTIONS

1. A surgeon is performing *in situ* fixation of a slipped upper femoral epiphysis using an unthreaded device over the physis.
   Which patient characteristic will benefit the most from the chosen fixation device?
   A. A 9-year-old boy
   B. A girl with BMI of 35
   C. Acute slip presenting less than 24 hours of symptom
   D. Head–shaft angle of 40°
   E. Open greater trochanter growth plate

2. A 13-year-old boy is under regular follow up after treatment for a distal femoral fracture. Standing full length alignment views demonstrate complete closure of the distal femoral physis and a leg length discrepancy of 10mm.
   Without intervention, what would be the estimated leg length discrepancy at skeletal maturity?
   A. 30mm
   B. 40mm
   C. 50mm
   D. 55mm
   E. 60mm

3. You are reviewing a 9-year-old boy with left hip Perthes disease in the outpatient clinic. AP radiographs show a stage of final healing with an aspherical congruent hip, coxa magna and short femoral neck. He has not had surgical intervention. On counselling the parents regarding further review, you describe potential deformities that may require intervention.
   Which of the following is the least likely anticipated surgery?
   A. Epiphysiodesis of right knee for leg length discrepancy
   B. Femoral neck lengthening osteotomy for greater trochanter overgrowth
   C. Lateral hemiepiphysiodesis of left distal femur for genu varum
   D. Osteochondroplasty of the hip for impingement
   E. Valgus extension osteotomy of proximal femur for hinge-abduction

4. A 6-month-old boy is referred to you by a consultant paediatrician who saw the child for plagiocephaly but also noted he had a torticollis. When questioned, parents reported the presence of head tilt and rotation since birth. The child is otherwise healthy with normal milestones and has had normal delivery. There is a palpable neck mass on the side of the head tilt.
   The least appropriate management at this stage would be which of the following?
   A. Physiotherapy for passive stretching of the torticollis
   B. Radiography cervical spine
   C. Referral for ophthalmic assessment
   D. Ultrasound of the hips
   E. Ultrasound of the neck

5. An 11-year-old boy complains of pain in the lateral aspect of his left ankle and it gives way easily. He is otherwise healthy and plays football regularly. You determine that there is flattening of medial longitudinal arch of the foot with forefoot abduction. His heel is in valgus with limited range of motion.
   Plain standing foot X-rays are likely to show which of the following?
   A. Dorsal dislocation of talonavicular joint not correctable with forced plantar flexion
   B. Dorsal subluxation of talonavicular joint which corrects with forced plantar flexion

C. Loss of middle facet joint
D. Narrowing and irregularity of calcaneonavicular joint
E. Positive C-sign

6. A 6-month-old girl presents with unilateral posteromedial bowing of the tibia.
Which of the following statements is correct?
A. Deformity improves the most after the child begins walking
B. Deformity usually will require surgical intervention before school age
C. Leg length discrepancy, if present, will worsen in length throughout growth
D. Most common residual deformity is residual bowing
E. On standard X-rays, the medial bow improves more than the posterior bow

7. A 9-year-old boy presents with a 2-day history of right knee pain and swelling. He also complains of pain and swelling in both ankles for the past week, which have now settled. He was healthy prior to these episodes. The parents report noticing a circular red, expanding rash behind the child's knee after returning from camping 3 months ago, which resolved spontaneously. He is able to mobilise with an aid and has fever of 38°C, WCC 11000/mm^3, ESR 40mm/h, CRP 10 mg/l.
What is the mainstay in diagnosis of this condition?
A. Blood culture and sensitivity
B. Serum anti-nuclear antibody, HLA-B27 and ophthalmic assessment
C. Serum enzyme-linked immunosorbent assay
D. Serum rheumatoid factor and anti-nuclear antibody
E. Synovial fluid polymerase chain reaction

8. An 18-month-old girl is brought to clinic with parental concerns due to in-toeing and the appearance of her lower legs. Standing long leg alignment views are shown in Figure 22.1.
What is the most appropriate next course of action?
A. Valgus producing proximal tibial osteotomy
B. Bracing with a knee ankle foot orthosis
C. A period of observation
D. Temporary lateral tibial hemi-epiphysiodesis
E. Temporary medial tibial hemi-epiphysiodesis

Figure 22.1
Weight bearing long leg alignment views

9. A health visitor noted left hip clicking in a female baby. She was born at term, cephalic presentation with no family history of developmental hip dysplasia. She is the first child and is now 2 months old. Her left hip ultrasound is shown in Figure 22.2.

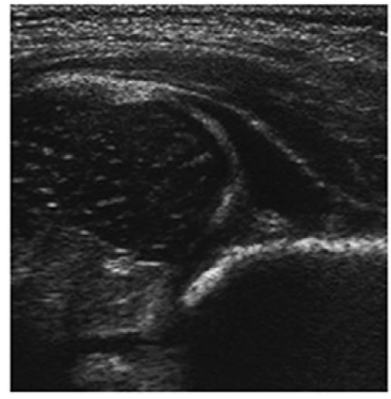


Figure 22.2
US hip

What is the next appropriate step of management?
A. Application of a Pavlik harness
B. Arthrogram, closed reduction and application of hip spica
C. Repeat scan in 4 weeks
D. Open reduction and application of hip spica
E. Reassure and follow up clinic appointment in 3 months

10. An 11-year-old girl presents with an 8-week history of right thigh pain. She is able to weight-bear unaided, but has an antalgic gait. Radiographs are shown in Figure 22.3.

Figure 22.3 Pelvic radiograph

Management should involve:

A. Non-steroidal anti-inflammatories and crutches
B. Closed reduction and pinning of the right hip
C. Open reduction and pinning of the right hip
D. Pinning *in situ* of the right hip with a single screw
E. Pinning *in situ* of the right hip with 2 or more screws

11. An 8-year-old girl presents several years following non-operative management of a left supracondylar fracture with the deformity shown in Figure 22.4.

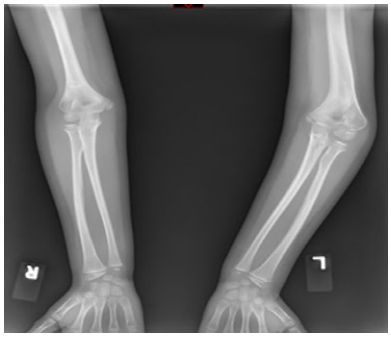


Figure 22.4 AP radiographs of both arms

Lateral closing wedge osteotomy of the distal humerus will likely result in:

A. Improved elbow function
B. Improved elbow range of motion
C. Reduced elbow pain
D. No improvement
E. Improved cosmesis

12. You are examining a 9-year-old girl with hemiplegic spastic cerebral palsy. She reports frequent tripping on the affected right side. On the right side, she has positive fixed Duncan–Ely test and you notice very little knee flexion during her swing phase.

In regard to her gait on the contralateral (unaffected) side, she is likely to have which compensatory mechanism?

A. Circumduction of leg
B. Early heel rise in stance phase
C. Shortened stance phase
D. Trunk flexes forward early in stance phase
E. Trunk leans towards the involved side

13. A child is admitted with a femur shaft fracture. You are considering using Gallows traction to manage this injury.

Which of the following is a contraindication for your choice?

A. Transverse fracture pattern
B. The child is 2 years old
C. The child weighs 20kg
D. There is an ipsilateral humerus fracture
E. There is a safeguarding concern

14. A 6-year-old presents with restricted range of motion of her left elbow following an injury 3 months ago. This was treated elsewhere with a short period of immobilisation in a cast. Her current radiographs are shown in Figure 22.5.

Figure 22.5 Lateral elbow radiograph

What would be the next appropriate step in management?

A. Further period of immobilisation in a cast
B. Referral to physiotherapy to improve elbow range of motion

C. Manipulation and cast immobilisation
D. Period of observation
E. Ulnar osteotomy +/− open reduction of the radial head

15. A neonatologist has referred a newborn male infant with lower limb deformity. He was born at term and is otherwise healthy. The mother is still recovering from a postpartum haemorrhage. You examined the infant on the ward and found bilateral cavovarus posture of the feet. The midfoot has curved lateral border and moderate medial and posterior creases. Attempt to correct the posture reveals prominent lateral head of talus and ankle dorsiflexion to 90°.
Which of the following is the best information for the parents in regard to the posture?
A. Can be treated best by casting with Achilles tenotomy after the child is walking
B. Condition is best treated by corrective surgery as soon as possible
C. Condition is best treated by serial manipulation and casting as soon as possible
D. Does not need intervention and will spontaneously improve
E. Needs intervention but can wait till the child is 1 year old by corrective surgery

16. A 9-year-old boy had closed reduction and crossed K-wire fixation of a supracondylar elbow fracture. During your morning round, he is found to have decreased sensation in the ipsilateral ring and little fingers and unable to abduct his fingers.
What is true of the injured nerve?
A. Courses between the lateral and medial head of triceps
B. Innervates the adductor pollicis
C. Innervates the flexor pollicis longus
D. Is a branch of brachial plexus containing fibres from spinal roots C7, C8 and T1
E. Primarily flexes the proximal interphalangeal joints of ring and little fingers

17. **The most likely cause of the injured nerve in Question 16 would be which of the following?**
A. Compartment syndrome
B. Constriction by the cubital tunnel retinaculum
C. Medial pinning
D. Multiple closed reduction attempts in the ED
E. Overshoot of lateral wires

18. A 4-year-old boy is referred with the elbow injury shown in Figure 22.6 and is planned to undergo open reduction and fixation.

Figure 22.6 AP elbow radiograph

When performing this procedure, dissection around which portion of the fragment should be avoided?
A. Anterior
B. Medial
C. Lateral
D. Posterior
E. Inferior

19. You are assessing the torsional profile of a 10-year-old girl presenting with bilateral in-toeing.
A torsional profile includes all of the following components EXCEPT:
A. Foot border profile
B. Foot progression angle
C. Hip rotation
D. Knee intercondylar distance
E. Thigh–foot angle

20. An 18-month-old girl was brought by her parents to a new patient clinic having had a harness programme for her bilateral developmental hip dysplasia in their home country. They have recently migrated to this country and have no documentation of previous treatment. The AP pelvis X-ray shows both the midpoints of the superior margin of the ossified metaphysis to be at the Perkin line and inferior to the Hilgenreiner line. Acetabular indices are 20° bilaterally.

The most appropriate next course of action is which of the following?

A. Closed reduction and hip spica for persisting dysplasia
B. List for hip arthrogram and examination under anaesthesia to check for hip laxity
C. Open reduction and femoral osteotomy to improve congruency
D. Open reduction and pelvic osteotomy to improve congruency and stability
E. Reassure parents and review child routinely

21. The Waldenström stages of Legg–Calvé–Perthes disease of the hip describe radiographic changes as the disease progresses.

Which of the following radiographic findings fits the stage where creeping substitution first occurs?

A. Density of femoral head remains normal
B. Increase in density of the ossific nucleus and apparent widening of medial joint space
C. Ossific nucleus becomes increasingly lucent
D. Ossification is apparent in the medial and lateral aspect of femoral head
E. Smaller ossific nucleus and slight lateralisation of the femoral head

22. A newborn baby is diagnosed with congenital talipes equinovarus bilaterally and is referred to clinic to commence serial casting shortly afterwards.

The technique to correct the deformity involves all of the following EXCEPT:

A. Forefoot pronation
B. Weekly cast changes
C. Above knee casting
D. Percutaneous Achilles tenotomy as needed prior to final cast application
E. Forefoot abduction with lateral pressure on the talar head

23. You are reviewing a 6-year-old child with cerebral palsy and counselling her parents about selective dorsal rhizotomy.

Which of the following features is the most suggestive of contraindication for the procedure?

A. Child has diagnosis of mild autism and attends mainstream education
B. The child uses a walker independently
C. History of premature birth at 30 weeks gestation
D. MRI shows injury to basal ganglia
E. Presence of clonus in both lower limbs

24. You are seeing a 5-year-old girl in clinic with a leg length discrepancy. The longer leg also has a bigger leg and thigh circumference compared with the contralateral side. You also notice asymmetry in the tongue.

The appropriate next course of action would be which of the following?

A. Arrange for the patient to undergo 8-plate epiphysiodesis on the longer side
B. Plan for limb lengthening on the shorter side
C. This condition is benign and can be monitored. Surgery for leg length discrepancy can be done just before puberty
D. Refer the patient for a screening abdominal ultrasound
E. Refer for MRI lower limbs to determine cause of soft tissue volume difference

25. An anteroposterior pelvis X-ray of a 7-year-old boy with bilateral hip pain is shown in Figure 22.7.

Figure 22.7 Anteroposterior (AP) radiograph pelvis

Regarding this condition, which of the following is true?

A. Children with this condition predominantly walk with an in-toeing gait pattern
B. The Hilgenreiner-epiphyseal angle can be used to monitor and guide treatment plan
C. This condition can be managed non-operatively with long-term vitamin D supplementation
D. This is a sequela of previous severe systemic sepsis
E. When planning surgery for the femur, a 90° angled construct is most commonly used

26. A 14-year-old boy attends the ED with a painful and swollen right knee following a fall while ice skating. Lateral X-ray of the knee is shown in Figure 22.8.

Figure 22.8 Lateral radiograph of the right knee

What is the most likely management for his injury?

A. Rest, ice, anti-inflammatory and physiotherapy for Osgood–Schlatter disease
B. Late excision of ossicle within the patella tendon
C. Repair of avulsed patella tendon sleeve
D. Arthroscopic excision of osteochondral fragment
E. Physiotherapy for anterior cruciate ligament injury

27. A 10-year-old previously healthy Caucasian boy has a 5-day history of painful, swollen and erythematous lateral heel. He bears weight on his toes and denies history of trauma. WCC normal, CRP 40 and temperature 38°C. A plain radiograph is normal. An image from MRI is shown in Figure 22.9.

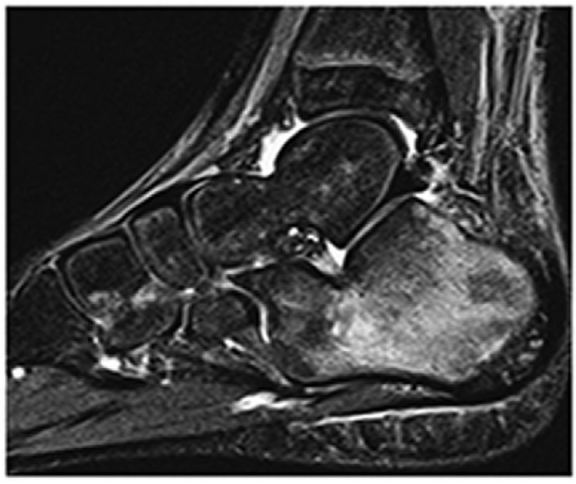


Figure 22.9 MRI T2 sagittal view ankle

How would you manage this patient?

A. Start oral fluoroquinolone antibiotic because it is as effective as intravenous form
B. Start intravenous penicillin beta-lactam antibiotic
C. List for urgent surgical aspiration and wash-out of ankle and calcaneum
D. Treat calcaneum fracture non-operatively in moonboot
E. Refer to musculoskeletal oncology department

28. You are reviewing a 16-year-old female with symptomatic bilateral feet deformities. Her condition is due to duplication of gene encoding PMP22 on chromosome 17.

Which of the following may not improve her deformity?

A. Achilles tendon lengthening
B. Custom-made orthosis
C. Lateral column calcaneum lengthening
D. Peroneus longus to brevis transfer
E. Split transfer of tibialis posterior tendon

29. **For children with Perthes disease, all of the following are associated with a worse clinical outcome, EXCEPT:**

A. Metaphyseal cysts
B. Lateral subluxation of the femoral head
C. Calcification lateral to the epiphysis
D. Horizontal physis
E. Maintenance of >50% of lateral pillar height

30. A 9-year-old girl with lumbar myelomeningocele reports increasing pain, weakness in her right leg and progressive right foot deformity resulting in difficulty mobilising with her walker.

What is the most appropriate management option?

A. Bloods for inflammatory markers to rule out infection
B. MRI of lower limb to rule out stress fracture
C. MRI of spine
D. Physiotherapy and hydrotherapy for chronic pain syndrome
E. X-ray of the leg and foot

31. An 8-month-old presents with a deformity to their left lower limb as shown in Figure 22.10.

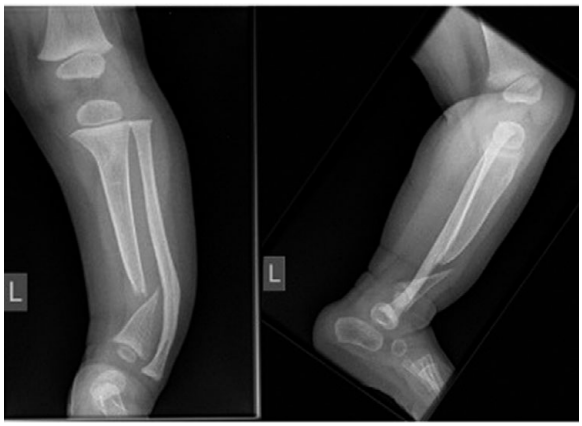


Figure 22.10 AP and lateral radiographs of the lower limb.

What other features in your systemic examination would suggest a commonly associated diagnosis?

A. Absent lateral rays of the foot
B. Coast of Maine skin pigmentation
C. Axillary freckling
D. Lens dislocation
E. Calcaneovalgus foot deformity

32. You assessed a 2-year-old healthy girl with flat feet and decided to perform X-rays of the feet.

Which of the following findings most likely suggests congenital vertical talus?

A. Lateral X-rays in dorsiflexion and plantar flexion showing irreducible talonavicular joint
B. Lateral X-rays in dorsiflexion and plantar flexion showing reducible tarsometatarsal joint
C. Lateral X-rays showing horizontally positioned talus which is almost parallel with calcaneus
D. Lateral X-rays showing positive 'anteater nose' sign
E. Lateral X-rays showing positive C-sign

33. You decided to perform percutaneous *in situ* fixation of a moderate but stable slipped upper femoral epiphysis in a 13-year-old boy.

Which is the least preferred fixation option?

A. A single fully threaded cannulated 6.5mm screw
B. A single partially threaded 32mm cannulated 6.5mm screw
C. Three parallel partially threaded 32mm cannulated 6.5mm screws
D. Two crossed partially threaded 32mm cannulated 6.5mm screws
E. Two parallel partially threaded 32mm cannulated 6.5mm screws

34. You decided to perform percutaneous *in situ* fixation of a moderate but stable slipped upper femoral epiphysis in an 11-year-old boy. You have recently been trained to use a 'growing' screw, which may allow proximal femoral growth. You assess the status of growth plates in the pelvis and proximal femur.

In which order do the growth plates normally close?

A. Femoral head, then greater trochanter, then triradiate cartilage
B. Femoral head, then triradiate cartilage, then greater trochanter
C. Greater trochanter, then triradiate cartilage, then femoral head
D. Triradiate cartilage, then femoral head, then greater trochanter
E. Triradiate cartilage, then greater trochanter, then femoral head

35. **In a case of unilateral slipped upper femoral epiphysis, you would consider prophylactically pinning the contralateral hip in each of the situations below, EXCEPT which?**

A. The patient has a new diagnosis of growth hormone deficiency and will commence growth hormone therapy soon
B. The patient is a healthy 8-year-old
C. The patient is known to have growth hormone deficiency and already on treatment
D. The patient is under the care of endocrine specialist for hypothyroidism
E. The triradiate cartilage is closed

36. **By applying a hyperextension force on a skeletally immature distal radius, most epiphyseal separation occurs?**

A. Through the hypertrophic cartilage cells and into the joint
B. Through the proliferative cartilage cells and cleavage into diaphysis
C. With both periosteum on the concave and convex sides ruptured
D. With the periosteum on the concave side intact
E. With the periosteum on the convex side intact

37. A 12-month-old girl is under follow up for a left-sided developmental hip dysplasia. She had completed a Pavlik harness programme, which was

started at 6 weeks of age. Her current pelvic X-rays show irregular ossification of both femoral heads.

Which of the following is the most likely diagnosis and plan of action

A. Bilateral early onset Perthes and send her to physiotherapist
B. Bilateral osteonecrosis due to Pavlik harness treatment and continue to monitor
C. Bilateral osteonecrosis due to acute lymphoblastic leukaemia and needs MDT workup of the case
D. She likely has a haemoglobinopathy and refer her to the paediatrician for bloods and investigation
E. This is a case of multiple epiphyseal dysplasia and refer to geneticist to confirm genetic mutation

38. **A child with a defect in the gene encoding cartilage oligometric protein (COMP), will demonstrate all of the following features EXCEPT:**

A. Rhizomelic limb shortening
B. Odontoid hypoplasia
C. Varus knee alignment
D. Midface hypoplasia
E. Disproportionate short stature

39. You review a 2-year-old in clinic with a significant leg length discrepancy secondary to the pathology shown in Figure 22.11.

Figure 22.11 Long leg alignment views

All of the following are known to be associated with this condition EXCEPT:

A. Proximal focal femoral deficiency
B. Ball and socket ankle joint
C. Tarsal coalition
D. Anterolateral tibial bowing
E. Hypoplastic lateral femoral condyle

40. A 12-year-old male presents to the emergency department after sustaining a left knee injury during a football match. Examination reveals a large knee effusion and extensor lag. Radiographs are shown in Figure 22.12.

Figure 22.12 Lateral knee radiograph

What is the most appropriate definitive management?

A. Open reduction and suture fixation
B. Immobilisation in a cylinder cast
C. Immobilisation in a hinged knee brace
D. Patellar tendon mid-substance repair
E. Patellar tension band wire

41. A 6-year-old boy presents with right-sided hip pain, refusal to weight bear and a 24-hour history of intermittent pyrexia. His temperature on presentation is 38°C. His blood tests show a white cell count of 14,000 mm^3 and ESR 25.

How many Kocher criteria have been met and what is the likelihood of this child having septic arthritis?

A. 1 out of 4, 3%
B. 2 out of 4, 40%
C. 2 out of 4, 50%
D. 3 out of 4, 93.1%
E. 4 out of 4, 99.6%

CHILDREN'S ORTHOPAEDICS III STRUCTURED SBA ANSWERS

1. Answer A. **A 9-year-old boy**
Threaded screw fixation across the physis is the most common method used in *in situ* fixation of SUFE. However, this commonly results in physeal arrest and growth disturbance of the femoral neck giving rise to symptoms of femoroacetabular impingement (FAI). Unthreaded fixation of the physis (Hansson hook-pin, proximal threaded screw, free-gliding SCFE screw) allows remodelling in the form of remaining longitudinal growth of the neck to decrease the risk of FAI. Remodelling of SUFE has been found to be the highest in a younger age group, open triradiate cartilage and in a mild slip. Risk of FAI is higher in males following SUFE. BMI and duration of slip have not been linked to remodelling potential. The greater trochanter fuses last nearing skeletal maturity.

2. Answer B. **40mm**
The patient has had a growth arrest secondary to a distal femoral fracture. He has 3 years of growth remaining with 10mm/year of growth from the distal femoral physis. Therefore 10×3 + existing 10mm discrepancy = 40mm at skeletal maturity.

In the final years of growth this arithmetic method can be used, which estimates growth per year from each physis and assumes girls will stop growing at 14 and boys at 16. This has the advantage of ease of calculation, but is less accurate for younger children (the Paley or Mosley methods would be more accurate in these cases).

Lower extremity growth estimations:

Proximal femur: 3mm/year

Distal femur: 10mm/year

Proximal tibia: 6mm/year

Distal tibia: 5mm/year

Hubbard EW, Liu RW, Iobst CA. Understanding skeletal growth and predicting limb-length inequality in pediatric patients. *J Am Acad Orthop Surg.* 2019;**27**:312–319.

3. Answer C. **Lateral hemiepiphysiodesis of left distal femur for genu varum**
This patient is likely to have leg length discrepancy and greater trochanter overgrowth. GT overgrowth can cause abduction lever arm failure, resulting in Trendelenburg gait and fatigue. Femoral neck lengthening can resolve this issue. Osteochondroplasty of the hip and valgus extension osteotomy are options for impingement or hinge-abduction. Genu varum is uncommon in Perthes disease.

4. Answer B. **Radiography cervical spine**
Congenital muscular torticollis (CMT) is a postural deformity evident shortly after birth, typically characterised by lateral flexion/side bending of the head to one side and cervical rotation/head turning to the opposite side due to unilateral shortening of the sternocleidomastoid muscle.

CMT is usually due to 'packaging disorder'.

Plagiocephaly is almost always present and up to 20% of cases are associated with developmental hip dysplasia. Ultrasound can confirm sternocleidomastoid muscle involvement. Paralytic squint and nystagmus may lead to torticollis in children and result in failure of torticollis treatment by physiotherapy or surgery, which is considered for severe torticollis not responding to stretching.

The majority of cases will resolve after several months of conservative management with manual stretching and physiotherapy. Surgical correction may be required in patients with residual deficits in range of motion of the neck, plagiocephaly or facial asymmetry, and late presentation.

Clinical examination is sufficient in the diagnosis of CMT in infants. Radiography, CT scanning and MRI are not necessary unless there is persistent torticollis after physiotherapy.

Williams CRP et al. Torticollis secondary to ocular pathology. *J Bone Joint Surg Br.* 1996;**78**:620.

5. Answer D. **Narrowing and irregularity of calcaneonavicular joint**
Symptoms of recurrent ankle sprains and pain are consistent with tarsal coalition. Most common types of tarsal coalition are calcaneonavicular and talocalcaneal joints. Of the two, the calcaneonavicular coalition is more frequent and patients present younger. Osseous calcaneonavicular

coalition will show bony bridge between anterior process of calcaneum and navicular. Fibrocartilaginous coalition will show narrowed and irregular joint space. C-sign and loss of middle facet joint are consistent with talocalcaneal coalition which usually affects the middle facet of subtalar joints. Answer A is vertical talus and answer B is oblique talus, which are not typical of the case presented.

6. Answer C. **Leg length discrepancy, if present, will worsen in length throughout growth**
Posteromedial bowing of the tibia is thought to be due to intrauterine moulding and corrects spontaneously. However, some authors have noted the presence of this abnormality during the 20-week antenatal scan. Deformity improves the most in the first year of life. Leg length discrepancy is the most common persistent deformity and worsens throughout growth although the relative shortening of tibia remains the same.

Wright J et al. Posteromedial bowing of the tibia: a benign condition or a case for limb reconstruction? *J Child Orthop*. 2018;**12**:187–196.

7. Answer C. **Serum enzyme-linked immunosorbent assay**
Polyarticular asymmetric arthritis with erythema migrans suggests Lyme arthritis. Patient may recall a tick bite. There is often a latent period from days to months between the presence of rash and onset of arthritis. The rash can easily go unnoticed, especially in darker-skinned individuals. Inflammatory markers are mildly elevated compared with bacterial septic arthritis. Diagnosis of Lyme disease is challenging due to its similarity with septic arthritis and low yield with a long incubation period required in routine blood cultures. Synovial fluid PCR specific for *Borrelia burgdorferi* is neither standardised nor readily available. ELISA and Western blotting are current standards to detect antibodies to *B. burgdorferi*. Answers B and E are relevant for psoriatic arthritis and juvenile idiopathic.

8. Answer C. **A period of observation**
The radiographs in Figure 22.1 demonstrate bilateral symmetrical genu varum. Given the child's age, the most likely diagnosis is physiological varus. Initial varus seen in children up to 2 years is known as 'physiological varus' and is by far the most common cause for genu varum in toddlers.

Physiological varus is typically bilateral and fairly symmetrical. Internal tibial torsion is frequently found in association with physiological genu varum and usually corrects concomitantly with the varus deformity. No active treatment is required for children with physiological varus; even pronounced genu varum can correct with continuing growth. Parental reassurance and periodic examination is all that is necessary as most cases resolve spontaneously by age 3.

Heath CH, Staheli LT. Normal limits of knee angle in white children: genu varum and genu valgum. *J Pediatr Orthop*. 1993;**13**:259–262.

9. Answer A. **Application of a Pavlik harness**
Ultrasound shows a dislocated left hip with shallow acetabulum (Figure 22.13 with keys). In this age group (up to 6 months old), the Pavlik harness is the first choice of treatment in most countries. While different centres will have different harness regimes, it is important to engage the family for compliance, perform regular

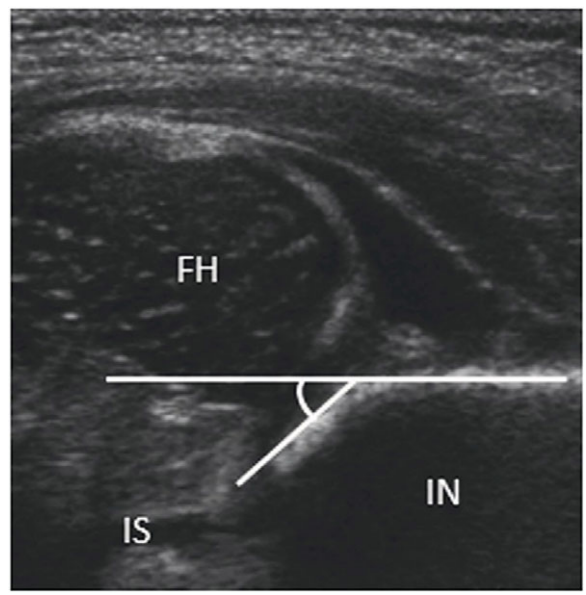


Figure 22.13 US hip. Key: FH – femoral head, IN – innominate bone, IS – ischium; alpha angle is the intersection between baseline (line of ilium as it intersects bony and cartilaginous portions of acetabulum) and roof of the bony acetabulum

harness checks for positioning and size and repeat ultrasound scan to look for success or failure of harness treatment. The Pavlik harness is not without its complications, even on the normal hip side.

10. Answer D. **Pinning *in situ* of the right hip with a single screw**
The radiographs in Figure 22.3 show a right slipped upper femoral epiphysis. This is considered stable as the patient is able to weight bear. *In situ* fixation of the hip with a single cannulated screw is usually the treatment of choice in these cases.

11. Answer E. **Improved cosmesis**
Figure 22.4 shows left-sided cubitus varus, which is the most common complication following paediatric supracondylar fractures. It typically causes cosmetic concerns, but often does not affect range of motion or function. The primary indication for surgical correction with distal humerus osteotomy is usually cosmesis.

Solfelt DA, Hill BW, Anderson CP, Cole PA. Supracondylar osteotomy for the treatment of cubitus varus in children: a systematic review. *Bone Joint J.* 2014;**96**:691–700.

12. Answer B. **Early heel rise in stance phase**
This case describes a stiff knee gait from a spastic rectus femoris. Compensatory changes can be observed in the affected side as well as the unaffected side to improve foot clearance on the stiff knee. Affected side – circumduction of leg, external rotation of foot, pelvic elevation, trunk leans away from involved side. Unaffected side – early heel rise in loading response and midstance (vaulting). Answer D describes gait pattern in weak quadriceps.

13. Answer C **The child weighs 20kg**
Gallows traction can be used in infants and small children weighing up to 15kg. Although there are a few institutions that have used Gallows traction with a higher-weight child, there are risks of vascular injury, compartment syndrome, common peroneal nerve palsy and skin breakdown. Children with a sensory deficiency should be contraindicated due to potential skin complications. Traction can be used temporarily prior to surgery or definitively. Age is not strictly a contraindication, although Gallows traction works best in infants up to 18 months. Older children have a risk of complications.

This involves the application of skin traction with the child's legs suspended overhead, with the hips flexed to 90° and the knees extended, utilising the child's body weight to apply traction to the fracture.

14. Answer E. **Ulnar osteotomy +/− open reduction of the radial head**
The radiographs in Figure 22.5 demonstrate a delayed presentation of a dislocated radiocapitellar joint from a missed Monteggia injury. Non-operative measures would not improve symptoms and it is unlikely that closed reduction would be successful.

Ulnar osteotomy with proximal opening wedge should bring the radial head back into joint, but may require open reduction in the same sitting.

15. Answer C. **Condition is best treated by serial manipulation and casting as soon as possible**
The case described is an idiopathic clubfoot. Examination findings report a non-flexible foot posture. Pirani score is commonly used to document severity of the deformity and guide response to treatment. The score consists of 3 signs in the mid-foot and 3 signs in the hindfoot. The case has not mentioned characteristics of the heel fat pad. Nonetheless, best management for idiopathic clubfoot is the Ponseti method of serial manipulation and casting as soon as possible.

16. Answer B. **Innervates the adductor pollicis**
This SBA is testing ulnar nerve anatomy. For the medial placement of the K-wire a mini-open technique has been proposed in order to minimise injury to the ulnar nerve. In lateral pinning, the median nerve is at risk of injury.

17. Answer C. **Medial pinning**
Iatrogenic ulnar nerve injury can be due to traction from multiple attempts at CMR in the operation theatre, medial pinning or 'over-shoot' of lateral wires. The majority of cases are due to the medial wire. As the ulnar nerve lies closely

posterior to the medial epicondyle, it has greater risk to be penetrated, pierced or constricted by surrounding soft tissue while placing the medial wire. The mini-open technique minimises this injury. The management in iatrogenic ulnar nerve injury includes immediate nerve exploration, removal of the medial wire and 'watch and see'. The removal of the medial wire may affect the stability of fracture fixation and the 'watch and see' is to await self-recovery of the nerve.

Anuar R, Gooi SG, Zulkiflee. The role of nerve exploration in supracondylar humerus fracture in children with nerve injury. *Malays Orthop J.* 2015;**9**:71–74.

18. Answer D. **Posterior**
The radiograph in Figure 22.6 demonstrates a displaced fracture of the lateral condyle. Given the degree of displacement, surgical treatment is warranted. Care must be taken not to devascularise the fragment. The main supply to the lateral condyle is via the radial collateral artery, which enters posteriorly; therefore, posterior dissection or approach should be avoided.

19. Answer D. **Knee intercondylar distance**
The knee intercondylar distance is useful for coronal plane genu valgum or varum deformity but is not part of the torsional profile of lower limbs. As femoral anteversion increases, internal rotation increases at the expense of external rotation, usually measured with patient prone and knee in flexion. Thigh–foot angle indicates amount of tibial torsion, external indicates external tibial torsion. A concave medial or convex lateral foot border indicates metatarsus adductus.

Loder R. Femoral anteversion. *In Paediatric Orthopaedics: A System of Decision-Making*, 115. London: Hodder Arnold; 2009.

20. Answer E. **Reassure parents and review child routinely**
The IHDI (International Hip Dysplasia Institute) classification uses the midpoint of the superior margin of the ossified metaphysis rather than centre of the ossific nucleus, which may not be present. The case described has normal or grade I IHDI classification and normal acetabular indices, therefore requiring monitoring only at this point (Figure 22.14).

Narayanan U et al. Reliability of a new radiographic classification for developmental dysplasia of the hip. *J Pediatr Orthop.* 2015;**35**:478–484.

21. Answer C. **Ossific nucleus becomes increasingly lucent**
Following necrosis of the capital femoral epiphysis, revascularisation and resorption occur that eventually allow fragmentation and remodelling by creeping substitution. Bone resorption predominates over bone formation in the fragmentation stage of Waldenström. Ossific nucleus in this stage becomes increasingly lucent.

22. Answer A. **Forefoot pronation**
The Ponseti method of manipulation and serial casting is the most commonly utilised technique for the treatment of CTEV. The sequence of deformity correction is cavus, abduction, varus and finally equinus (CAVE). The forefoot is held supinated (not pronated). Lateral pressure with the thumb over the talar head and above knee casting is used with the knee in flexion. Equinus should be corrected without causing a midfoot break after approximately 60° of abduction has been achieved. Percutaneous Achilles tenotomy is often required prior to this step, followed by a final cast for 2–3 weeks.

Ponseti IV. Congenital clubfoot. In *Fundamentals of Treatment*, 2nd Ed. Oxford: Oxford University Press; 1996.

23. Answer D. **MRI shows injury to basal ganglia**
Selective dorsal rhizotomy (SDR) is a procedure which permanently reduces tone to sectioned lumbosacral afferent nerve rootlets to treat lower limb spasticity. A patient is required to undergo extensive rehabilitation after the surgery. Patients with involvement of the basal ganglia, brainstem or cerebellum generally exhibit significant dystonia which does not benefit from SDR as much as a typical periventricular leukomalacia. Postoperative rehabilitation is likely to be difficult and hence of poorer prognosis.

Graham D, Aquilina K, Mankad, Wimalasundera N. Selective dorsal rhizotomy: current state of practice and the role of imaging. *Quant Imaging Med Surg.* 2018;**8**:209–218.

Want K, Munger M, Chen B, Novacheck T. Selective dorsal rhizotomy in ambulant children with cerebral palsy. *J Child Orthop.* 2018;**12**:413–427.

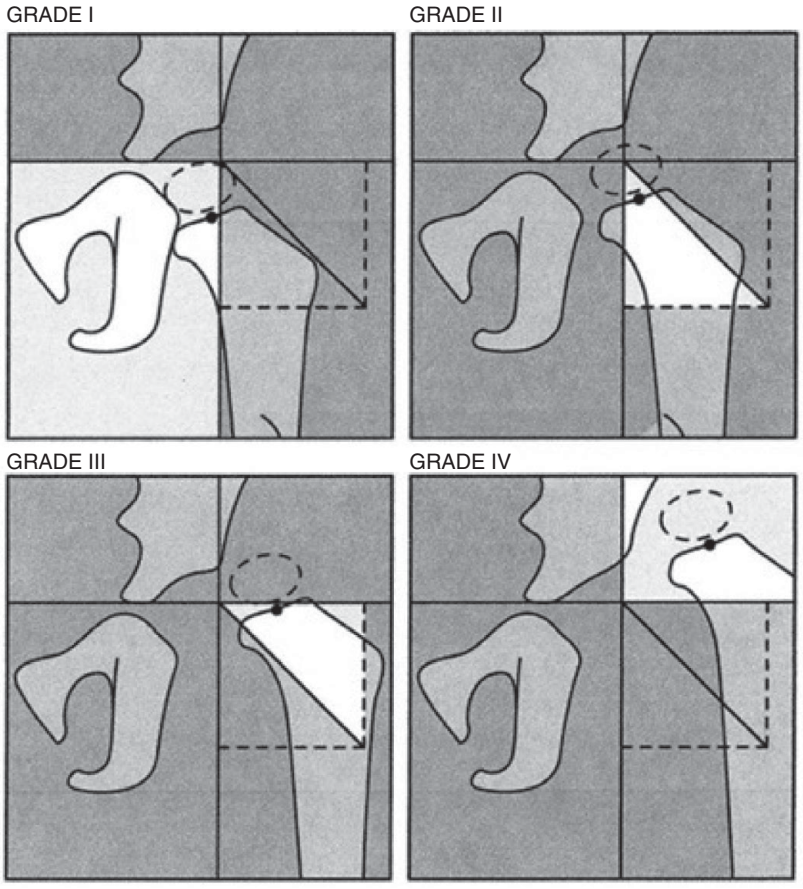


Figure 22.14 IHDI classification for DDH (relies on the location of the ossific nucleus). Grade I: ossification centre capital epiphysis is medial to the perpendicular line from the superolateral margin acetabulum (Perkin line). Grade II: ossification centre capital epiphysis lateral to the Perkin line, but below superolateral margin acetabulum (SMA line). Grade III: ossification centre at the level superolateral margin acetabulum. Grade IV: ossification centre is above superolateral margin acetabulum.

24. Answer D. **Refer the patient for a screening abdominal ultrasound**

The case describes the presentation and findings of hemihypertrophy. This condition can occur in isolation or as part of a clinical syndrome such as Beckwith–Wiedemann syndrome. Children with Beckwith–Wiedemann syndrome and isolated hemihypertrophy are at an increased risk for developing childhood neoplasia such as Wilms tumour, hepatoblastoma and adrenal carcinoma. Liaison with the geneticist and paediatrician is advised.

Duffy K et al. Tumor screening in Beckwith–Wiedemann syndrome: parental perspectives. *J Genet Couns.* 2018;**27**:844–853.

Herring JA (ed.). Limb length discrepancy. In *Tachdjian's Pediatric Orthopaedics*, 5th Ed., 884. Philadelphia, PA: Elsevier Saunders; 2014.

25. Answer B. **The Hilgenreiner-epiphyseal angle can be used to monitor and guide treatment plan**

Figure 22.7 shows a triangular metaphyseal fragment in the inferior neck, hallmark of developmental coxa vara. The condition is associated with femoral retroversion, therefore out-toeing gait. An increased Hilgenreiner-epiphyseal angle indicates likelihood of progression and guides treatment decision. There is no associated link with vitamin D deficiency. Deformity correction is valgus osteotomy, which requires a higher angled construct (e.g. 130° fixed-angle proximal femur plate).

26. Answer D. **Arthroscopic excision of osteochondral fragment**

In the presence of a traumatic injury, the X-ray shows a large effusion with an osteochondral

loose fragment within the knee joint (arrow in Figure 22.15). This turns out to be an osteochondral defect from the lateral femoral condyle following a traumatic patella dislocation. There is an ossicle at the region of tibia tuberosity from Osgood–Schlatter disease, but this will not result in a haemarthrosis. Segond fracture seen in ACL is generally seen on AP X-ray and is from tibial condyle.

Figure 22.15 Lateral radiograph right knee demonstrating osteochondral fragment (arrow)

27. Answer B. **Start intravenous penicillin beta-lactam antibiotic**
The case describes a febrile child with signs of infection. There is oedema within calcaneum in the MRI. The first course of action is to start antibiotics for infection. *Staphylococcus aureus* is the most common causative organism for acute osteomyelitis. It is good practice to obtain blood culture before starting antibiotics. A proportion of patients with calcaneum osteomyelitis need surgery, especially in presence of collection or abscess, but there should not be delay in providing antibiotics.

28. Answer C. **Lateral column calcaneum lengthening**
The patient has Charcot–Marie–Tooth disease. The common foot deformity is cavovarus and affects bilaterally. The unopposed pull of peroneus longus plantar flexes the first ray and results in a compensatory hindfoot varus. Weakened intrinsics also causes claw toes. Treatment is individualised depending on degree of rigidity and disability. These range from non-operative to operative soft tissue and/or bony surgery. Lateral column lengthening is not suitable in pes cavovarus.

29. Answer E. **Maintenance of >50% of lateral pillar height**
Answers A–D have been described as poor prognostic indicators in Perthes. Conversely, answer E is a positive prognostic indicator.
Radiographs of patients with Perthes can be assessed for the head-at-risk signs to guide prognosis. Catterall (1971) originally described four head-at-risk signs: Gage's sign, calcification lateral to the epiphysis, lateral subluxation of the femoral head, and the presence of a horizontal growth plate. Smith et al. (1982) added a fifth by confirming metaphyseal cystic changes to be a poor prognostic indicator.
Catterall A. The natural history of Perthes' disease. *J Bone Joint Surg Br.* 1971;**53**:37–53.
Smith SR, Ions GK, Gregg PJ. The radiological features of the metaphysis in Perthes' disease. *J Paediatr Orthop.* 1982;**2**:401–404.

30. Answer C. **MRI of spine**
Following a myelomeningocele repair, tethering of the cord in scar tissue at the repair site can cause functional impairment as the child grows. Symptoms usually include back pain, scoliosis, progressive lower limb weakness and spasticity, progressive foot deformity and urinary incontinence. Early liaison with neurosurgery is advised. Patients with myelomeningocele are susceptible to pathological fractures, which are associated with swelling and erythema.

31. Answer C. **Axillary freckling**
Congenital pseudarthrosis of the tibia (CPT) is a rare condition which classically presents as an anterolateral bow. When a child presents with CPT, a thorough clinical assessment, including a neurological and dermatological examination should be undertaken and complete family history to differentiate isolated CPT from that associated with neurofibromatosis type-1 (NF-1).
The incidence of CPT in NF-1 is less than 4%, but over half of the patients with CPT are NF-1 carriers.
Diagnostic criteria for NF-1 are shown in Table 22.1.

Table 22.1 NF-1 Diagnostic Criteria

Diagnostic criteria are met in an individual who does not have a parent with NF-1 if 2 or more of the following are present:	
Sign	**Requirement**
Café au lait macules	6 or more >5mm if pre-pubertal >15mm if post-pubertal
Axillary or inguinal freckling	Any
Cutaneous neurofibromas	2 or more
Plexiform neurofibroma	1 or more
Optic pathway glioma	Any
Iris Lisch nodules identified on slit lamp exam	2 or more
Distinctive osseous lesion e.g. sphenoid dysplasia, anterolateral tibial bowing or pseudarthrosis	Any

A child of a parent who meets the above diagnostic criteria merits a NF-1 diagnosis if one or more of the above are present.

Crawford AH, Schorry EK. Neurofibromatosis update. *J Pediatr Orthop.* 2006;**26**:413–423.

Legius E et al. Revised diagnostic criteria for neurofibromatosis type 1 and Legius syndrome: an international consensus recommendation. *Genet Med.* 2021;**23**:1506.

32. Answer A. **Lateral X-rays in dorsiflexion and plantar flexion showing irreducible talonavicular joint**
Congenital vertical talus is a condition with rigid flatfoot deformity with irreducible dorsal dislocation of the navicular on the talus. With forced plantar flexion lateral X-ray, the dislocation does not reduce, which distinguishes it from flexible flat foot or congenital oblique talus.

33. Answer C. **Three parallel partially threaded 32mm cannulated 6.5mm screws**
There is no difference in biomechanical stability between a partially threaded or fully threaded 6.5mm cannulated screw in *in situ* pinning of slipped upper femoral epiphysis. The use of multiple screws or pins increases the risk of osteonecrosis and unrecognised penetration of femoral head.

Dragoni M et al. Biomechanical study of 16-mm threaded, 32- mm threaded, and fully threaded SCFE screw fixation. *J Pediatr Orthop.* 2012;**32**:70–74.

34. Answer D. **Triradiate cartilage, then femoral head, then greater trochanter**
The change of shape of the proximal femoral growth plate from pleated to more spherical is one of the risk factors for the incidence of SCFE in children 10 years old and older.

Approximately 30% of the overall longitudinal growth of the femur occurs at the proximal end, in equal amounts from the femoral head and greater trochanteric physes (see Figure 22.16). This 30% is not constant throughout growth. At birth and shortly thereafter the proximal end contributes 50% of the longitudinal growth. With continuing growth there is gradual decline of the percentage of growth from the proximal end so that by age 14 years in girls and 16 years in boys, virtually all the growth occurs from the distal physis.

Another unusual aspect of growth of the proximal femur is the independent parts played by the femoral capital physis and by the greater trochanter. One will usually continue to grow when the other has prematurely ceased growth. Thus, some growth in length of the entire bone occurs proximally even with damage to one of these physes (Figure 22.17).

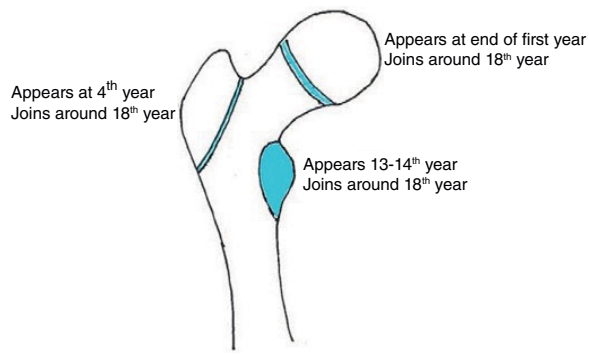


Figure 22.16 With physeal growth, the epiphysis divides into the femoral head epiphysis and greater trochanter apophysis

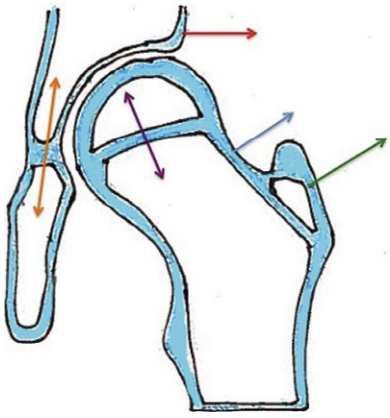


Figure 22.17 Growth occurs at many sites about the upper femur, including appositional growth of the femoral neck. Damage to the greater trochanteric apophysis causes a reduction in width and functional elongation of the femoral neck. Most growth of the acetabulum occurs from the triradiate cartilage. Additional growth occurs from the acetabular epiphysis.

Parvaresh KC, Upasani VV, Bomar JD, Pennock AT. Secondary ossification center appearance and closure in the pelvis and proximal femur. *J Pediatric Orthop.* 2018;**38**:418–423.

35. Answer E. **The triradiate cartilage is closed**
Patients with endocrinopathies have higher risk of SUFE hence prophylactic pinning should be considered. Growth hormone deficiency is a risk, regardless of pre- or post-treatment. Closure or fusion of the triradiate cartilage occurs in mid-adolescence, typically by 15–16 years in males and 13–14 years in females (see Figure 22.18). Therefore, if fused, there is low risk of SUFE.

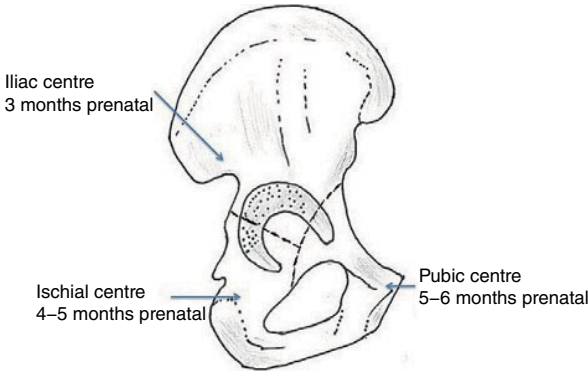


Figure 22.18 The three primary ossification centres in each pelvic bone represent the developing ilium, ischium and pubis. Age of appearance of the ossification centres in the pelvic bone. The Y- shaped triradiate cartilage at the acetabulum separates the ilium, pubis and ischium. Age of appearance of the ossification centres in the pelvic bone.

36. Answer D. **With the periosteum on the concave side intact**
The periosteum is usually torn on the convex side of a fracture, but the periosteum on the concave (compression) side may remain intact. Deformity exaggerated to relax the intact periosteum on the compression (concave) side of a long bone fracture. This will allow careful apposition of the fracture ends before the residue angulation is corrected with bending.

The intact periosteum is able to act as a hinge, which restricts the degree of displacement and provides the key to closed reduction and position of immobilisation in a cast. Translated or off-ended fractures must initially have the deformity exaggerated to relax the intact periosteum on the compression side of the long bone.

37. Answer B. **Bilateral osteonecrosis due to Pavlik harness treatment and continue to monitor**
Pavlik harness is not without risk in the healthy hip. Appropriate application of harness and recognition of risk are essential. The risk of development of ON with Pavlik harness management is higher in sonographical Graf type IV or radiographically dislocated hips. Initiation of the treatment >3 months of age, non-visible ossific nucleus at the time of starting treatment, prolonged duration of treatment and significant adductor muscle contracture increase the risk of ON developing. The rate of ON in the contralateral healthy hip in unilateral cases treated by Pavlik's method is around 3%, and almost all such cases have a mild type ON. The biggest risk factor is the length of use of the Pavlik harness.

Pap K et al. The incidence of avascular necrosis of the healthy, contralateral femoral head at the end of the use of Pavlik harness in unilateral hip dysplasia. *Int Orthop.* 2006;**30**:348–351.

38. Answer: D. **Midface hypoplasia**
Pseudoachondroplasia is an autosomal dominant condition resulting from a mutation in the COMP gene. Clinical features include those listed in the answers, except midface hypoplasia, which is a feature of achondroplasia. Unlike achondroplasia the skull and midface are unaffected, which helps differentiate the two conditions.

39. Answer D. **Anterolateral tibial bowing**
The radiographs demonstrate a child with fibular hemimelia; there is complete absence of the fibula, with associated femoral shortening and foot deformity. Fibular hemimelia is the most common long-bone deficiency, resulting from a longitudinal growth disturbance of the fibula. Part or all of the fibula is hypoplastic, dysplastic or aplastic, which can cause anteromedial (not anterolateral) tibial bowing. The phenotype is widely variable, ranging from mild to severe limb length discrepancies and multiple associated deformities (Table 22.2).

Table 22.2 Deformities associated with fibular hemimelia

Proximal focal femoral deficiency or congenitally short femur	Valgus ankle
Hypoplastic lateral femoral condyle	Ball & socket ankle joint
Leg length discrepancy	Tarsal coalition
Knee instability	Equinovalgus deformity
Flexion contracture of the knee	Absent lateral foot rays

40. Answer A. **Open reduction and suture fixation**
Patellar fractures usually result from a direct blow or forced flexion to the knee. A patellar sleeve fracture is a variation seen in children. The bony component is usually small but there is a large chondral segment not visible on radiographs. Fractures through the bone may be treated as in adults; sleeve fractures are treated by repairing the associated retinacular tears as well as inserting strong sutures through the cartilaginous and bony parts of the fracture.

41. Answer B. **2 out of 4, 40%**
Kocher identified four predictive factors that can aid in differentiating septic arthritis of the hip from transient synovitis:

Fever $>38.5°C$

Inability to weight bear

White blood cell count (WBC) $>12{,}000/mm^3$

Erythrocyte sedimentation rate (ESR) $\geq 40mm/h$

The predicted probability of septic arthritis was determined for all 16 combinations of these four predictors and is summarised as:

0.2% for zero predictors.

3% for one predictor.

40% for two predictors.

93.1% for three predictors.

99.6% for four predictors.

Kocher MS, Zurakowski D, Kasser JR. Differentiating between septic arthritis and transient synovitis of the hip in children: an evidence-based clinical prediction algorithm. *J Bone Joint Surg Am* 1999;**81**:1662–1670.

Chapter 23

Anatomy and Surgical Approaches Structured SBA

Christopher George Ghazala

ANATOMY AND SURGICAL APPROACHES STRUCTURED SBA QUESTIONS

Upper Limb

1. A child is referred to you from the paediatric team with concerns of an ulnar deviated carpus, an absent ulna, and ulnar-sided digits.
   Which protein is most likely to be under-expressed during limb development for the described phenotype?
   A. Fibroblast growth factor 8
   B. Sonic hedgehog
   C. Wingless 7A (WNT7A)
   D. LMX1B
   E. Engrailed 1 (EN-1)

2. A patient has an autosomal dominant congenital syndrome, characterised by absent nails, hypoplastic patellae, iliac horns (exostoses) and chronic kidney disease.
   This condition is caused by a mutation in which of the following genes?
   A. Fibroblast growth factor 8
   B. Sonic hedgehog
   C. Wingless 7A (WNT7A)
   D. LMX1B
   E. Engrailed 1 (EN-1)

3. A nerve decompression is carried out at the wrist, where the patient has a large ganglion and symptoms of paraesthesia involving the small and ring fingers, with intrinsic weakness and a positive Froment sign.
   Which structure forms the radial (lateral) border of the fibro-osseous tunnel transmitting this nerve?
   A. Pisiform
   B. Hook of the hamate
   C. Scaphoid
   D. Trapezium
   E. Capitate

4. An anterior approach is performed to expose the glenohumeral joint.
   During this approach, which of the following signs will most likely be due to excessive medial retraction of the conjoint tendon?
   A. Paraesthesia of the medial forearm
   B. Paraesthesia involving the region of the inferior lateral deltoid (regimental badge area)
   C. Supination weakness
   D. Weakness of wrist and finger extension
   E. Paraesthesia involving the central dorsal region of the forearm

5. In the deltopectoral approach to the shoulder, the conjoint tendons are retracted. Deep to these and anterior to the capsule is a muscle and its tendon.
   What is the main function of this deep anterior shoulder muscle?
   A. External rotation
   B. Abduction
   C. Internal rotation
   D. Forward flexion
   E. Extension

6. The distal humeral shaft is approached anterolaterally. During this approach, a nerve is seen to emerge between biceps brachii and brachialis.
   What is the normal function of this nerve?
   A. Sensory to the anterolateral forearm
   B. Sensation to the anteromedial forearm

C. Dorsal sensation to two-thirds of the hand and proximal three and a half lateral digits
D. Wrist and finger extension
E. Wrist and finger flexion

7. An anterior approach to the cubital fossa is carried out to explore the brachial artery.
Regarding the internervous planes to this approach, which nerve is related to both the proximal and distal extents of the dissection?
A. Musculocutaneous nerve
B. Radial nerve
C. Median nerve
D. Lateral cutaneous nerve
E. Ulnar nerve

8. During the posterior approach to the scapula, excessive medial retraction of a muscle results in significant arterial bleeding, and the surgeon is concerned there is now an associated nerve injury.
If this is true, which of the following movements will likely be chronically weakened?
A. Abduction and external rotation of the arm
B. Abduction of the arm
C. Adduction and internal rotation of the arm
D. Extension of the arm
E. Internal rotation of the arm

9. A posterior portal is created to carry out a diagnostic shoulder arthroscopy.
Which structure is most at risk of injury if a portal is created that is too medial than the typically described approach?
A. Axillary nerve
B. Infraspinatus
C. Posterior circumflex humeral artery
D. Radial nerve
E. Suprascapular nerve

10. **Which of the following shoulder muscles are innervated by a nerve that arises from the upper trunk of the brachial plexus?**
A. Subscapularis
B. Deltoid
C. Supraspinatus
D. Teres minor
E. Teres major

11. A bone reduction clamp is placed under the inferior surface of the clavicle, positioned between the clavicle and a slender muscle running along the inferior surface.
The innervation to this specific muscle arises from which of the following root(s) of the brachial plexus?
A. C5
B. C6
C. C7
D. C5–6
E. C6–7

12. You are assisting a plastic surgery consultant in exploring the brachial plexus at the axilla. The part of the axillary artery below pectoralis minor is noted to have two nerve roots joining anterior to it to form a nerve which lies just lateral to the artery.
What is this nerve?
A. Axillary nerve
B. Median nerve
C. Musculocutaneous nerve
D. Radial nerve
E. Ulnar nerve

13. **With respect to the muscles of the pectoral girdle, which muscle inserts into the lateral lip of the intertubercular (bicipital) sulcus of the humerus and receives its innervation that is derived from both the medial and lateral cords of the brachial plexus?**
A. Latissimus dorsi
B. Pectoralis major
C. Pectoralis minor
D. Serratus anterior
E. Trapezius

14. The subscapularis muscle is dually innervated. These nerves arise as two branches from the same cord of the brachial plexus.
Of the following nerves, which nerve also originates from this specific cord of the brachial plexus?
A. Medial pectoral nerve
B. Lateral pectoral nerve
C. Musculocutaneous nerve
D. Medial cutaneous nerve of the arm
E. Thoracodorsal nerve

15. A male patient presents to clinic after a game of rugby with pain over the volar surface of the distal phalanx to the ring finger. Examination has confirmed no active flexion at the distal interphalangeal joint, and this joint was held in slight relative extension to the other digits.
Which zone does this injury correspond to?
A. Zone I
B. Zone II
C. Zone III
D. Zone IV
E. Zone V

16. A patient presents with signs consistent with medial scapular winging.
The injured nerve is a branch from which of the following nerve root(s)?
A. C4
B. C5
C. C3–5
D. C5–6
E. C5–7

17. A 50-year-old male presents with acute arm pain, swelling, bruising, and weakness on resisted forearm supination and flexion.
What are the nerve roots to this affected muscle?
A. C8–T1
B. C1–3
C. C3–5
D. C5–7
E. C7–8

18. **During exploration of the cubital fossa, what structure is typically expected to be running medial to a tendon that inserts at the radial tuberosity?**
A. Median nerve
B. Brachial artery
C. Radial nerve
D. Median cubital vein
E. Medial cutaneous nerve of the forearm

19. The superficial anterior forearm compartment comprises five muscles that cross the elbow joint.
Which of the following muscles is NOT a superficial flexor of the forearm?
A. Flexor carpi radialis
B. Flexor carpi ulnaris
C. Flexor pollicis longus
D. Palmaris longus
E. Pronator teres

20. **During the volar (Henry) approach to the proximal third of the radius, which structure is protected from the field by retracting the supinator muscle laterally?**
A. Anterior interosseous nerve
B. Posterior interosseous nerve
C. Radial artery
D. Radial recurrent artery
E. Superficial radial nerve

21. A 21-year-old male undergoes open reduction and internal fixation for an open radial shaft fracture. Post-operatively this patient is noted to have significant weakness of extension to the wrist and digits.
What nerve has most likely been injured?
A. Anterior interosseous nerve
B. Median nerve
C. Posterior interosseous nerve
D. Radial nerve
E. Ulnar nerve

22. An open median nerve decompression is performed for carpal tunnel syndrome.
What is the structure that is expected to arise between the tendons of palmaris longus and flexor carpi radialis, and course superficial to the flexor retinaculum?
A. Anterior interosseous nerve
B. Median nerve
C. Palmar cutaneous branch of the median nerve
D. Recurrent (motor) branch of the median nerve
E. Ulnar nerve

23. During median nerve decompression surgery, a branch of the median nerve is inadvertently severed as the flexor retinaculum is divided.
This injury will most likely result in weakness of which of the following muscles?
A. Abductor pollicis brevis
B. Abductor pollicis longus

C. Adductor pollicis
D. Lateral three lumbricals
E. Opponens digiti minimi

24. With respect to the flexor tendons of the hand, an injury is noted to involve the flexor digitorum profundus (FDP) tendons just distal to the flexor retinaculum but proximal to the A1 pulley.
Which flexor zone does this injury correspond to?
A. Zone I
B. Zone II
C. Zone III
D. Zone IV
E. Zone V

25. **Which muscle is within the posterior deep compartment of the forearm?**
A. Extensor pollicis longus
B. Anconeus
C. Pronator teres
D. Palmaris longus
E. Supinator

26. Following Henry's approach to the forearm, the patient is noted to have a new wrist drop.
Which of the following structures has likely been excessively retracted during this procedure?
A. Brachioradialis
B. Flexor carpi radialis
C. Flexor pollicis longus
D. Pronator teres
E. Supinator

27. A 65-year-old who has been non-operatively managed for a distal radial fracture is assessed in clinic. There was no movement on assessing extension at both the interphalangeal and metacarpophalangeal joints, and a tendon rupture is diagnosed.
Which extensor compartment does this specific tendon belong to?
A. Compartment 1
B. Compartment 2
C. Compartment 3
D. Compartment 4
E. Compartment 5

28. You are exploring a wound located within flexor zone III of the hand. A structure is noted that is radial to the ring finger metacarpophalangeal joint and originates from a tendon rather than bone; the origin of this structure is noted to also be bicipital.
What is this structure and its most common nerve supply?
A. Ring finger flexor digitorum profundus and ulnar nerve
B. Ring finger lumbrical and median nerve
C. Ring finger lumbrical and ulnar nerve
D. Ring finger palmar interosseous muscle and median nerve
E. Ring finger palmar interosseous muscle and ulnar nerve

29. You are teaching second-year medical students the anatomy of the hand. A student points to one of the annular pulleys that is situated at the level of the proximal interphalangeal joint of the index finger.
What annular pulley does this correspond to?
A. A1
B. A2
C. A3
D. A4
E. A5

30. A patient undergoes open reduction and internal fixation of a clavicular fracture.
What is the nerve supply to the muscle that is encountered just deep to the skin?
A. Ansa cervicalis
B. Cranial nerve V
C. Cranial nerve VII
D. Cranial nerve XI
E. Supraclavicular nerves

31. An anatomical shoulder replacement is performed.
During this approach, which structure is most at risk when the clavipectoral fascia is incised to expose a specific tendon complex, but especially during retraction of this tendon?
A. Axillary artery
B. Axillary nerve
C. Cephalic vein
D. Median nerve
E. Musculocutaneous nerve

32. While performing an anterior approach to the humeral shaft, the surgeon is trying to manage a haemorrhaging vessel during proximal deep dissection.
Which vessel has likely been severed but should be expected to cross the operative field during this dissection?
A. Anterior circumflex humeral artery
B. Axillary artery
C. Axillary vein
D. Brachial artery
E. Cephalic vein

33. An anterior approach to the elbow is performed, during which a nerve is preserved that emerges lateral to a tendon that inserts into the radial tuberosity. This nerve then passes distally and divides into anterior and posterior branches.
Complete transection of this nerve will cause which of the following?
A. Anaesthesia of the lateral (radial) surface of the forearm
B. Anaesthesia of the medial (ulnar) surface of the forearm
C. Anaesthesia of the midposterior (dorsal) forearm
D. Weakness of elbow flexion and forearm supination
E. Wrist drop

34. A posterior approach to the radial shaft is performed and the surgeon identifies and preserves a nerve that passes through and innervates supinator.
What is this specific nerve?
A. Deep branch of the radial nerve
B. Deep branch of the ulnar nerve
C. Median nerve
D. Muscular branches of the ulnar nerve
E. Superficial branch of the ulnar nerve

35. **With respect to the anatomy of the carpal tunnel, which of the following statements is INCORRECT?**
A. The roof of the carpal tunnel, the flexor retinaculum, extends from the hook of hamate and pisiform medially to the scaphoid tubercle and ridge of the trapezium laterally
B. The tendon of flexor carpi radialis runs between the deep and superficial layers of the flexor retinaculum and not within the carpal tunnel
C. The tendon of flexor pollicis longus runs through the carpal tunnel
D. The tendons of flexor digitorum superficialis (FDS) to the middle and ring ringers are superficial to the FDS tendons of the index and little fingers
E. The tendons of FDS to the index and little fingers are superficial to the FDS tendons of the middle and ring fingers

36. A dorsolateral approach to the scaphoid is performed, centred within the anatomical snuffbox.
Regarding the anatomical snuffbox, what structure can be clinically palpated (or visualised during surgical exploration) as it crosses the tendon which forms the ulnar (medial) border of the anatomical snuffbox and must be preserved during this approach?
A. Cephalic vein
B. Extensor pollicis brevis tendon
C. Extensor pollicis longus tendon
D. Radial artery
E. Superficial branch of the radial nerve

37. **Which of the flexor tendon pulleys should be preserved to reduce the risk of bowstringing and significant weakness?**
A. A1 and A3
B. A2 and A4
C. A3 and A5
D. C1
E. C2

38. A child attends with a fingertip laceration. Examination reveals a longitudinal deep laceration extending from the centre of the thumb nail to involve the distal tip. This laceration involves the deeper soft tissues of the nail.
In terms of nail anatomy, which structures are likely involved?
A. Nail plate and germinal matrix
B. Nail plate and lunula
C. Nail plate and sterile matrix

D. Nail plate, germinal matrix, hyponychium and eponychium
E. Nail plate, sterile matrix and hyponychium

39. The hand of a 55-year-old manual worker is examined. They have decreased sensation over the little and ring fingers and weakened grip strength. They are asked to grasp a piece of paper between their thumb and the radial border of their index finger. They hold this paper by hyperflexing at the interphalangeal joint to the thumb. This test is repeated on the normal contralateral hand, and they grasp the paper firmly, keeping their thumb straight rather than flexing at this joint.
Which muscle is being assessed and is demonstrated to be weakened?
A. Adductor pollicis
B. Adductor pollicis longus
C. Flexor pollicis brevis
D. Flexor pollicis longus
E. Opponens pollicis

40. **With respect to the dorsal tubercle of the radius, which extensor tendon is expected to be just ulnar (medial) to this prominence?**
A. Abductor pollicis longus
B. Extensor digitorum communis
C. Extensor indicis
D. Extensor pollicis brevis
E. Extensor pollicis longus

Lower Limb

41. A 12-year-old boy, who has no comorbidities, presents with acute on chronic atraumatic hip pain and is unable to weight bear. Trethowan's sign is present, which is diagnostic.
Which of the following physeal regions is likely to be implicated in the pathology of this condition?
A. Reserve zone
B. Proliferative zone
C. Hypertrophic zone
D. Primary spongiosa
E. Secondary spongiosa

42. The hip is exposed using a posterior (Moore or Southern) approach.
What structure is expected to pass superior to piriformis?
A. Superior gluteal nerve
B. Inferior gluteal nerve
C. Sciatic nerve
D. Pudendal nerve
E. Inferior gluteal artery

43. A two-incision approach is performed for acute compartment syndrome of the leg. A necrotic muscle is noted in the compartment that is decompressed when the fascia is incised longitudinally and anterior to the intermuscular septum.
Which of the following structures is not a constituent of this compartment?
A. Peroneus tertius
B. Superficial peroneal nerve
C. Deep peroneal nerve
D. Extensor hallucis longus
E. Extensor digitorum longus

44. You are asked to assess a patient who has had a knife injury to their groin.
The surface anatomy for the common femoral artery within the femoral triangle is defined as which of the following?
A. Halfway between the anterior superior iliac spine and the pubic symphysis
B. Halfway between the anterior superior iliac spine and the pubic tubercle
C. One-third the distance from the anterior superior iliac spine and pubic symphysis
D. One-third the distance from the anterior superior iliac spine and the pubic tubercle
E. Two-thirds the distance from the anterior superior iliac spine and the pubic tubercle

45. A child presents with a septic hip, and an anterior approach is performed to irrigate and drain the joint. Regarding this approach, a nerve is at risk as it passes deep to the fascia lata and crosses the lateral border of a muscle which is retracted during the approach.
What is this muscle?
A. Rectus femoris
B. Sartorius
C. Tensor fascia lata
D. Vastus intermedius
E. Vastus lateralis

46. An anterior approach is performed for an intra-articular distal tibia fracture.
During this approach, at the level of the ankle joint, which of the following structures is expected to be just deep to a tendon that inserts at the base of the distal phalanx of the great toe?
A. Deep peroneal nerve
B. Saphenous nerve
C. Small (short) saphenous vein
D. Superficial peroneal nerve
E. Sural nerve

47. The ilioinguinal approach is performed to reduce and stabilise an acetabular fracture.
Which structure travels outside the spermatic cord but follows its course within the inguinal canal to exit the superficial inguinal ring?
A. Cremasteric artery
B. Genital branch of the genitofemoral nerve
C. Ilioinguinal nerve
D. Pampiniform plexus
E. Testicular artery

48. A patient is unable to plantarflex at their ankle joint following percutaneous iliosacral screw fixation of an unstable sacroiliac joint.
Which spinal nerve does this complication correlate to?
A. L4
B. L5
C. S1
D. S2
E. S3

49. The short external rotators are exposed during a routine posterior approach to the hip joint.
What is the name of the muscle that is exposed during this procedure and has, emerging from above its superior border, the nerve and vessels that supply the hip abductors?
A. Inferior gemellus
B. Obturator externus
C. Obturator internus
D. Piriformis
E. Superior gemellus

50. A young patient sustains an intracapsular neck of femur fracture. You are explaining to a medical student the rationale for management.
Which artery does not contribute towards the trochanteric anastomosis?
A. Ascending branch of the lateral circumflex femoral artery
B. Ascending branch of the medial circumflex femoral artery
C. Descending branch of the superior gluteal artery
D. Inferior gluteal artery
E. Transverse branch of the medial circumflex femoral artery

51. During the posterior approach to the hip, a major nerve is at risk.
As this structure passes through to the gluteal region, it lies anterior and then inferior to which of the following external rotators?
A. Inferior gemellus
B. Obturator internus
C. Piriformis
D. Quadratus femoris
E. Superior gemellus

52. **During the posterior approach to the knee, which structure is noted to be deep to the fascia but just medial to a muscle which forms the superolateral border of the popliteal fossa?**
A. Common peroneal nerve
B. Popliteal artery
C. Popliteal vein
D. Short saphenous vein
E. Tibial nerve

53. A two-incision leg fasciotomy is performed for compartment syndrome.
For a fasciotomy of the posterior leg compartments, which of the following structures is at risk of injury?
A. Anterior tibial vein
B. Deep peroneal nerve
C. Great saphenous vein
D. Short saphenous vein
E. Superficial peroneal nerve

54. An anterolateral approach to the tibial plateau is performed.
Classically, this incision crosses which of the following bony landmarks?

A. Fibula head
B. Gerdy's tubercle
C. Intercondylar eminence
D. Neck of the fibula
E. Tibial tuberosity

55. **The anterior and lateral compartments of the leg are innervated by two terminal branches of a nerve. These two branches typically originate within which of the following muscles?**
A. Biceps femoris
B. Peroneus brevis
C. Peroneus longus
D. Peroneus tertius
E. Plantaris

56. A patient develops acute compartment syndrome of the leg following a high-energy tibial fracture, with maximal pain on passive extension of the lesser toes.
Which of the following muscles is also related to the specific compartment that is being assessed?
A. Extensor digitorum longus
B. Extensor hallucis longus
C. Flexor hallucis longus
D. Peroneus tertius
E. Soleus

57. An anterior approach to the ankle is performed, and care is taken to identify the anterior tibial artery and deep peroneal nerve.
Proximal to the ankle joint, where would one expect to locate these two neurovascular structures?
A. Between the tendons of flexor hallucis longus and flexor digitorum longus
B. Between the tendons of extensor digitorum longus and extensor hallucis longus
C. Deep to the extensor hallucis longus tendon
D. Lateral to the extensor digitorum longus tendon
E. Lateral to the extensor hallucis longus tendon

58. The posterolateral approach is performed for a posterior malleolar ankle fracture. To expose the tibia, the surgeon retracts a deep muscle which arises from the fibula and interosseous membrane.
What is the name of this specific muscle?
A. Flexor digitorum longus
B. Flexor hallucis longus
C. Peroneus brevis
D. Peroneus longus
E. Tibialis posterior

59. A patient sustains an injury that affects just the deep peroneal nerve.
Which clinical signs best correlate with this type of injury?
A. Weakness of ankle plantar flexion and decreased sensation between the great (first) and second toes (first web space)
B. Weakness of great toe extension
C. Weakness of great toe extension and decreased sensation between the great (first) and second toes (first web space)
D. Weakness of great toe flexion
E. Weakness of great toe flexion and decreased sensation between the great (first) and second toes (first web space)

60. A dorsomedial approach to the first (great toe) metatarsophalangeal joint is carried out to perform an arthrodesis of this joint.
The nerve that is normally visible and at risk during this approach originates from which major nerve?
A. Deep peroneal (fibular) nerve
B. Saphenous nerve
C. Superficial peroneal (fibular) nerve
D. Sural nerve
E. Tibial nerve

61. **With respect to the gluteal region, which statement is INCORRECT?**
A. A positive Trendelenburg sign is noted by the pelvis sagging on the standing side
B. Gluteus maximus arises from the gluteal region of the ilium, sacrum, lumbar fascia and the sacrotuberous ligament
C. The greater sciatic foramen is formed by the greater sciatic notch and the sacrospinous ligament
D. The inferior gluteal nerve only innervates the gluteus maximus, and the blood supply to this muscle comes from both the superior and inferior gluteal arteries

E. The lesser sciatic foramen is formed by the lesser sciatic notch and the sacrotuberous ligament

62. Which of the following approaches to the knee is considered to help reduce post-operative pain and facilitate an earlier functional recovery?
A. Lateral parapatellar
B. Trivector
C. Mid-vastus
D. Subvastus
E. Medial parapatellar

Spine

63. **Which of the following is the precursor tissue to the paired segmental structures that are seen in normal vertebral development?**
A. Lateral plate mesoderm
B. Paraxial mesoderm
C. Intermediate mesoderm
D. Neural tube
E. Sclerotome

64. A transperitoneal approach is performed to approach the spine at levels L4 to S1 anteriorly.
Which vertebral level corresponds to the typical distal extent and bifurcation of the abdominal aorta?
A. T12
B. L1
C. L2
D. L3
E. L4

65. During the anterior approach to the cervical spine, a deep structure is reflected subperiosteally and laterally to the midline, exposing the anterior vertebral body.
From those listed, what is this structure?
A. Longus capitis
B. Longus colli
C. Multifidus
D. Prevertebral fascia
E. Sternocleidomastoid

66. A left-sided transthoracic approach to the thoracic spine is performed.
Which structure is most at risk during this left-sided approach?
A. Artery of Adamkiewicz
B. Azygos vein
C. Intercostal vessels
D. Lung
E. Oesophagus

67. You review a female patient following an anterior cervical discectomy and fusion. There are concerns regarding their voice, which is felt to sound low-pitched and softer in volume.
Which muscle is NOT innervated by the nerve that has been injured during this procedure?
A. Cricothyroid
B. Lateral cricoarytenoid
C. Posterior cricoarytenoid
D. Thyroarytenoid
E. Transverse and oblique arytenoids

68. An anterior retroperitoneal approach to the L3–4 level lumbar spine is performed. A structure is injured that runs just deep to the psoas fascia, on the anteromedial surface of the psoas major muscle.
Post-operatively, which of the following signs and symptoms will best correlate with this type of injury?
A. Decreased power on assessing adduction of the thigh
B. Decreased power on assessing hip flexion and knee extension
C. Decreased sensation over the anterolateral thigh
D. Decreased sensation over the upper anterior thigh and anterior scrotum (or labia majora)
E. Oliguria, flank pain and fever

69. **In the adult, which level would you typically expect the spinal cord to terminate?**
A. T12–L1
B. L1–2
C. L2–3
D. L3–4
E. L4–5

ANATOMY AND SURGICAL APPROACHES STRUCTURED SBA ANSWERS

Upper Limb

1. Answer B. **Sonic hedgehog**

Limb Development

This question relates to the pathogenesis of ulnar longitudinal deficiency. To answer this question correctly, one should be able to reach the diagnosis of ulnar longitudinal deficiency and understand the basic embryology of limb development. The following text aims to give a brief overview of limb development and how failure of this process, specifically Sonic hedgehog signalling, may lead to ulnar longitudinal deficiency.

Embryology is the area of science that is dedicated to embryogenesis and development of the foetus, which also includes the study of congenital diseases. Embryology is a potential theme during both parts of the examination, so the following text aims to introduce this topic.

The embryo represents the organism that forms when the male and female gametes fuse (fertilisation), producing a zygote, up to the point of early organ development; from week 9 onwards until birth, it is referred to as a foetus. Weeks 3–8 is the period of organogenesis, where the three germ layers that form through the process of gastrulation differentiate into early organs and tissues and is thus the main period where major congenital defects can arise. Week 9 until birth is the foetal period, which is characterised by maturation of these tissues and organs and significant growth. Gastrulation, beginning at week 3 is a process that gives rise to the trilaminar disc, consisting of the three germ layers (endoderm, mesoderm and ectoderm) from the differentiation of epiblastic cells.

The appendicular skeleton consists of the limbs, shoulders and pelvis. Limb development and patterning start at the end of the fourth developmental week, with the upper limb forming a couple of days before its distal counterpart.

The limb buds, which are the early structures of limb development, form at precise positions along the rostrocaudal (craniocaudal) axis. These limb buds are outgrowths of mesoderm into the overlying ectoderm and consist of an inner mesodermal layer of mesenchymal cells from the lateral plate and somatic mesoderms. The limb buds form ridges on the lateral body wall that causes the ectoderm to bulge out and surround this structure. Myoblasts from the myotome region of the somite eventually migrate into the limb buds and give rise to the musculature.

Forelimb (upper limb) development is initiated by the transcription factor TBX5; TBX4 determines the development of the hindlimb (lower limb) bud.

Limb bud growth is typically described as occurring along three axes, which are governed by three signalling centres. These axes are: (1) Rostrocaudal (craniocaudal), (2) Anteroposterior and (3) Dorsoventral; each of these axes are intimately linked through various signalling pathways.

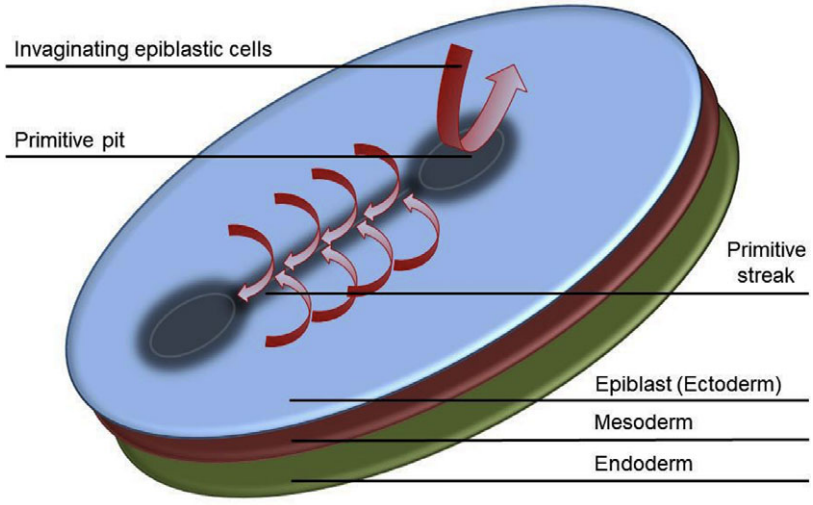


Figure 23.1 Dorsal surface of the trilaminar disc during gastrulation, showing invagination (red arrows) of the epiblastic cells through the primitive node and streak, giving rise to the mesoderm and ectoderm layers

1. Proximodistal growth

Proximodistal growth (limb length) occurs at the apicalectodermal ridge (AER), largely under the influence of fibroblast growth factors (FGFs); of note, FGF8 is felt to be an obligatory factor for normal proximodistal limb growth. Loss of the AER or FGF signalling results in limb truncation.

Initiated by either TBX5 (fore or upper limb) or TBX4 (hind or lower limb), FGF10 from the lateral plate mesoderm promotes proximodistal growth through development of the AER. The AER is a thickened ectodermal ridge that bridges the dorsal and ventral surfaces. FGF10 results in FGF8 expression from the overlying ectoderm, which then leads to a positive feedback loop relating to FGF10 and 8, where expression is maintained.

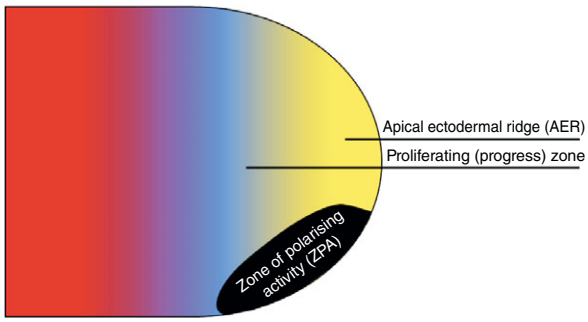


Figure 23.2 The apical ectodermal ridge (AER) releases fibroblast growth factors which induces and maintains the proliferating zone (progress zone). The progress zone is a region of undifferentiated mesenchymal tissue that results in proximal to distal growth of the limb bud; cells proximal to this zone and the AER begin to differentiate into their definitive tissues

FGF signalling from the AER ensures that there is an undifferentiated zone of proliferating mesenchymal cells adjacent to the AER, known as the progress zone, stimulating growth at this region. Mesenchymal cells that leave this progress zone differentiate first, thus differentiation of the limb progresses proximal to distal.

2. Anteroposterior growth

The second signalling centre, the zone of polarising activity (ZPA), regulates anteroposterior axis patterning. As this takes place before the normal rotation of the upper and lower limbs, the radial side of the upper limb, for example, is anterior, while the little finger and ulnar aspect is posterior. Week 7 is characterised by the 90° rotation of the upper and lower limbs in opposing directions, where the upper limb rotates laterally and the lower limb rotates medially; this results in the thumbs facing laterally and the toes medially, respectively.

The ZPA is a region of mesodermal (mesenchymal) cells in the posterior region of the AER that also travels distally as the limb grows. Through the action of retinoic acid, which is secreted by the ZPA, this causes the cells within the ZPA to produce and secrete sonic hedgehog (SHH), a cell signalling protein that is implicated in morphogenesis of the anteroposterior axis. Other than the thumb, which is independent to SHH, SHH is a key protein that is involved in the differentiation of individual digits and is dependent on both the duration and exposure to SHH. Those cells closest to the ZPA are dependent on SHH to differentiate into, for example, the ulna, little and ring fingers; whereas those furthest away and thus more anterior (which develop into the radius and thumb, for example) are least dependent on SHH signalling. Through positive feedback, SHH also acts on the AER to stimulate FGF4; FGF4 also stimulates SHH expression. Loss of SHH signalling produces the spectrum of ulnar longitudinal deficiencies that is being assessed through this single best answer question.

3. Dorsoventral growth

The third signalling centre relates to the non-AER ectoderm that produces the dorsoventral axis (dorsum of hand to palm). This is determined by WNT7A signalling in the dorsal ectoderm; WNT7A causes the upregulation and production of LMX1B and specifies cells to be dorsal and differentiate into the dorsal structures such as the skin, nails and extensor tendons. There is also a positive feedback loop where WNT7A also influences the ZPA to maintain SHH expression. Furthermore, Engrailed-1 expression (EN-1) in the ventral ectoderm limits WNT7A and thus LMX1B dorsally, leading to formation of the volar structures (palm and flexor tendons).

Digit Development

Apoptosis leads to the interdigital spaces and digits, but preceding formation of the interdigital spaces, the future digits form a precartilaginous matrix and then segmentation to the respective phalangeal regions. Apoptosis within set regions of the AER leads to the interdigital spaces; failure of this process leads to syndactyly.

Al-Qattan MM, Kozin SH. Update on embryology of the upper limb. *J Hand Surg.* 2013;**38**:1835–1844.

Oberg KC, Feenstra JM, Manske PR, Tonkin MA. Developmental biology and classification of congenital abnormalities of the hand and upper extremity. *J Hand Surg.* 2010;**35**:2066–2076.

Sadler TW. *Medical Embryology*, 14th Ed. Philadelphia, PA: Wolters Kluwer; 2019.

2. Answer D. **LMX1B**
As described earlier, this question is firstly assessing one's ability to recognise the condition that has been described, which is nail patella syndrome, and then to apply their knowledge of this condition to answer the specific question. Higher order thinking is required, which involves reaching the diagnosis based on the clinical information provided; but to answer this question, one needs to know nail patella syndrome is due to a mutation in the gene LMX1B. An overview of basic limb bud development and the role of LMX1B has been provided in the previous question. Nail patella syndrome results in hypoplastic nails and patellae, renal abnormalities and posterior iliac horns (exostoses).

Al-Qattan MM, Kozin SH. Update on embryology of the upper limb. *J Hand Surg.* 2013;**38**:1835–1844.

3. Answer B. **Hook of the hamate**
This question is assessing one's knowledge of Guyon's canal (ulnar tunnel). This fibro-osseous canal transmits the ulnar nerve and artery as they pass from the wrist to the hand.

Just proximal to the wrist, the ulnar nerve gives off a dorsal sensory branch (which supplies the dorsum of the hand and ulnar one and half fingers proximal to the nail beds) and a palmar cutaneous branch (sensory to the hypothenar region). At the wrist, the ulnar nerve and artery pass over the flexor retinaculum (transverse carpal ligament) which forms the floor of Guyon's canal. The ulnar artery is radial (lateral) to the nerve and the flexor carpi ulnaris tendon is the most ulnar (medial) structure; this tendon inserts on the pisiform. Lacerations at the wrist involving the tendon also frequently involve the artery and nerve.

The roof of Guyon's canal is formed by the volar carpal ligament, the medial (ulnar) wall by the pisiform and the lateral (radial) wall by the hook of the hamate; as previously mentioned, the flexor retinaculum (transverse carpal ligament) forms the floor.

Within the canal, the nerve divides into superficial and deep branches. The superficial branch innervates palmaris brevis and the volar skin to the small and ulnar half of the ring finger. The deep branch innervates all the intrinsic hand muscles excluding those of the thenar eminence and radial two lumbricals (recurrent motor branch of the median nerve). The intrinsic muscles supplied by the deep branch are the three hypothenar muscles (abductor digiti minimi, flexor digiti minimi brevis and opponens digiti minimi), the ulnar two lumbricals, the interossei and adductor pollicis.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

4. Answer C. **Supination weakness**
The deltopectoral approach to the shoulder (anterior approach) is often used to perform an open reduction of a dislocated shoulder; proximal humeral shaft fracture fixation; open washout of the joint and shoulder arthroplasty.

During this approach, an incision is made and developed from the coracoid process, travelling inferiorly along the deltopectoral groove. This is an internervous plane between the axillary (deltoid) and medial and lateral pectoral nerves (pectoralis major).

The deltopectoral groove is identified and the cephalic vein is generally retracted laterally, along with the deltoid; the pectoralis major is retracted medially. Deep dissection involves release of the fascia overlying the conjoint tendon (short head of biceps brachii and coracobrachialis, each innervated by the musculocutaneous nerve), followed by medial retraction of this tendon to expose the underlying subscapularis muscle and tendon. With the arm externally rotated and stay sutures applied, the subscapularis tendon is released to expose the underlying joint capsule.

The musculocutaneous nerve (a branch of the lateral cord of the brachial plexus) innervates biceps brachii, brachialis and coracobrachialis and terminates as the lateral cutaneous nerve of the forearm, emerging just lateral to the distal biceps tendon (sensory to the lateral border of the forearm). The musculocutaneous nerve is at risk during this approach during dissection and

retraction; it runs obliquely around 5–8 cm inferior to the coracoid, pierces and innervates coracobrachialis from its medial side, followed by biceps brachii and brachialis.

Injury or neuropraxia to the musculocutaneous nerve could result in weakness of elbow flexion, supination or sensory symptoms involving the lateral border of the forearm.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

Vajapey SP, Contreras ES, Cvetanovich GL, Neviaser AS. Neurologic complications in primary anatomic and reverse shoulder arthroplasty: a review. *J Clin Orthop Trauma* 2021;**20**:101475.

5. Answer C. **Internal rotation**
The deltopectoral (anterior) approach to the shoulder has been previously described. This deep anterior shoulder muscle is subscapularis. It is seen during this approach to be crossing anterior to the joint capsule to insert on the lesser tuberosity of the humerus. It helps to stabilise the shoulder, limiting external rotation and its main function is to bring about internal rotation of the humerus. Clinically, it can be isolated and tested using Gerber's lift-off test or the belly press test.

6. Answer A. **Sensory to the anterolateral forearm**
This approach is used to expose the humeral shaft, especially when exposure of the distal third is needed.

A curved incision is made along the lateral border of the biceps brachii to just above the elbow. The deep fascia is incised and the lateral borders of the biceps brachii and brachialis are identified; the biceps is retracted medially.

The lateral cutaneous nerve of the forearm (terminal branch of the musculocutaneous nerve) laterally emerges between the biceps brachii tendon and brachialis muscle; this is the sensory innervation to the anterolateral border of the forearm. This nerve is also known as the lateral antebrachial cutaneous nerve. The natural interval between brachioradialis and brachialis is then dissected and just proximal to the elbow, the radial nerve is identified between these two muscles and followed proximally. The humeral shaft is exposed by retracting the biceps and brachialis muscles medially, with the brachioradialis retracted laterally; the periosteum on the anterolateral humeral shaft is then incised and reflected to expose the bone.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

7. Answer B. **Radial nerve**
The anterior approach to the cubital fossa provides good access to the neurovascular structures, including the anterior elbow capsule. This is an internervous plane between the musculocutaneous nerve (brachialis) and radial nerve (brachioradialis) proximally. Distally, the internervous plane runs between the radial nerve again (brachioradialis) and pronator teres (median nerve).

A curved incision is made, starting on the medial side of the biceps brachii, and curving this anteriorly and then distally along the medial border of the brachioradialis muscle. The deep fascia is then incised. Care must be taken to preserve the lateral cutaneous nerve of the forearm (as previously described), which emerges laterally between the biceps brachii tendon and brachialis. The bicipital aponeurosis is released close to the biceps tendon and reflected; deep to this is the brachial artery. To expose the anterior elbow capsule, then biceps and brachialis are retracted medially, with brachioradialis retracted laterally.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

8. Answer A. **Abduction and external rotation of the arm**
This approach utilises the internervous plane between infraspinatus (suprascapular nerve) and teres minor (axillary nerve). Superficial dissection begins with an incision that runs from the posterior edge of the acromion along the spine of the scapula; the deltoid is detached from the spine of the scapula. Deeper dissection involves identifying the plane between infraspinatus and teres minor. The infraspinatus is retracted superiorly and the teres minor inferiorly to expose the posterior glenoid and neck of the scapula. The infraspinatus muscle must not be retracted too medially as this may cause significant traction to the suprascapular nerve, artery and vein.

Within the posterior triangle of the neck, the suprascapular nerve arises from the upper trunk of the brachial plexus (C5–6), coursing posteriorly and deep to trapezius, then passing through the suprascapular foramen to innervate supraspinatus, and then descending lateral to the spine of the scapula to innervate infraspinatus.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

9. Answer E. **Suprascapular nerve**

The posterior portal is a routinely used approach in shoulder arthroscopy, and the patient is normally in the 'beach chair' position. Key fixed landmarks are the acromion and coracoid process. The posterior portal is typically approached through a 'stab incision' 2cm inferior and 1cm medial to the posterolateral coroner of the acromion. This is an internervous plane between the axillary and supraclavicular nerves.

Once the incision has been made, the arthroscopic trocar is orientated in the direction of the coracoid process; this will likely pass through but be of no significant risk to the infraspinatus. It may also pass through the interval of infraspinatus and teres minor.

The axillary nerve (C5–6) is a branch of the posterior cord of the brachial plexus. This nerve, along with the posterior circumflex humeral artery and vein, passes from the axilla to the shoulder through the quadrangular space. This anatomical passage is between teres major (inferior border), teres minor (superior border), the surgical neck of the humerus (lateral) and long head of triceps brachii (medial) (Figure 23.3). On exiting this space, these neurovascular structures pass inferior to the capsule of the shoulder, and the nerve gives an articular branch to the shoulder; the axillary nerve then divides into anterior and posterior branches. The anterior branch winds around the surgical neck of the humerus and innervates the deltoid, but also provides cutaneous innervation to the anterolateral shoulder; the posterior branch innervates the teres minor and deltoid, then wraps around the posterior border of deltoid to end in the lateral cutaneous nerve of the arm. During posterior portal placement, the axillary nerve may be injured if the portal is sited too inferior.

The suprascapular nerve is a branch from the upper trunk of the brachial plexus (C5–6) and arises in the posterior triangle of the neck. It passes posterior and lateral, deep to trapezius, then through the suprascapular foramen (formed from the suprascapular notch, with the superior transverse scapular ligament) to innervate supraspinatus. It then descends lateral to the spine of the scapula (with the suprascapular artery and vein) and through the spinoglenoid fossa to innervate infraspinatus. This nerve and vessels are at risk if the portal is sited too medially.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

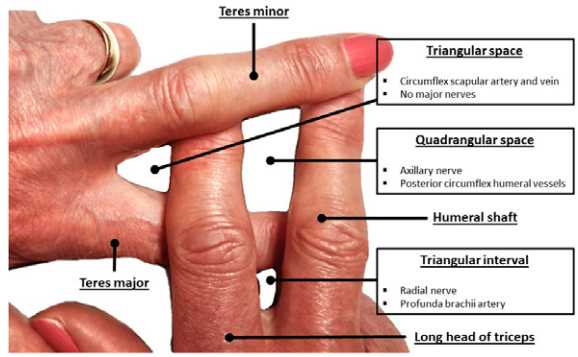


Figure 23.3 Interlock the two fingers of both hands as shown here. The two vertically orientated fingers represent the humerus and long head of triceps brachii. The two horizontally orientated fingers represent teres minor (superior) and teres major (which is inferior). Remember 'minor superior to major'

10. Answer C. **Supraspinatus**

Six muscles run from the scapula to the humerus: deltoid, the rotator cuff muscles (supraspinatus, infraspinatus, subscapularis and teres minor) and teres major.

The three posterior scapular muscles of the rotator cuff (supraspinatus, infraspinatus and teres minor) insert onto the greater tubercle of the humerus; subscapularis inserts into the lesser tubercle. Teres major inserts onto the shaft of the humerus, at the medial lip of the intertubercular sulcus.

The suprascapular nerve innervates supraspinatus and infraspinatus and arises from the superior trunk of the brachial plexus (C5 and

C6). Injury to this nerve will therefore result in loss of abduction and external rotation.

Teres minor is innervated by the posterior branch of the axillary nerve, one of the large two terminal branches of the posterior cord of the brachial plexus; the other larger terminal branch is the radial nerve. Subscapularis is innervated by a branch that arises from the posterior division of the brachial plexus, the upper and lower subscapular nerves (C5 and C6). Teres major is innervated by the lower subscapular nerve.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

11. Answer D. **C5–6**
This muscle is subclavius, and it is innervated by the nerve to subclavius (C5–6), which is one of three branches arising from the roots of the brachial plexus. The other two nerve root branches are: (1) the dorsal scapular nerve, which arises from the C5 root and innervates the rhomboids and levator scapulae and (2) the long thoracic nerve (of Bell), which innervates serratus anterior and arises from nerve roots C5–7. Subclavius arises from the first rib at the costochondral junction and inserts at the subclavian groove of the clavicle.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

12. Answer B. **Median nerve**
The roots of the brachial plexus (C5–T1) arise in the posterior triangle of the neck, between the muscles of scalenus anterior and medius. The trunks (superior, middle and inferior) also lie in the posterior triangle of the neck, while the divisions lie deep to the middle third of the clavicle and the cords are related to the second part of the axillary artery in the axilla.

Three branches arise directly from the roots: dorsal scapular nerve (C5), which innerves both rhomboids; nerve to subclavius (C5–6), and the long thoracic nerve (C5–7), which supplies serratus anterior. One branch arises from the trunks, which is the suprascapular nerve (C5–6) that innervates supraspinatus, infraspinatus and the shoulder and acromioclavicular joints.

The lateral cord gives rise to three branches (lateral pectoral nerve, musculocutaneous nerve and the lateral root of the median nerve). The musculocutaneous nerve (C5–7) has muscular and cutaneous branches, and supplies the flexors to the arm, arising high up in the axilla to initially innervate coracobrachialis before descending to supply biceps brachii and brachialis. The lateral root of the median nerve (C5–7) combines with the medial root (continuation of the medial cord) of the median nerve lateral and anterior to the axillary artery, forming the median nerve (Figure 23.4).

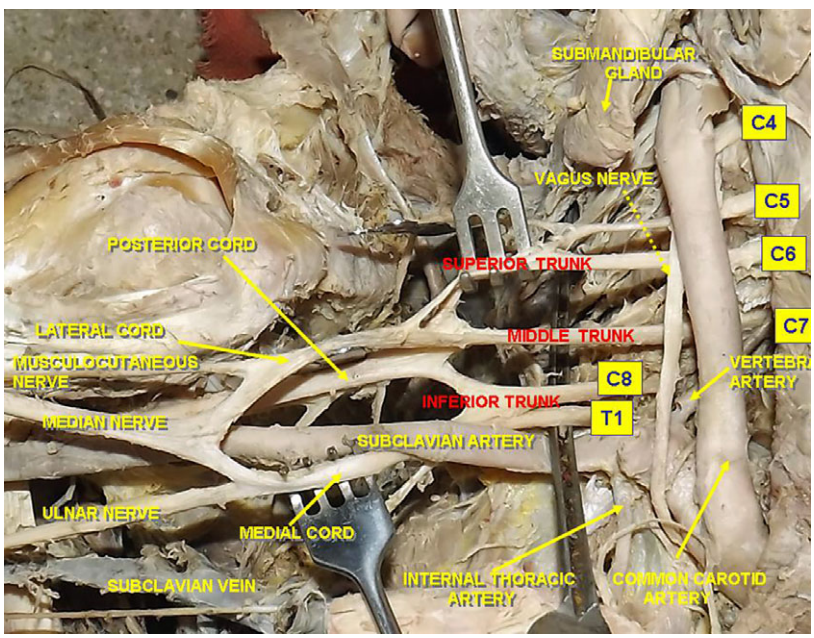


Figure 23.4 Brachial plexus. Anatomist90. Creative Commons CC0 licence

The axillary nerve (C5–6), which is a branch of the posterior cord, passes posteriorly from the axilla towards the shoulder, traversing through the quadrangular space.

The radial nerve (C5–T1) is a continuation of the posterior cord and runs inferiorly and superficial to the latissimus dorsi tendon.

The ulnar nerve (C7–T1) arises from the medial cord and passes inferiorly and medially down the arm, lying medial to the axillary and brachial arteries.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

13. Answer B. **Pectoralis major**
The pectoral girdle comprises bony and muscular attachments to the axial skeleton. The bones are the clavicle and the scapula, which are connected to the axial skeleton by the sternoclavicular joint, and to each other by the acromioclavicular joint. The coracoclavicular ligament also stabilises these two bones, and the clavicle is anchored to the first rib by the costoclavicular ligament.

The muscles can be described as direct and indirect attachments between the axial skeleton and pectoral girdle.

Direct muscles insert into the clavicle or scapula: pectoralis minor (medial pectoral nerve), subclavius (nerve to subclavius), trapezius (spinal accessory nerve, and proprioceptive fibres from the cervical plexus C3–4), rhomboid major and minor (dorsal scapular nerve), levator scapulae (dorsal scapular nerve, and C3–4 cervical plexus fibres) and serratus anterior (long thoracic nerve of Bell).

The indirect muscles attach to the proximal humerus and consist of pectoralis major (medial and lateral pectoral nerve) and latissimus dorsi (thoracodorsal nerve).

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

14. Answer E. **Thoracodorsal nerve**
Five branches arise from the posterior cord of the brachial plexus: upper (subscapularis) and lower (subscapularis and teres major) subscapular nerves (C5–6); thoracodorsal (latissimus dorsi) nerve (C6–8); axillary nerve (C5–6), and the radial nerve (C5–T1).

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

15. Answer A. **Zone I**
This corresponds to flexor zone I and this specific injury is colloquially known as Jersey finger. There are five flexor zones.

Zone I is distal to the insertion of flexor digitorum superficialis and represents just the flexor digitorum profundus tendon. Zone II is from the proximal aspect of the A1 pulley (distal palmar crease) to the insertion of flexor digitorum superficialis (middle three-fifths of the middle phalanx); at zone II, the flexor digitorum superficialis splits to form Camper's chiasm, around the flexor digitorum profundus tendon. Zone III is from the distal extent of the carpal tunnel to the proximal aspect of the A1 pulley. Zone IV is within the carpal tunnel. Zone V extends from the forearm to the proximal carpal tunnel (distal palmar crease) (Figure 23.5).

Wolfe S, Hotchkiss R, Green, D. *Green's Operative Hand Surgery*, 6th Ed. Philadelphia, PA: Elsevier Churchill Livingstone; 2011.

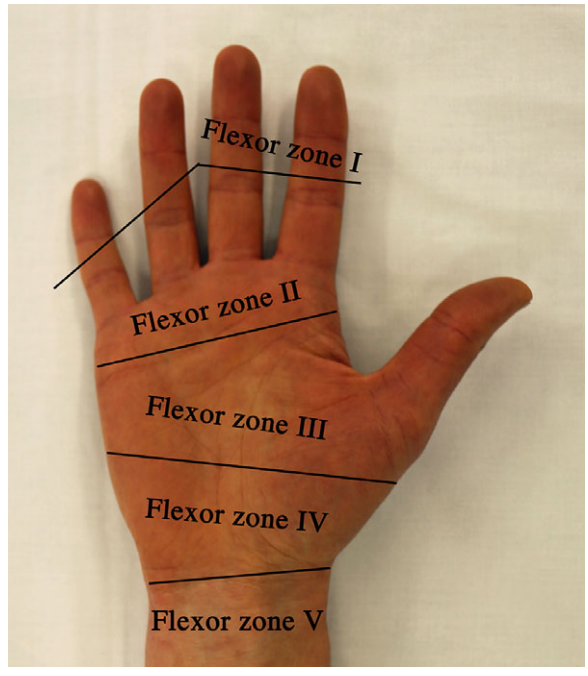


Figure 23.5 Zone classification of flexor tendon injuries

16. Answer E. **C5–7**
The long thoracic nerve (of Bell) arises from the ventral rami of nerve roots C5–7, innervating serratus anterior. Injury to this nerve causes the medial border of the scapula to move laterally and posteriorly from the thoracic wall.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

17. Answer D. **C5–7**
The musculocutaneous nerve (C5–7) is one of three branches of the lateral cord; the other two are the lateral pectoral nerve and the lateral root of the median nerve. The musculocutaneous nerve has muscular branches to the flexors of the arm (coracobrachialis, biceps brachii and brachialis) and a cutaneous branch to the forearm (lateral cutaneous nerve of the forearm). The lateral cutaneous nerve of the forearm passes lateral to the biceps tendon at the elbow, and supplies sensation to the radial border of the skin from the elbow to wrist by both anterior and posterior branches.

C1–3 combine to form the ansa cervicalis, which is a component of the cervical plexus that innervates the following infrahyoid muscles except thyrohyoid (C1): omohyoid, sternohyoid and sternothyroid.

C3–5 are branches of the cervical plexus that combine to form the phrenic nerve, with innervation primarily from C4, providing motor innervation to the diaphragm.

C8–T1 are the nerve root derivates of the medial cord branches (medial pectoral nerve, medial root of the median nerve, medial cutaneous nerve of the arm, medial cutaneous nerve of the forearm and the ulnar nerve).

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

18. Answer B. **Brachial artery**
The cubital fossa is the triangular depression on the anterior elbow, represented medially by the pronator teres, laterally by the brachioradialis and superiorly limited by the medial and lateral epicondyles of the humerus. The roof of the cubital fossa is formed by the deep fascia of the forearm, reinforced by the bicipital aponeurosis medially, and the skin as the most superficial. The floor is formed proximally by brachialis and distally by supinator.

The contents of the cubital fossa, from medial to lateral are the median nerve, brachial artery (the artery is palpable medial to the biceps brachii tendon), biceps brachii tendon, radial nerve (deep to brachioradialis and so not strictly within the fossa, which divides into its superficial and deep branches).

Superficially, in the subcutaneous tissue and anterior to the bicipital aponeurosis, lies the median cubital vein and the medial and lateral cutaneous nerves of the forearm.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

19. Answer C. **Flexor pollicis longus**
The flexor muscles, which are divided into three layers, are in the anterior compartment of the forearm. They are separated from the extensor compartment by the radius, ulna and the connecting interosseous membrane.

The superficial group is made of four muscles that arise from the common flexor origin at the medial epicondyle of the humerus and cross the elbow joint (the deep group do not cross this joint). This superficial group consists of pronator teres, flexor carpi radialis, palmaris longus and flexor carpi ulnaris (Figure 23.6). The intermediate group comprises one muscle only, the flexor digitorum superficialis. The three muscles of the deep group are: flexor digitorum profundus, flexor pollicis longus and pronator quadratus.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

20. Answer B. **Posterior interosseous nerve**
This approach exposes the length of the radius, and although the extent of the incision depends on the region of the radius to be exposed, the full incision extends just lateral to the biceps brachii tendon to the radial styloid.

Superficial dissection incises through the superficial fascia of the forearm and then the interval between brachioradialis and flexor carpi

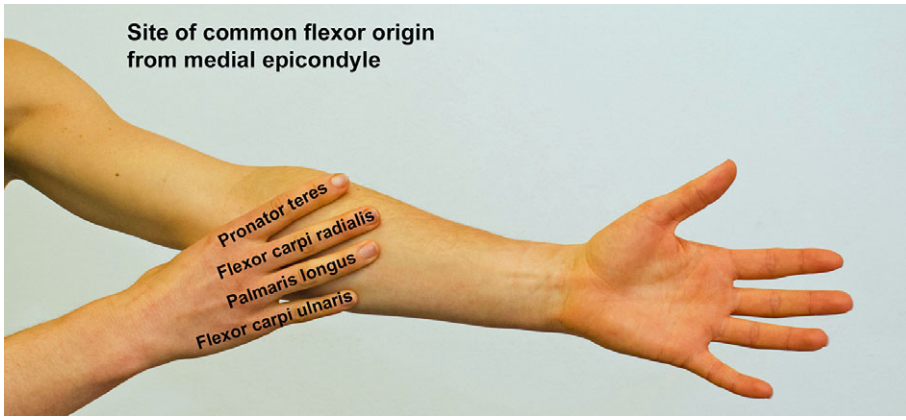


Figure 23.6 Common flexor origin

radialis. Dissection then depends on which region of the radius is being exposed. Proximally, a plane should be developed between pronator teres and brachioradialis; the superficial branch of the radial nerve should be protected and can be identified deep to brachioradialis. Brachioradialis should be reflected radially (lateral). Superficial dissection distally involves developing a plane between brachioradialis and flexor carpi radialis.

Deeper dissection likewise depends on the region being exposed. For the proximal third of the radius, the bursa is incised just lateral to the biceps brachii tendon, exposing the proximal shaft that is covered by supinator, being mindful for the radial artery during this dissection. The posterior interosseous nerve is at risk during this approach proximally and is formed when the deep branch of the radial nerve pierces the supinator to pass from the cubital fossa to the posterior compartment of the forearm; when it leaves the supinator muscle, it strictly becomes the posterior interosseous nerve. During proximal dissection, this nerve is protected by ensuring the forearm is fully supinated, and the radius is exposed by incising the supinator at its insertion into the radius, reflecting the muscle from the bone medial to lateral, and retracting the supinator muscle radially (laterally) to clear and protect the nerve.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

21. Answer C. **Posterior interosseous nerve**
The posterior interosseous nerve is a continuation of the deep branch of the radial nerve as it passes through and exits the supinator muscle; it is prone to injury during fractures and surgery of the proximal radial shaft (Figure 23.7). This nerve innervates extensor digitorum, extensor digiti minimi and extensor carpi

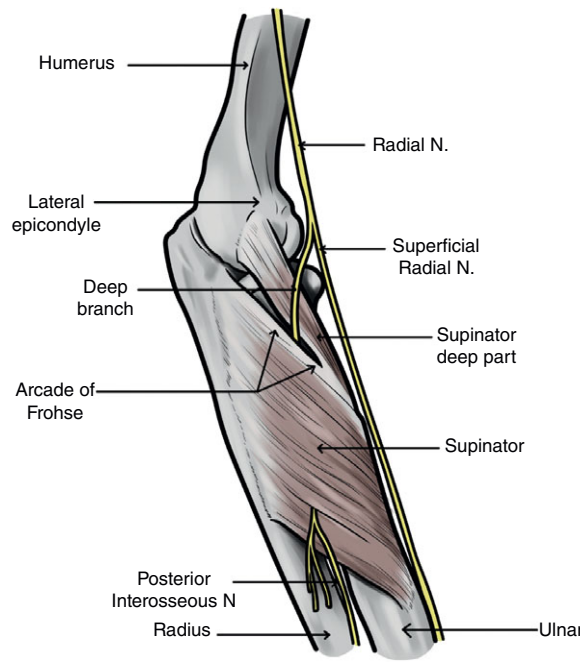


Figure 23.7 Posterior interosseous nerve and relationship to supinator muscle

ulnaris, extensor pollicis brevis and longus, extensor indicis and abductor pollicis longus. Extensor carpi radialis longus and brachioradialis are supplied by the radial nerve; extensor carpi radialis brevis and supinator are usually innervated by the deep branch of the radial nerve.

Sinnatamby C. *Last's Anatomy*, 12th *E*d. Edinburgh: Churchill Livingstone; 2011.

22. Answer C. **Palmar cutaneous branch of the median nerve**

The palmar cutaneous branch of the median nerve arises superficial to the flexor retinaculum, between the tendons of flexor carpi radialis and palmaris longus (Figure 23.8).

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

23. Answer A. **Abductor pollicis brevis**

The median nerve usually gives rise to its recurrent motor branch distal to the flexor retinaculum (carpal tunnel), where it innervates the thenar muscles. Variations in this can occur, where this branch may penetrate through the flexor retinaculum (Figure 23.9).

Distal to the carpal tunnel, the median nerve divides into a medial branch that splits into two (the first branch is sensory to the skin of the radial half of the ring finger, the middle finger, and the ulnar side of the index finger; the second branch innervates the second lumbrical). The lateral branch is motor to the first lumbrical and sensory to the palmar surface and distal dorsal thumb and the radial side of the index finger.

The recurrent motor branch of the median nerve supplies the thenar muscles. The thenar eminence comprises three muscles arising from the flexor retinaculum: abductor pollicis brevis is the most radial, followed by flexor pollicis brevis and opponens pollicis. Each of these muscles is innervated by the recurrent motor branch of the median nerve, but flexor pollicis brevis may be innervated by branches of the ulnar nerve, median nerve, or combinations of both.

Abductor pollicis longus is innervated by the posterior interosseous nerve (from the deep branch of the radial nerve).

Adductor pollicis and opponens digiti minimi are hypothenar muscles, innervated by the deep branch of the ulnar nerve.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics.* Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

24. Answer C. **Zone III**

This corresponds to flexor zone III, which is in the palm, extending from the distal flexor retinaculum to the A1 pulley.

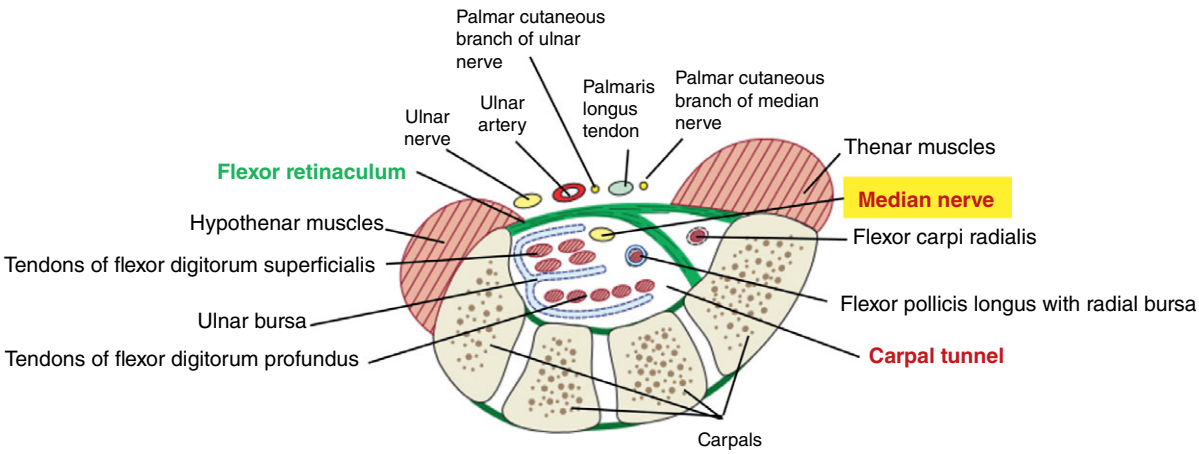


Figure 23.8 Cross section at the wrist and carpal tunnel

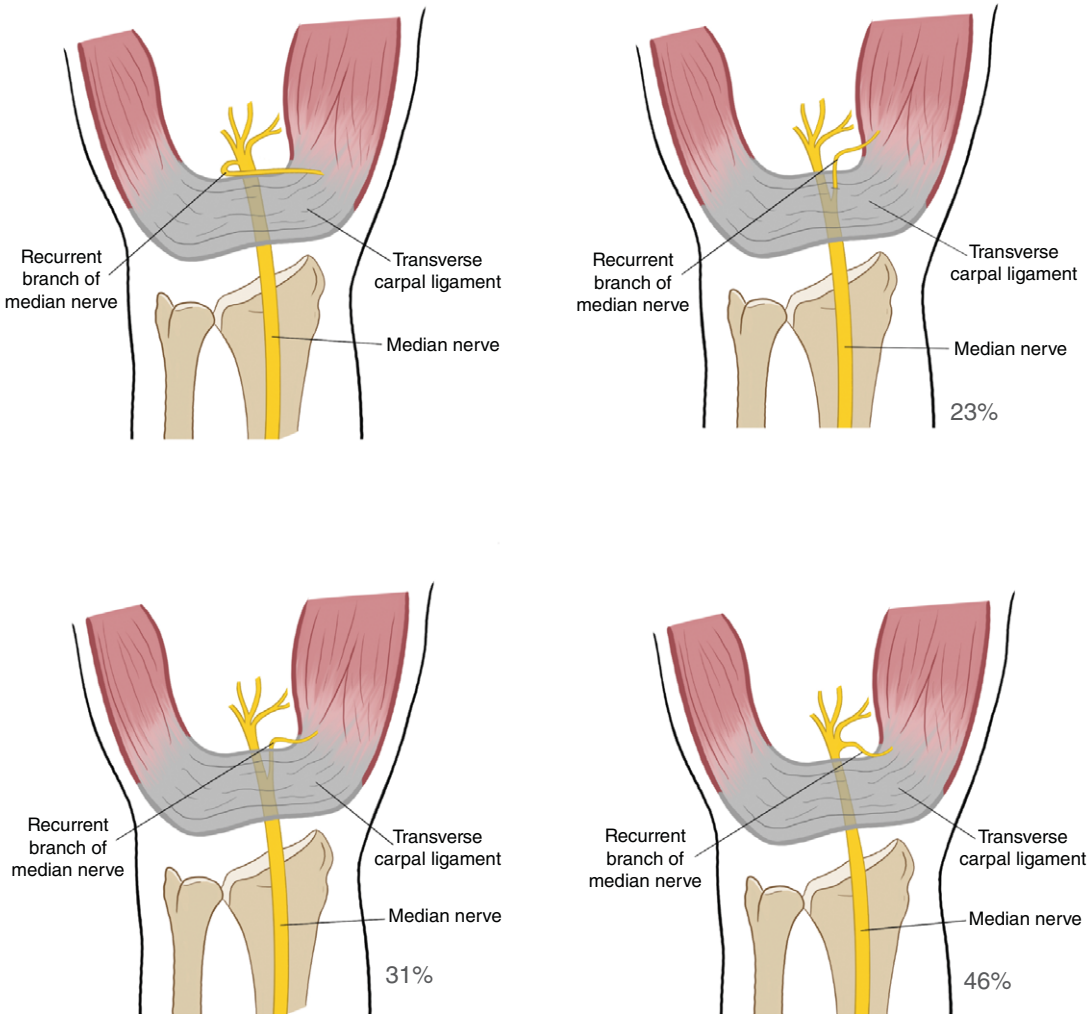


Figure 23.9 Variations in a transligament recurrent motor branch median nerve

Wolfe S. Hotchkiss R, Green D. *Green's Operative Hand Surgery*, 6th Ed. Philadelphia, PA: Elsevier Churchill Livingstone; 2011.

25. Answer A. **Extensor pollicis longus**
The forearm consists of an anterior (flexor) and posterior (extensor) compartment, separated from each other by the radius, ulna and intervening interosseous membrane (Figure 23.10).

The anterior compartment is subdivided into superficial and deep layers. The superficial layer muscles are all innervated by the median nerve except flexor carpi ulnaris.

The following five muscles make up the superficial anterior compartment: pronator teres, flexor carpi radialis, flexor digitorum superficialis (some texts describe this as being within the intermediate compartment), palmaris longus and flexor carpi ulnaris.

The deep group contains the following three muscles: flexor pollicis longus, flexor digitorum profundus and pronator quadratus; the median nerve innervates these muscles except for the ulnar half of flexor digitorum profundus, which is innervated by the ulnar nerve.

The posterior compartment (extensor group) is likewise divided into superficial and deep layers and are all supplied by the radial nerve. The superficial layer comprises seven muscles: brachioradialis, extensor carpi radialis longus

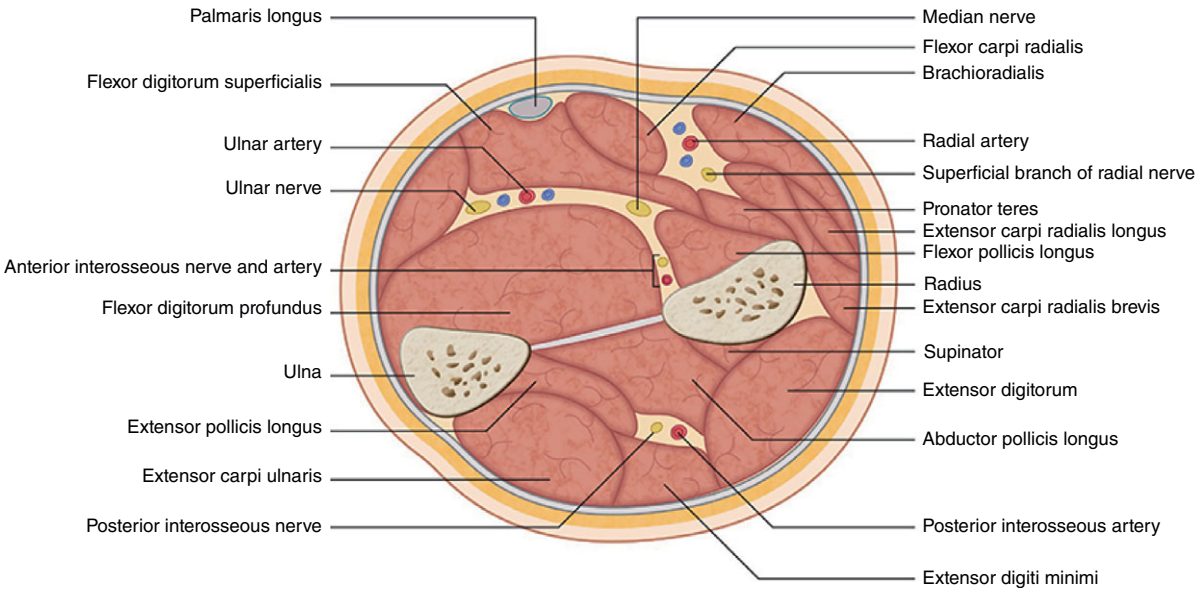


Figure 23.10 Cross section at the midforearm

and brevis, extensor digitorum, extensor digiti minimi, extensor carpi ulnaris and anconeus. There are five deep posterior compartment muscles: supinator, abductor pollicis longus, extensor pollicis longus and brevis and extensor indicis.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingston; 2011.

26. Answer E. **Supinator**
The posterior interosseous nerve is a continuation of the deep branch of the radial nerve as it passes through and exits the supinator muscle; it is prone to injury during fractures and surgery of the proximal radial shaft.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

27. Answer C. **Compartment 3**
There are six extensor compartments at the wrist (Table 23.1). This case has rupture to the tendon within the third extensor compartment, the extensor pollicis longus tendon.

Wolfe S, Hotchkiss R, Green D. *Green's Operative Hand Surgery*, 6th Ed. Philadelphia, PA: Elsevier Churchill Livingstone; 2011.

Table 23.1 Extensor compartments of the wrist

Compartment	Tendon	Pathology
1	Extensor pollicis brevis and abductor pollicis longus	De Quervain's tenosynovitis
2	Extensor carpi radialis longus and brevis	Intersection syndrome
3	Extensor pollicis longus	Traumatic rupture
4	Extensor indicis proprius and extensor digitorum communis	Extensor tenosynovitis
5	Extensor digiti minimi	Vaughan–Jackson syndrome
6	Extensor carpi ulnaris	Extensor carpi ulnaris instability

28. Answer C. **Ring finger lumbrical and ulnar nerve**
Flexor zone III extends from the distal aspect of the flexor retinaculum (distal extent of the carpal

tunnel) to the A1 pulley. The lumbricals flex the digits at the metacarpophalangeal joints and extend the interphalangeal joints. They originate from the tendons of the flexor digitorum profundus and travel to their insertion on the dorsal side of the proximal phalanx, inserting into the lateral (radial) surface of the extensor expansion.

The ring and little finger lumbricals are bipennate muscles. The ring finger lumbrical arises from the middle and ring finger profundus tendons; the little finger lumbrical originates from the ring and little finger profundus tendons. The radial two lumbricals are innervated by the median nerve and the ring and little finger lumbricals are supplied by the deep branch of the ulnar nerve.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

29. Answer C. **A3**
All five digits have on their volar surface an osseofibrous tunnel, the flexor sheath, extending from the metacarpal heads to the distal phalanges. For the thumb, this sheath contains the tendon of flexor pollicis longus, and for the remaining digits the two flexor tendons for each finger: flexor digitorum superficialis and profundus. This flexor sheath, which reduces friction and flexor tendon bowstringing, is reinforced at various points by annular (A) and cruciate pulleys (C). The fingers have five annular pulleys (A1–5) and three cruciate pulleys (C1–3), while the thumb has two annular pulleys and one oblique pulley.

For the fingers, the A1 pulley is anterior to the metacarpophalangeal joint; the middle third of the proximal phalanx is the location for the A2 pulley; the A3 pulley overlies the proximal interphalangeal joint; the A4 pulley is situated at the middle third of the middle phalanx, and the A5 pulley is at the volar surface of the distal interphalangeal joint. The cruciate pulleys lie between the annular pulleys, with C1 distal to A2, C2 between A3 and A4 and C3 just distal to A4. The A2 and A4 pulleys prevent tendon bowstringing. For the thumb, the A1 pulley is likewise anterior to the metacarpophalangeal joint, but the A2 pulley is just proximal to the interphalangeal joint; an oblique pulley lies over the middle third of the proximal phalanx and prevents bowstringing of the flexor pollicis longus tendon.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

30. Answer C. **Cranial nerve VII**
For this approach, the sternal notch is the most medial landmark if this incision length is necessary and extends longitudinally over the surface of the clavicle. Superficially, dissection is through skin and the platysma muscle before reaching the clavicle. The platysma is innervated from the cervical branch of the facial nerve (cranial nerve VII) and is a muscle of facial expression.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

31. Answer E. **Musculocutaneous nerve**
The deltopectoral approach is usually performed for an anatomical shoulder replacement. During this approach, which follows the deltopectoral groove, it begins at the coracoid process and extends inferiorly along this groove. The deltopectoral fascia is incised and the pectoralis major muscle is retracted medially and deltoid laterally, and the cephalic vein is identified and retracted, usually laterally. From the coracoid process are the conjoined tendons of coracobrachialis and short head of biceps brachii, as well as the origin of pectoralis minor. Deeper dissection involves incising the clavipectoral fascia lateral to the conjoined tendons to expose the subscapularis tendon and to allow for medial retraction of the conjoined tendons. When incising the clavipectoral fascia and retracting the conjoined tendons medially, the surgeon should be mindful that the musculocutaneous nerve pierces the coracobrachialis muscle medially, just below the coracoid.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

32. Answer A. **Anterior circumflex humeral artery**
With the arm abducted on an arm board, this approach extends from the coracoid process,

distally down the deltopectoral groove and the arm, following the lateral border of biceps brachii. Superficially and proximally, the cephalic vein is identified and the pectoralis major and deltoid are retracted, and dissection is continued distally down to the deltoid tuberosity. The deep fascia is incised, and the interval between biceps brachii and brachialis is identified. Proximally, the humeral shaft is exposed by incising the periosteum lateral to the long head of biceps brachii. The anterior circumflex humeral artery, which originates from the third part of the axillary artery, crosses medially to laterally and should be identified and ligated.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

33. Answer A. **Anaesthesia of the lateral (radial) surface of the forearm**
A curved incision is made over the anterior elbow, beginning proximally and medially to biceps brachii, curving over the flexion crease, and extending distally down the medial border of brachioradialis. Superficially, during incision of the deep fascia, the lateral cutaneous nerve of the forearm (a branch of the musculocutaneous nerve) should be identified, usually by exploring the interval between brachialis and the tendon of biceps brachii. This nerve will be seen travelling from medial to lateral, between the biceps tendon and brachialis. It divides into anterior and posterior branches to supply the skin along the radial border of the forearm.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

34. Answer A. **Deep branch of the radial nerve**
At the cubital fossa, the radial nerve divides into superficial and deep branches. The deep branch of the radial nerve pierces the supinator to pass from the cubital fossa to the posterior compartment of the forearm; when this nerve leaves the supinator, it becomes the posterior interosseous nerve.

Moore K, Dalley A. *Clinically Oriented Anatomy*. Philadelphia, PA: Lippincott Williams & Wilkins; 1999.

35. Answer E. **The tendons of FDS to the index and little fingers are superficial to the FDS tendons of the middle and ring fingers**
The carpal tunnel is the osseofibrous canal at the volar wrist, which has the flexor retinaculum as its roof and the carpal bones as the floor. The flexor retinaculum extends from the hook of hamate and pisiform to the scaphoid tubercle and ridge of the trapezium. Ten structures travel through the carpal tunnel: the median nerve, the eight flexor tendons of the index to little fingers (flexor digitorum superficialis and profundus) and the flexor pollicis longus tendon of the thumb. The flexor digitorum superficialis (FDS) tendons are in two layers; the middle and ring finger FDS tendons lie superficial to those of the index and little fingers, and the four profundus tendons are deep to these.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

36. Answer E. **Superficial branch of the radial nerve**
The anatomical snuffbox is a depression that lies on the dorsoradial surface of the hand. The borders of this concavity are the extensor pollicis longus tendon (EPL) on the ulnar side, and the extensor pollicis brevis (EPB) and abductor pollicis longus (APL) tendons radially. The roof of the snuffbox is covered by fascia and skin, and the floor consists of the scaphoid, trapezium and base of the first (thumb) metacarpal distally.

The dorsolateral approach to the scaphoid involves identifying these structures within the anatomical snuffbox and incising the fascia in the centre, taking care to identify and preserve the superficial branch of the radial nerve which lies superficial to the EPL tendon; this branch can be clinically palpated against the EPL tendon. These tendons are retracted, taking EPL dorsally.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

37. Answer B. **A2 and A4**
The annular pulleys (A) reinforce the flexor sheath, reducing the risk of flexor tendon bowstringing and reduced flexion. A1 is anterior to the metacarpophalangeal joint (MCPJ), A2 at the middle third of the proximal phalanx, A3 at the proximal interphalangeal joint, A4 at the middle third of the middle phalanx, and the A5 pulley is

sited at the distal interphalangeal joint. A2 and A4 are crucial to preventing tendon bowstringing and insert at the periosteum of the proximal phalanx and the middle phalanx, respectively. The thumb has an A1 pulley anterior to the MCPJ and an A2 pulley just proximal to the interphalangeal joint; an oblique is at the middle third of the proximal phalanx.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

38. Answer E. **Nail plate, sterile matrix and hyponychium**

The nail serves as protection to the fingertip and facilitates in tactile sensation and thermoregulation.

The perionychium represents the soft tissue of the nail and comprises the eponychium, paronychium, nail fold, nailbed and hyponychium.

The nailbed is the soft tissue deep to the nail plate and covers the distal phalanx; it is divided into germinal and sterile matrix components. The germinal matrix is proximal and begins under the nail fold and ends at the lunula and produces most of the nail plate. The sterile matrix is distal to the lunula and helps to keep the nail plate tethered to the bed.

The nail fold is the most proximal part region of the perionychium and consists of ventral and dorsal floors, where the ventral floor contains the germinal matrix. The eponychium is the skin which covers the proximal extent of the nail, superficial to the dorsal floor, extending from the proximal nail fold; distal to the eponychium to the nail is the cuticle.

The paronychium represents the folds of skin on the radial and ulnar borders of the nail. The lunula is a white crescent shape of tissue just distal to the eponychium that represents the distal extent of the germinal matrix. The hyponychium is the distal margin between the skin and sterile matrix of the nailbed.

Wolfe S, Hotchkiss R, Green D. *Green's Operative Hand Surgery*, 6th Ed. Philadelphia, PA: Elsevier Churchill Livingstone; 2011.

39. Answer A. **Adductor pollicis**

Froment's test assesses ulnar nerve function and is performed by asking the patient to grasp a piece of paper. When there is an ulnar nerve palsy, this test demonstrates weakness to the adductor pollicis and first dorsal interosseous muscles (supplied by the deep branch of the ulnar nerve, but the lesion may be proximal to this nerve's origin). Froment's sign is therefore the compensatory action of flexor pollicis longus (FPL) to achieve this grip, a muscle which is innerved by the anterior interosseous branch of the median nerve.

Solomon L, Warwick D, Nayagam S, Apley A. *Apley's System of Orthopaedics and Fractures.* London: Hodder Arnold; 2010.

Wolfe S, Hotchkiss R, Green D. *Green's Operative Hand Surgery*, 6th Ed. Philadelphia, PA: Elsevier Churchill Livingstone; 2011.

40. Answer E. **Extensor pollicis longus**

The tendon of extensor pollicis longus runs just ulnar to the dorsal tubercle of the radius, a palpable prominence which is also known as Lister's tubercle, named after the eminent surgeon Joseph Lister. The extensor pollicis longus tendon inserts into the base of the distal phalanx, and as it passes from the forearm to its insertion, it crosses the wrist at the ulnar border of the dorsal tubercle of the radius and obliquely changes direction to form the ulnar border of the anatomical snuffbox (the radial borders are formed by extensor pollicis brevis and abductor pollicis longus). The tendon of extensor carpi radialis brevis runs just radial to Lister's tubercle. Spontaneous rupture of this tendon may occur following a fracture to the distal radius, which can result from necrosis.

There are six extensor compartments at the wrist (see Table 23.1).

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

Lower Limb

41. Answer C. **Hypertrophic zone**

The clinical features that are presented in this question are pathognomonic for a slipped upper femoral epiphysis (SUFE).

This condition has a higher incidence in adolescent males and is rare before the age of 10. It is characterised by mechanical weakness and slippage of the proximal femoral physis, specifically through the hypertrophic zone. Children with renal

osteodystrophy are also at risk of developing a SUFE, though when this occurs, it is usually through the secondary spongiosa and not the hypertrophic zone of the physis. This slippage results in anterior and superior displacement of the metaphysis relative to the femoral head epiphysis.

This mechanical failure of the physis can result from abnormal loads through a normal physis or normal physiological loads through an abnormally weak physis.

A typical clinical presentation for SUFE may be an adolescent male with atraumatic groin, thigh or knee pain. The leg may be shortened and externally rotated, with limited passive flexion and internal rotation; the hip may externally rotate as it is flexed (obligate external rotation). Radiologically, Klein's line passes along the superior cortex of the femoral neck, which should also intersect the epiphysis. Trethowan's sign is when this line passes above the epiphysis due to anterior and superior slippage of the metaphysis relative to the epiphysis.

Rathi RA and Khan T. Slipped upper femoral epiphysis. *Orthop Trauma* 2016:**30**: 482–491.

42. Answer A. **Superior gluteal nerve**

The posterior approach to the hip is frequently performed in both primary and revision surgery. The incision is centred over the posterior aspect of the greater trochanter, where proximally it curves to run with the gluteus maximus fibres, and distally along the femoral shaft. Superficially, the fascia lata is incised over the femoral shaft, and proximally, the gluteus maximus fibres are bluntly split. A Charnley retractor is then inserted between the split gluteus maximus fibres and fascia lata, being mindful to the sciatic nerve whilst this is applied. This exposes the posterolateral hip joint, covered by the overlying short external rotators; the hip is internally rotated to stretch these muscles and to also help move the sciatic nerve away from the dissection. The hip joint is exposed by releasing the short external rotators close to their main insertion on the medial surface of the greater trochanter; this release usually begins at the interval between gluteus medius and piriformis.

The short external rotators relate to five individual muscles on the posterolateral aspect of the hip. From superior to inferior, these are: (1) Piriformis, (2) Superior gemellus, (3) Obturator internus, (4) Inferior gemellus and (5) Quadratus femoris. Neurovascular structures pass from the pelvis to the gluteal region through the greater sciatic foramen, either above or below piriformis, which also passes through this foramen (Figure 23.11).

Figure 23.11 Anatomy gluteal region

1 Gluteus medius
2 Superior gluteal nerve and vessels
3 Piriformis
4 Sacrotuberous ligament
5 Inferior gluteal nerve and vessels
6 Sciatic nerve
7 Obturator internus
8 Ischial tuberosity
9 Posterior cutaneous nerve of the thigh
10 Quadratus femoris
11 Gluteus maximus (reflected)
12 Hamstring part of adductor magnus
13 Short head of biceps femoris
14 Semimembranosus
15 Semitendinosus
16 Long head of biceps femoris
17 Vastus lateralis
18 Tibial nerve and popliteal vessels
19 Common peroneal nerve
20 Medial head of gastrocnemius
21 Lateral head of gastrocnemius

The superior gluteal nerve and vessels emerge above piriformis. The following structures travel to the gluteal region below piriformis: (1) Inferior gluteal nerve and vessels, (2) Nerve to obturator internus, (3) Sciatic nerve, (4) Posterior femoral cutaneous nerve, (5) Pudendal nerve and vessels and (6) The nerve to quadratus femoris.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

43. Answer B. **Superficial peroneal nerve**
This question is assessing one's knowledge of the anterior compartment of the leg; however, also knowing how to perform a four-compartment fasciotomy may also help to focus on this compartment's contents.

The anterolateral approach decompresses the anterior and lateral compartments; the posteromedial approach decompresses the posterior superficial and deep compartments.

For the anterolateral approach, a long incision is made around 2cm lateral to the tibial crest. The anterior intermuscular septum is identified within the deep crural fascia of the leg. The anterior compartment is decompressed by releasing the fascia ~1cm anterior to the intermuscular septum; the lateral compartment is decompressed by making a further incision in the fascia ~1 cm posterior to the anterior intermuscular septum.

The anterior compartment consists of four muscles: tibialis anterior, extensor hallucis longus, extensor digitorum longus and peroneus tertius. It also contains the deep peroneal nerve and anterior tibial vessels. The lateral compartment contains two muscles: peroneus brevis and longus; it also contains the superficial peroneal nerve.

The posteromedial approach is made around 2cm posterior to the posteromedial tibial cortex. The deep fascia is released to decompress the superficial deep compartment. Be mindful to protect the saphenous vein and nerve. The deep posterior compartment is decompressed by releasing the soleus bridge to its origin at the tibia; the fascia is then released longitudinally just posterior to the tibia.

The superficial posterior compartment consists of gastrocnemius (medial and lateral heads), plantaris and soleus. The deep posterior compartment contains the following four muscles: flexor digitorum longus, flexor hallucis longus, tibialis posterior and popliteus. The tibial division of the sciatic nerve is also in the deep posterior compartment, and the posterior tibial and peroneal vessels.

Singh K, Bible JE, Mir HR. Single and dual-incision fasciotomy of the lower leg. *J Bone Joint Surg Essential Techniques* 2015;**5**:e25.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

44. Answer A. **Halfway between the anterior superior iliac spine and the pubic symphysis**

45. Answer B. **Sartorius**
During this approach, the internervous plane is between the femoral nerve (sartorius) and the superior gluteal nerve (tensor fascia lata) superficially, and the femoral nerve (rectus femoris) and the superficial gluteal nerve (gluteus medius) during deeper dissection. The specific nerve described is the lateral femoral cutaneous nerve (lateral cutaneous nerve of the thigh), which is a sensory branch of the lumbar plexus (L2–3), providing cutaneous sensation primarily to the lateral thigh. This nerve emerges from behind or through the inguinal ligament just medial to the anterior superior iliac spine and enters the thigh deep to the fascia lata, eventually dividing into anterior and posterior branches. As it passes deep to the fascia lata, it crosses over the sartorius muscle; the surgeon should therefore be mindful of this nerve when incising the fascia lata to dissect the interval between tensor fascia latae and sartorius, retracting tensor fascia lata laterally and sartorius medially. Deep to these are the rectus femoris and the gluteus medius.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

46. Answer A. **Deep peroneal nerve**
This approach is made in the midline, just proximal and distal to the ankle joint. Branches of the superficial peroneal nerve are at risk during superficial dissection when superficial to the extensor retinaculum; deep to this retinaculum lie the extensor tendons. At the level of the ankle

joint, the anterior tibial artery and deep peroneal nerve are expected to be just deep to the extensor hallucis longus tendon (inserts on the dorsal surface of the distal phalanx of the great toe), which are retracted medially along with this tendon.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

47. Answer C. **Ilioinguinal nerve**
During this approach, the spermatic cord (or round ligament in the female) is mobilised. The spermatic cord (or round ligament) travels through the inguinal canal by passing from the deep to superficial inguinal rings. The spermatic cord contains the vas deferens, lymphatics (draining to the para-aortic lymph nodes), the testicular artery, artery to the vas, cremasteric artery, the pampiniform plexus of veins and three layers of fascia (internal and external spermatic fascia and the cremaster muscle). It also contains three nerves: nerve to the cremaster from the genital branch of the genitofemoral nerve and autonomic nerves. The ilioinguinal nerve also runs in the inguinal canal but is not within the cord.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

48. Answer C. **S1**
An S1 nerve root injury is a recognised complication of this procedure.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

49. Answer D. **Piriformis**
The greater sciatic foramen is formed by the greater sciatic notch and the sacrospinous ligament. The piriformis muscle, which arises from the sacrum, passes through this foramen and effectively divides the foramen into two, and then inserts onto the upper border of the greater trochanter. Several structures pass from the pelvis to the gluteal region either above or below piriformis. Above piriformis are the superior gluteal nerve and vessels. Inferior to piriformis are the inferior gluteal nerve and vessels, pudendal nerve and vessels, nerve to obturator internus, sciatic nerve, posterior femoral cutaneous nerve and the nerve to quadratus femoris.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

50. Answer E. **Transverse branch of the medial circumflex femoral artery**
The femoral head receives most of its blood supply via the trochanteric anastomosis and its nutrient arteries. This anastomosis is formed by the descending branch of the superior gluteal artery and the ascending branches of the lateral and medial circumflex femoral arteries, and a small contribution is made by the inferior gluteal artery. Nutrient arteries branch off from this anastomosis within the retinacular fibres of the capsule and pass towards the femoral head. There is a further anastomosis at the level of the lesser trochanter, the cruciate anastomosis, where the transverse branch of the medial circumflex femoral artery anastomoses with the transverse branch of the lateral circumflex femoral artery. Joining this is the ascending branch of the first perforating artery (a branch of the profunda femoris) and the descending branch of the inferior gluteal artery.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

51. Answer C. **Piriformis**
The sciatic nerve exits the pelvis through the greater sciatic foramen, passing anterior then inferior to piriformis to enter the gluteal region.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

52. Answer A. **Common peroneal nerve**
The popliteal fossa, a diamond-shaped depression of the posterior knee joint, is bordered

inferiorly by the medial and lateral heads of gastrocnemius, superolaterally by biceps femoris and superomedially by semimembranosus and, lateral to this, the semitendinosus. The roof is formed by the fascia lata (the short saphenous vein pierces this to enter the popliteal vein, and lateral to this runs the medial sural cutaneous nerve, which is a branch of the tibial nerve). The floor is formed by the femur and capsule of the knee.

Deep to the roof and passing through the fossa are the popliteal artery (the deepest structure, close to the posterior joint capsule) and vein (superficial to the artery, and deep to the tibial nerve), the tibial nerve (the most superficial structure of the main neurovascular structures, which lies in the midline of the fossa) and common peroneal nerve (most lateral structure, superficial to the posterior border of biceps femoris), and several popliteal lymph nodes. The popliteal artery (with its branches) begins from the hiatus of the adductor magnus and enters the fossa medial to the tibial nerve, but as it descends, it lies lateral to the nerve, exiting the fossa through the fibrous arch within the soleus (with the tibial nerve and popliteal vein), to become the posterior tibial artery, which ultimately divides into anterior and posterior branches.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

53. Answer C. **Great saphenous vein**
A four-compartment leg fasciotomy is best performed through anterolateral and posteromedial incisions. The anterior and lateral compartments are decompressed via the anterolateral incision, centred between the fibula and the tibial crest. The subcutaneous tissue is dissected, exposing the crural fascia. The anterior compartment is released by incising the fascia just anterior to the anterior intermuscular septum. The lateral compartment is then fully released, incising the fascia that is posterior to the anterior intermuscular septum, taking care to protect the superficial peroneal nerve. The posterior superficial and deep compartments are released through the posteromedial incision, 2cm posterior to the posterior tibial border. Superficially, the great saphenous vein and saphenous nerve are at risk. The septum between the superficial and deep compartments is exposed, the fascia is released over the deep posterior compartment proximally and distally; the fascia of the superficial posterior compartment is also released.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

54. Answer B. **Gerdy's tubercle**
Used for lateral tibial plateau fractures, this incision typically extends from the lateral border of the patellar tendon just proximal to the joint line, curving inferiorly over Gerdy's tubercle (the insertion of the iliotibial band).

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

55. Answer C. **Peroneus longus**
The superficial and deep peroneal nerves are terminal branches of the common peroneal nerve and arise within the peroneus longus muscle at the region of the fibular neck.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

56. Answer C. **Flexor hallucis longus**
Acute compartment syndrome arises when increasing intracompartmental pressure compromises the perfusion to the tissues within that compartment. Intense pain (out of proportion to the initial clinical condition) is often the first sign of acute compartment syndrome, especially when the affected muscle group is passively stretched. For this specific question, passive extension of the lesser toes stretches flexor digitorum longus, which is a member of the deep posterior department (see Table 23.2). The other two members of this deep posterior compartment are (1) Flexor hallucis longus, (2) Tibialis posterior and (3) Popliteus.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

McQueen MM, Duckworth AD. The diagnosis of acute compartment syndrome: a review. *Eur J Trauma Emerg Surg.* 2014;**40**:421–528.

Table 23.2 Muscles of the four leg compartments with corresponding nerve supply

Anterior		Superficial posterior		Deep posterior		Lateral	
Muscles	***Innervation***	***Muscles***	***Innervation***	***Muscles***	***Innervation***	***Muscles***	***Innervation***
Tibialis anterior	**Deep peroneal nerve**	Gastrocnemius	**Tibial nerve**	Flexor digitorum longus	**Tibial nerve**	Peroneus longus	**Superficial peroneal nerve**
Extensor hallucis longus		Soleus		Flexor hallucis longus		Peroneus brevis	
Extensor digitorum longus		Plantaris		Tibialis posterior			
Peroneus tertius				Popliteus			

57. Answer B. **Between the tendons of extensor digitorum longus and extensor hallucis longus**
An anterior incision is made midway between the malleoli, extending to the dorsum of the foot. The crural fascia is incised, followed by the extensor retinaculum, and the plane between the extensor hallucis longus and extensor digitorum longus is developed. Just proximal to the ankle joint, the anterior tibial artery and deep peroneal nerve are generally expected to be between the tendons of extensor digitorum longus and extensor hallucis longus, but at the ankle joint, these neurovascular structures pass deep to the extensor hallucis longus tendon.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

58. Answer B. **Flexor hallucis longus**
For this approach, a longitudinal incision is made between the Achilles tendon and lateral malleolus. The deep fascia (crural fascia) is incised and the tendons of peroneus brevis and longus are identified, along with the Achilles tendon. The peroneal retinaculum is incised, and the peroneal tendons are retracted, exposing the flexor hallucis longus muscle (FHL). FHL is retracted medially to expose the periosteum of the posterior tibia.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

59. Answer C. **Weakness of great toe extension and decreased sensation between the great (first) and second toes (first web space)**
The deep peroneal nerve innervates the four anterior compartment muscles to the leg: tibialis anterior, extensor hallucis longus, extensor digitorum longus and peroneus tertius. It is also sensory to the dorsum of the foot at the first web space.

Moore K, Dalley, A. *Clinically Oriented Anatomy.* Philadelphia, PA: Lippincott Williams & Wilkins; 1999.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

60. Answer C. **Superficial peroneal (fibular) nerve**
A dorsomedial incision is made just proximal to the interphalangeal joint, extending over the first metatarsophalangeal joint and metatarsal, ending just distal to the tarsometatarsal joint. During dissection and retraction, care should be taken to protect the dorsal digital branch of the medial cutaneous nerve, which is often retracted laterally; the medial cutaneous nerve is a sensory branch to the foot from the superficial peroneal nerve.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

61. Answer A. **A positive Trendelenburg sign is noted by the pelvis sagging on the standing side**
The gluteal region lies from the iliac crest to the gluteal fold. The sacrospinous ligament attaches to the ischial spine, forming the greater sciatic foramen from the greater sciatic notch; the lesser sciatic foramen is formed by the lesser sciatic notch and the sacrotuberous ligament. Muscles of the gluteal region include gluteus maximus (extension and external rotation), gluteus medius, minimus and tensor fasciae latae (abductors) and the deep short external rotators (piriformis, superior gemellus, obturator internus, inferior gemellus and quadratus femoris). Gluteus maximus arises from the gluteal surface of the ilium, the lumbar fascia and sacrum, and from the sacrotuberous ligament; it is innervated by the inferior gluteal nerve and receives its blood supply from the superior and inferior gluteal arteries. The Trendelenburg's test assesses the stability of the hip. Standing on both feet, the centre of gravity is midway between these points; however, when standing on one leg, the centre of gravity moves towards this side and the pelvis raises on the unsupported side. Normally, when standing on one leg (stance leg), the abductors on this weight-bearing side (medius, minimus and tensor fasciae latae) stabilise the hip; however, if there is any weakness in these muscles (trauma, poliomyelitis), the body's weight will cause the pelvis to dip on the contralateral side (Trendelenburg sign), but the weakness is on the stance side (sound side sags).

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

62. Answer D. **Subvastus**
The subvastus approach is known for its ability to give earlier recovery due to less post-operative pain and early mobilisation (due to rapid quadriceps recovery). This approach is considered as a relative contraindication for TKA in knees with limited ROM due to difficulty in exposure which can increase the risk of complications such as patellar tendon avulsion or medial collateral injury. Short stature and obesity are also relative contraindications.

An anterior midline incision with medial parapatellar arthrotomy is the most common incision for primary TKA. Technically easy to do with good exposure of the knee.

The subvastus approach leaves the extensor mechanism intact. This results in faster restoration of quadriceps strength, retains greater vascularity in the patella, increases patient satisfaction while reducing post-operative pain, and reduces the need for lateral release. Intraoperative knee visualisation is reduced compared with the medial parapatellar approach, especially in obese individuals and those who have had previous knee procedures. There is also concern about the potential for component misalignment. The muscle belly of vastus medialis is lifted off intermuscular septum.

The trivector approach is used for a minimally invasive approach to the knee. Quicker recovery with less loss of quadriceps strength but exposure less predictable. Blom et al. (2021) reported that the midvastus approach (used in 3% of cases) was associated with a 20% reduced risk of revision surgery compared with the medial parapatellar approach (used in 91.9% of cases). They recommended the use of the midvastus approach and advised surgeons to consider utilising this approach more frequently. Minimally invasive approaches did not appear to convey any clinical advantage in this study over conventional approaches for primary TKR.

Blom AW, Hunt LP, Matharu GS, Reed M, Whitehouse MR. The effect of surgical approach in total knee replacement on outcomes: an analysis of 875,166 elective operations from the National Joint Registry for England, Wales, Northern Ireland and the Isle of Man. *Knee* 2021;**31**:144–157.

Spine

63. Answer B. **Paraxial mesoderm**
The mesoderm, which is the middle layer of the trilaminar disc, is subdivided into paraxial, intermediate and lateral mesoderm. The axial skeleton (skull, vertebral column, ribs and sternum) begins to form by around the third week, where the characteristic segmentation of the vertebral

column is established early, during the embryonic period; defects during this process can lead to congenital disorders of the spine such as congenital scoliosis. The following sections will discuss somitogenesis, which is the formation of somites from the paraxial mesoderm. Somites are the precursors to the sclerotome and dermatomyotome and develop in pairs along the neural tube; ultimately, they give rise to the structures of the vertebral column, muscle and dermis.

Somitogenesis

Somitogenesis is the process of segmentation and somite development from the paraxial mesoderm, giving rise to the axial skeleton and the characteristic segmented structure of the vertebral column. The mesoderm of the trunk is subdivided into the lateral plate mesoderm, intermediate mesoderm, and the paraxial mesoderm (also known as the presomitic mesoderm); the paraxial mesoderm is the precursor to the axial skeleton and the lateral plate mesoderm gives rise to the appendicular skeleton. Somites are transient epithelial spheres that are precursors to the axial skeleton and are rhythmically developed in pairs along the anteroposterior axis and surround the neural tube and notochord at consistent intervals. The 'clock and wavefront model' explains this process of repetitive segmentation. The rate of somite development is consistent between species but varies amongst different species.

These somites extend from the occipital region caudally as paired segmental structures of tissue either side of the neural tube and notochord, and eventually differentiate to form tissues of the vertebral column, cartilage, skeletal muscle, tendons and dermis. Somites form at a predictable rate in a cranial-caudal direction. The total number and rate of somite formation is fixed but varies between species, where in humans, these form at a rate of around three per day; the first forms at around day 20, and by the fifth week, there are 42–44 pairs (4 occipital, 8 cervical, 12 thoracic, 5 lumbar, 5 sacral and 8–10 coccygeal). The first occipital and 5–7 coccygeal eventually degenerate.

The clock and wavefront model is a popular theory that explains the segmentation of paraxial mesoderm into somite pairs, where somatic pairs bud off from the paraxial mesoderm at a precise rate, and this is governed by the cyclical expression of specific signalling pathways involving Notch, WNT, b-catenin and FGF. The segmentation clock refers to the periodic expression of specific genes within the paraxial mesoderm that interacts with signalling gradients (maturation wavefront). Abnormalities in normal segmentation can lead to congenital disorders such as congenital scoliosis (most frequent congenital spinal deformity), with segmental defects visible on radiographs that may include hemivertebrae, vertebral fusions and bars.

Somite differentiation

Differentiated somites consist of two major cell types: the sclerotome and dermatomyotome. Cells within the ventromedial walls of the somites differentiate through a process of epithelial-to-mesenchymal transition (EMT), induced by noggin and sonic hedgehog signalling proteins, forming the sclerotome; the sclerotome differentiates into tissues of the vertebral column (vertebrae, intervertebral discs, and tendons), skull base and ribs. Sclerotome formation is characterised by the expression of specific transcription factors such as paired-box gene (PAX) 1 and 9 and SOX9. Those remaining cells that lie dorsolaterally remain epithelial and form the dermomyotome, which has two components: the myotome and dermatome. The myotome differentiates to produce skeletal muscle of the ventral wall and limbs; the dermatome gives rise to the dermis. Neural crest cells also differentiate into mesenchymal cells that give rise to the bones of the skull.

As previously stated, the vertebrae develop from the sclerotome, which is transient pluripotent mesenchymal tissue derived from the venteromedial region of the somite, and the paraxial mesoderm is the precursor to these tissues. During week four, sonic hedgehog signalling proteins from the floor of the neural tube and notochord stimulate the sclerotome cells of the somite to proliferate ventrally and surround the spinal cord and notochord, and merge with their counterparts from the other somite in the pair to form ultimately the vertebral body and intervertebral discs. The dorsomedial sclerotome forms the neural arches.

Sadler TW. *Medical Embryology*, 14th Ed. Philadelphia, USA: Wolters Kluwer; 2019.

Scaal M. Early development of the vertebral column. *Semin Cell Develop Biol.* 2016;**49**:83–91.

Tani S, Chung U, Hojo H. Understanding paraxial mesoderm development and sclerotome specification for skeletal repair. *Exp Mol Med.* 2020;**52**:1166–1177.

Williams S, Alkhatib B, Serra R. Development of the axial skeleton and intervertebral disc. *Curr Topics Dev Biol.* 2019;**133**:49–90.

64. Answer E. **L4**
The abdominal aorta begins behind the diaphragm at the aortic hiatus at the level of the twelfth thoracic vertebrae and ends at the level of the fourth lumbar vertebrae, bifurcating into the common iliac arteries.

65. Answer B. **Longus colli**
The sternocleidomastoid muscle is retracted laterally along with the carotid sheath and its contents (vagus nerve, carotid artery and internal jugular); the oesophagus, larynx and trachea, thyroid and strap muscles are retracted medially. Deep dissection involves incising the prevertebral fascia to expose the longus colli muscles and the anterior longitudinal ligament, which are superficial to the cervical vertebrae. The longus colli is split in the midline and is reflected laterally to the midline along with the anterior longitudinal ligament to expose the cervical vertebral body (Figure 23.13).

66. Answer A. **Artery of Adamkiewicz**
This approach is usually performed on the right side, but this depends on the indication and surgeon's preference. The lung, oesophagus and intercostal vessels are at risk of injury during either a right- or left-sided approach, while the artery of Adamkiewicz is generally found on the left side of the posterior mediastinum and the azygos vein is generally to the right.

67. Answer A. **Cricothyroid**
The anterior approach (Smith–Robinson) to the cervical spine extends superficially through superficial fascia and platysma, which is split longitudinally. The anterior border of the sternocleidomastoid is identified, and the investing layer of deep fascia is incised, retracting the muscle laterally; sternohyoid and sternothyroid, with the trachea and oesophagus retracted medially. The carotid sheath and its contents are retracted laterally by developing a plane between the carotid sheath and the thyroid, trachea and oesophagus (incising the pretracheal fascia). Deep to this plane lies the prevertebral fascia, covering the longus colli muscle, anterior longitudinal ligament and the cervical vertebrae.

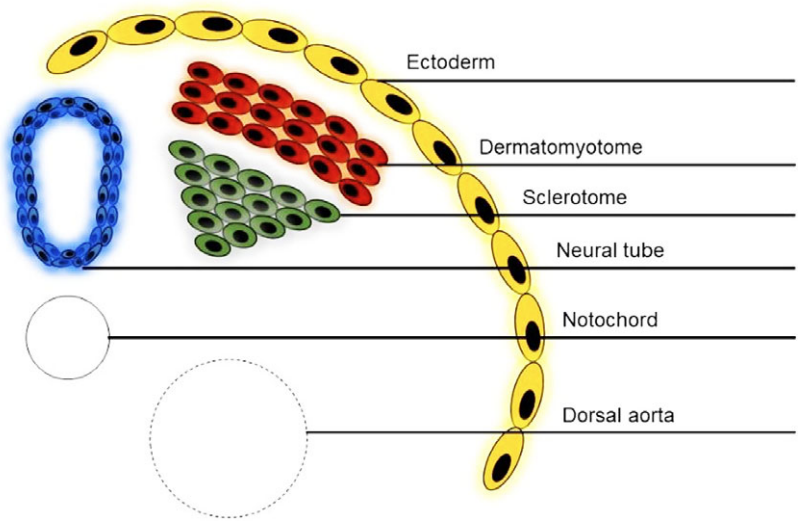


Figure 23.12 Transverse section through the embryo, showing the main regions of the somite: the sclerotome and dermatomyotome

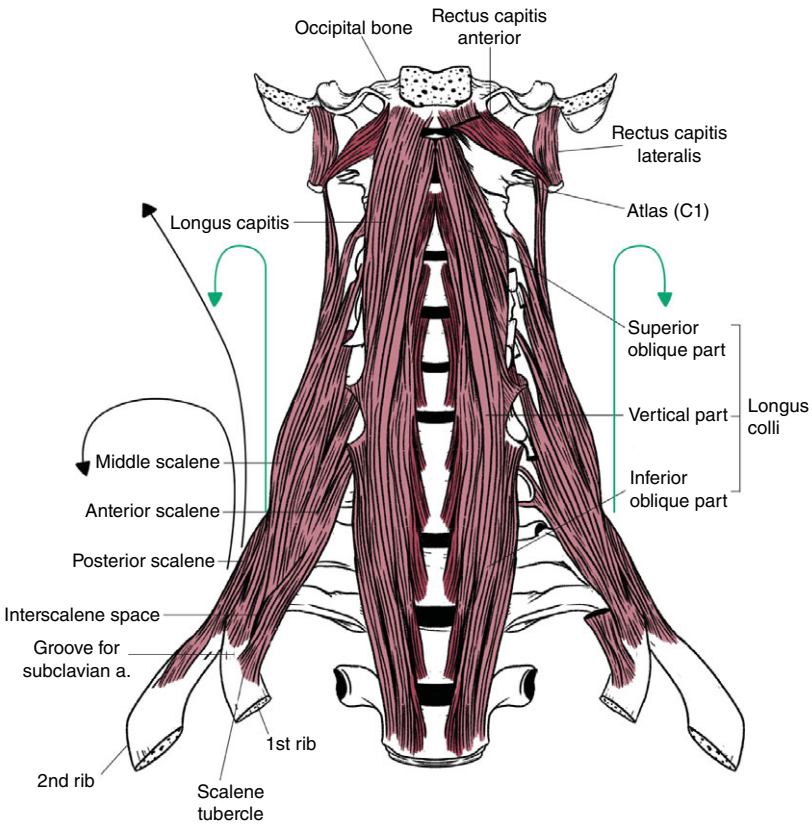


Figure 23.13 The longus colli connects the cervical spine to the thoracic spine. Of the neck flexors it is the only one that attaches to the anterior cervical spine

During this approach, the recurrent laryngeal nerve is a structure at risk, and unilateral palsy can result in hoarseness. Both nerves ascend the posterolateral border of the trachea in the tracheoesophageal groove. All intrinsic muscles of the larynx are supplied by the recurrent laryngeal nerves other than cricothyroid, which is innervated by the external laryngeal nerve, which is a further branch of the vagus nerve (CN X). The recurrent laryngeal innervates the following intrinsic laryngeal muscles: thyroarytenoid, posterior cricoarytenoid, lateral cricoarytenoid, transverse and oblique arytenoids.

68. Answer D. **Decreased sensation over the upper anterior thigh and anterior scrotum (or labia majora)**

During this approach, an oblique incision is usually made from the posterior aspect of the twelfth rib to the lateral border of the rectus abdominis. Dissection is made through the skin, subcutaneous fat and external oblique aponeurosis, followed by the external oblique, internal oblique and transversus abdominis muscles. The peritoneum and its contents are retracted medially, usually with the ipsilateral ureter, which is frequently adhered to the peritoneum. The genitofemoral nerve (L1–2), which supplies the area of skin over the upper anterior thigh and anterior scrotum or labia majora, emerges from the anterior surface of the psoas major muscle, and passes inferiorly, deep to the psoas fascia and anterior to the muscle. The ureter, which is also at risk, runs between the peritoneum (usually adhered to) and psoas fascia.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Moore K, Dalley A. *Clinically Oriented Anatomy.* Philadelphia, PA: Lippincott Williams & Wilkins; 1999.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

69. Answer B. **L1–2**
In the fetus, the spinal cord extends from the foramen magnum to the second sacral vertebra, and at birth, the end of the spinal cord, known as the conus medullaris, is opposite the third lumbar vertebra. The final position of the conus medullaris in the adult is generally at the level of the first or second lumbar vertebrae.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

Chapter 23

Anatomy and Surgical Approaches Structured SBA

Christopher George Ghazala

ANATOMY AND SURGICAL APPROACHES STRUCTURED SBA QUESTIONS

Upper Limb

1. A child is referred to you from the paediatric team with concerns of an ulnar deviated carpus, an absent ulna, and ulnar-sided digits.
   Which protein is most likely to be under-expressed during limb development for the described phenotype?
   A. Fibroblast growth factor 8
   B. Sonic hedgehog
   C. Wingless 7A (WNT7A)
   D. LMX1B
   E. Engrailed 1 (EN-1)

2. A patient has an autosomal dominant congenital syndrome, characterised by absent nails, hypoplastic patellae, iliac horns (exostoses) and chronic kidney disease.
   This condition is caused by a mutation in which of the following genes?
   A. Fibroblast growth factor 8
   B. Sonic hedgehog
   C. Wingless 7A (WNT7A)
   D. LMX1B
   E. Engrailed 1 (EN-1)

3. A nerve decompression is carried out at the wrist, where the patient has a large ganglion and symptoms of paraesthesia involving the small and ring fingers, with intrinsic weakness and a positive Froment sign.
   Which structure forms the radial (lateral) border of the fibro-osseous tunnel transmitting this nerve?
   A. Pisiform
   B. Hook of the hamate
   C. Scaphoid
   D. Trapezium
   E. Capitate

4. An anterior approach is performed to expose the glenohumeral joint.
   During this approach, which of the following signs will most likely be due to excessive medial retraction of the conjoint tendon?
   A. Paraesthesia of the medial forearm
   B. Paraesthesia involving the region of the inferior lateral deltoid (regimental badge area)
   C. Supination weakness
   D. Weakness of wrist and finger extension
   E. Paraesthesia involving the central dorsal region of the forearm

5. In the deltopectoral approach to the shoulder, the conjoint tendons are retracted. Deep to these and anterior to the capsule is a muscle and its tendon.
   What is the main function of this deep anterior shoulder muscle?
   A. External rotation
   B. Abduction
   C. Internal rotation
   D. Forward flexion
   E. Extension

6. The distal humeral shaft is approached anterolaterally. During this approach, a nerve is seen to emerge between biceps brachii and brachialis.
   What is the normal function of this nerve?
   A. Sensory to the anterolateral forearm
   B. Sensation to the anteromedial forearm

C. Dorsal sensation to two-thirds of the hand and proximal three and a half lateral digits
D. Wrist and finger extension
E. Wrist and finger flexion

7. An anterior approach to the cubital fossa is carried out to explore the brachial artery.
Regarding the internervous planes to this approach, which nerve is related to both the proximal and distal extents of the dissection?
A. Musculocutaneous nerve
B. Radial nerve
C. Median nerve
D. Lateral cutaneous nerve
E. Ulnar nerve

8. During the posterior approach to the scapula, excessive medial retraction of a muscle results in significant arterial bleeding, and the surgeon is concerned there is now an associated nerve injury.
If this is true, which of the following movements will likely be chronically weakened?
A. Abduction and external rotation of the arm
B. Abduction of the arm
C. Adduction and internal rotation of the arm
D. Extension of the arm
E. Internal rotation of the arm

9. A posterior portal is created to carry out a diagnostic shoulder arthroscopy.
Which structure is most at risk of injury if a portal is created that is too medial than the typically described approach?
A. Axillary nerve
B. Infraspinatus
C. Posterior circumflex humeral artery
D. Radial nerve
E. Suprascapular nerve

10. **Which of the following shoulder muscles are innervated by a nerve that arises from the upper trunk of the brachial plexus?**
A. Subscapularis
B. Deltoid
C. Supraspinatus
D. Teres minor
E. Teres major

11. A bone reduction clamp is placed under the inferior surface of the clavicle, positioned between the clavicle and a slender muscle running along the inferior surface.
The innervation to this specific muscle arises from which of the following root(s) of the brachial plexus?
A. C5
B. C6
C. C7
D. C5–6
E. C6–7

12. You are assisting a plastic surgery consultant in exploring the brachial plexus at the axilla. The part of the axillary artery below pectoralis minor is noted to have two nerve roots joining anterior to it to form a nerve which lies just lateral to the artery.
What is this nerve?
A. Axillary nerve
B. Median nerve
C. Musculocutaneous nerve
D. Radial nerve
E. Ulnar nerve

13. **With respect to the muscles of the pectoral girdle, which muscle inserts into the lateral lip of the intertubercular (bicipital) sulcus of the humerus and receives its innervation that is derived from both the medial and lateral cords of the brachial plexus?**
A. Latissimus dorsi
B. Pectoralis major
C. Pectoralis minor
D. Serratus anterior
E. Trapezius

14. The subscapularis muscle is dually innervated. These nerves arise as two branches from the same cord of the brachial plexus.
Of the following nerves, which nerve also originates from this specific cord of the brachial plexus?
A. Medial pectoral nerve
B. Lateral pectoral nerve
C. Musculocutaneous nerve
D. Medial cutaneous nerve of the arm
E. Thoracodorsal nerve

15. A male patient presents to clinic after a game of rugby with pain over the volar surface of the distal phalanx to the ring finger. Examination has confirmed no active flexion at the distal interphalangeal joint, and this joint was held in slight relative extension to the other digits.
Which zone does this injury correspond to?
A. Zone I
B. Zone II
C. Zone III
D. Zone IV
E. Zone V

16. A patient presents with signs consistent with medial scapular winging.
The injured nerve is a branch from which of the following nerve root(s)?
A. C4
B. C5
C. C3–5
D. C5–6
E. C5–7

17. A 50-year-old male presents with acute arm pain, swelling, bruising, and weakness on resisted forearm supination and flexion.
What are the nerve roots to this affected muscle?
A. C8–T1
B. C1–3
C. C3–5
D. C5–7
E. C7–8

18. **During exploration of the cubital fossa, what structure is typically expected to be running medial to a tendon that inserts at the radial tuberosity?**
A. Median nerve
B. Brachial artery
C. Radial nerve
D. Median cubital vein
E. Medial cutaneous nerve of the forearm

19. The superficial anterior forearm compartment comprises five muscles that cross the elbow joint.
Which of the following muscles is NOT a superficial flexor of the forearm?
A. Flexor carpi radialis
B. Flexor carpi ulnaris
C. Flexor pollicis longus
D. Palmaris longus
E. Pronator teres

20. **During the volar (Henry) approach to the proximal third of the radius, which structure is protected from the field by retracting the supinator muscle laterally?**
A. Anterior interosseous nerve
B. Posterior interosseous nerve
C. Radial artery
D. Radial recurrent artery
E. Superficial radial nerve

21. A 21-year-old male undergoes open reduction and internal fixation for an open radial shaft fracture. Post-operatively this patient is noted to have significant weakness of extension to the wrist and digits.
What nerve has most likely been injured?
A. Anterior interosseous nerve
B. Median nerve
C. Posterior interosseous nerve
D. Radial nerve
E. Ulnar nerve

22. An open median nerve decompression is performed for carpal tunnel syndrome.
What is the structure that is expected to arise between the tendons of palmaris longus and flexor carpi radialis, and course superficial to the flexor retinaculum?
A. Anterior interosseous nerve
B. Median nerve
C. Palmar cutaneous branch of the median nerve
D. Recurrent (motor) branch of the median nerve
E. Ulnar nerve

23. During median nerve decompression surgery, a branch of the median nerve is inadvertently severed as the flexor retinaculum is divided.
This injury will most likely result in weakness of which of the following muscles?
A. Abductor pollicis brevis
B. Abductor pollicis longus

C. Adductor pollicis
D. Lateral three lumbricals
E. Opponens digiti minimi

24. With respect to the flexor tendons of the hand, an injury is noted to involve the flexor digitorum profundus (FDP) tendons just distal to the flexor retinaculum but proximal to the A1 pulley.
Which flexor zone does this injury correspond to?
A. Zone I
B. Zone II
C. Zone III
D. Zone IV
E. Zone V

25. **Which muscle is within the posterior deep compartment of the forearm?**
A. Extensor pollicis longus
B. Anconeus
C. Pronator teres
D. Palmaris longus
E. Supinator

26. Following Henry's approach to the forearm, the patient is noted to have a new wrist drop.
Which of the following structures has likely been excessively retracted during this procedure?
A. Brachioradialis
B. Flexor carpi radialis
C. Flexor pollicis longus
D. Pronator teres
E. Supinator

27. A 65-year-old who has been non-operatively managed for a distal radial fracture is assessed in clinic. There was no movement on assessing extension at both the interphalangeal and metacarpophalangeal joints, and a tendon rupture is diagnosed.
Which extensor compartment does this specific tendon belong to?
A. Compartment 1
B. Compartment 2
C. Compartment 3
D. Compartment 4
E. Compartment 5

28. You are exploring a wound located within flexor zone III of the hand. A structure is noted that is radial to the ring finger metacarpophalangeal joint and originates from a tendon rather than bone; the origin of this structure is noted to also be bicipital.
What is this structure and its most common nerve supply?
A. Ring finger flexor digitorum profundus and ulnar nerve
B. Ring finger lumbrical and median nerve
C. Ring finger lumbrical and ulnar nerve
D. Ring finger palmar interosseous muscle and median nerve
E. Ring finger palmar interosseous muscle and ulnar nerve

29. You are teaching second-year medical students the anatomy of the hand. A student points to one of the annular pulleys that is situated at the level of the proximal interphalangeal joint of the index finger.
What annular pulley does this correspond to?
A. A1
B. A2
C. A3
D. A4
E. A5

30. A patient undergoes open reduction and internal fixation of a clavicular fracture.
What is the nerve supply to the muscle that is encountered just deep to the skin?
A. Ansa cervicalis
B. Cranial nerve V
C. Cranial nerve VII
D. Cranial nerve XI
E. Supraclavicular nerves

31. An anatomical shoulder replacement is performed.
During this approach, which structure is most at risk when the clavipectoral fascia is incised to expose a specific tendon complex, but especially during retraction of this tendon?
A. Axillary artery
B. Axillary nerve
C. Cephalic vein
D. Median nerve
E. Musculocutaneous nerve

32. While performing an anterior approach to the humeral shaft, the surgeon is trying to manage a haemorrhaging vessel during proximal deep dissection.
Which vessel has likely been severed but should be expected to cross the operative field during this dissection?
A. Anterior circumflex humeral artery
B. Axillary artery
C. Axillary vein
D. Brachial artery
E. Cephalic vein

33. An anterior approach to the elbow is performed, during which a nerve is preserved that emerges lateral to a tendon that inserts into the radial tuberosity. This nerve then passes distally and divides into anterior and posterior branches.
Complete transection of this nerve will cause which of the following?
A. Anaesthesia of the lateral (radial) surface of the forearm
B. Anaesthesia of the medial (ulnar) surface of the forearm
C. Anaesthesia of the midposterior (dorsal) forearm
D. Weakness of elbow flexion and forearm supination
E. Wrist drop

34. A posterior approach to the radial shaft is performed and the surgeon identifies and preserves a nerve that passes through and innervates supinator.
What is this specific nerve?
A. Deep branch of the radial nerve
B. Deep branch of the ulnar nerve
C. Median nerve
D. Muscular branches of the ulnar nerve
E. Superficial branch of the ulnar nerve

35. **With respect to the anatomy of the carpal tunnel, which of the following statements is INCORRECT?**
A. The roof of the carpal tunnel, the flexor retinaculum, extends from the hook of hamate and pisiform medially to the scaphoid tubercle and ridge of the trapezium laterally
B. The tendon of flexor carpi radialis runs between the deep and superficial layers of the flexor retinaculum and not within the carpal tunnel
C. The tendon of flexor pollicis longus runs through the carpal tunnel
D. The tendons of flexor digitorum superficialis (FDS) to the middle and ring ringers are superficial to the FDS tendons of the index and little fingers
E. The tendons of FDS to the index and little fingers are superficial to the FDS tendons of the middle and ring fingers

36. A dorsolateral approach to the scaphoid is performed, centred within the anatomical snuffbox.
Regarding the anatomical snuffbox, what structure can be clinically palpated (or visualised during surgical exploration) as it crosses the tendon which forms the ulnar (medial) border of the anatomical snuffbox and must be preserved during this approach?
A. Cephalic vein
B. Extensor pollicis brevis tendon
C. Extensor pollicis longus tendon
D. Radial artery
E. Superficial branch of the radial nerve

37. **Which of the flexor tendon pulleys should be preserved to reduce the risk of bowstringing and significant weakness?**
A. A1 and A3
B. A2 and A4
C. A3 and A5
D. C1
E. C2

38. A child attends with a fingertip laceration. Examination reveals a longitudinal deep laceration extending from the centre of the thumb nail to involve the distal tip. This laceration involves the deeper soft tissues of the nail.
In terms of nail anatomy, which structures are likely involved?
A. Nail plate and germinal matrix
B. Nail plate and lunula
C. Nail plate and sterile matrix

D. Nail plate, germinal matrix, hyponychium and eponychium
E. Nail plate, sterile matrix and hyponychium

39. The hand of a 55-year-old manual worker is examined. They have decreased sensation over the little and ring fingers and weakened grip strength. They are asked to grasp a piece of paper between their thumb and the radial border of their index finger. They hold this paper by hyperflexing at the interphalangeal joint to the thumb. This test is repeated on the normal contralateral hand, and they grasp the paper firmly, keeping their thumb straight rather than flexing at this joint.
Which muscle is being assessed and is demonstrated to be weakened?
A. Adductor pollicis
B. Adductor pollicis longus
C. Flexor pollicis brevis
D. Flexor pollicis longus
E. Opponens pollicis

40. **With respect to the dorsal tubercle of the radius, which extensor tendon is expected to be just ulnar (medial) to this prominence?**
A. Abductor pollicis longus
B. Extensor digitorum communis
C. Extensor indicis
D. Extensor pollicis brevis
E. Extensor pollicis longus

Lower Limb

41. A 12-year-old boy, who has no comorbidities, presents with acute on chronic atraumatic hip pain and is unable to weight bear. Trethowan's sign is present, which is diagnostic.
Which of the following physeal regions is likely to be implicated in the pathology of this condition?
A. Reserve zone
B. Proliferative zone
C. Hypertrophic zone
D. Primary spongiosa
E. Secondary spongiosa

42. The hip is exposed using a posterior (Moore or Southern) approach.
What structure is expected to pass superior to piriformis?
A. Superior gluteal nerve
B. Inferior gluteal nerve
C. Sciatic nerve
D. Pudendal nerve
E. Inferior gluteal artery

43. A two-incision approach is performed for acute compartment syndrome of the leg. A necrotic muscle is noted in the compartment that is decompressed when the fascia is incised longitudinally and anterior to the intermuscular septum.
Which of the following structures is not a constituent of this compartment?
A. Peroneus tertius
B. Superficial peroneal nerve
C. Deep peroneal nerve
D. Extensor hallucis longus
E. Extensor digitorum longus

44. You are asked to assess a patient who has had a knife injury to their groin.
The surface anatomy for the common femoral artery within the femoral triangle is defined as which of the following?
A. Halfway between the anterior superior iliac spine and the pubic symphysis
B. Halfway between the anterior superior iliac spine and the pubic tubercle
C. One-third the distance from the anterior superior iliac spine and pubic symphysis
D. One-third the distance from the anterior superior iliac spine and the pubic tubercle
E. Two-thirds the distance from the anterior superior iliac spine and the pubic tubercle

45. A child presents with a septic hip, and an anterior approach is performed to irrigate and drain the joint. Regarding this approach, a nerve is at risk as it passes deep to the fascia lata and crosses the lateral border of a muscle which is retracted during the approach.
What is this muscle?
A. Rectus femoris
B. Sartorius
C. Tensor fascia lata
D. Vastus intermedius
E. Vastus lateralis

46. An anterior approach is performed for an intra-articular distal tibia fracture.
During this approach, at the level of the ankle joint, which of the following structures is expected to be just deep to a tendon that inserts at the base of the distal phalanx of the great toe?
A. Deep peroneal nerve
B. Saphenous nerve
C. Small (short) saphenous vein
D. Superficial peroneal nerve
E. Sural nerve

47. The ilioinguinal approach is performed to reduce and stabilise an acetabular fracture.
Which structure travels outside the spermatic cord but follows its course within the inguinal canal to exit the superficial inguinal ring?
A. Cremasteric artery
B. Genital branch of the genitofemoral nerve
C. Ilioinguinal nerve
D. Pampiniform plexus
E. Testicular artery

48. A patient is unable to plantarflex at their ankle joint following percutaneous iliosacral screw fixation of an unstable sacroiliac joint.
Which spinal nerve does this complication correlate to?
A. L4
B. L5
C. S1
D. S2
E. S3

49. The short external rotators are exposed during a routine posterior approach to the hip joint.
What is the name of the muscle that is exposed during this procedure and has, emerging from above its superior border, the nerve and vessels that supply the hip abductors?
A. Inferior gemellus
B. Obturator externus
C. Obturator internus
D. Piriformis
E. Superior gemellus

50. A young patient sustains an intracapsular neck of femur fracture. You are explaining to a medical student the rationale for management.
Which artery does not contribute towards the trochanteric anastomosis?
A. Ascending branch of the lateral circumflex femoral artery
B. Ascending branch of the medial circumflex femoral artery
C. Descending branch of the superior gluteal artery
D. Inferior gluteal artery
E. Transverse branch of the medial circumflex femoral artery

51. During the posterior approach to the hip, a major nerve is at risk.
As this structure passes through to the gluteal region, it lies anterior and then inferior to which of the following external rotators?
A. Inferior gemellus
B. Obturator internus
C. Piriformis
D. Quadratus femoris
E. Superior gemellus

52. **During the posterior approach to the knee, which structure is noted to be deep to the fascia but just medial to a muscle which forms the superolateral border of the popliteal fossa?**
A. Common peroneal nerve
B. Popliteal artery
C. Popliteal vein
D. Short saphenous vein
E. Tibial nerve

53. A two-incision leg fasciotomy is performed for compartment syndrome.
For a fasciotomy of the posterior leg compartments, which of the following structures is at risk of injury?
A. Anterior tibial vein
B. Deep peroneal nerve
C. Great saphenous vein
D. Short saphenous vein
E. Superficial peroneal nerve

54. An anterolateral approach to the tibial plateau is performed.
Classically, this incision crosses which of the following bony landmarks?

A. Fibula head
B. Gerdy's tubercle
C. Intercondylar eminence
D. Neck of the fibula
E. Tibial tuberosity

55. **The anterior and lateral compartments of the leg are innervated by two terminal branches of a nerve. These two branches typically originate within which of the following muscles?**
A. Biceps femoris
B. Peroneus brevis
C. Peroneus longus
D. Peroneus tertius
E. Plantaris

56. A patient develops acute compartment syndrome of the leg following a high-energy tibial fracture, with maximal pain on passive extension of the lesser toes.
Which of the following muscles is also related to the specific compartment that is being assessed?
A. Extensor digitorum longus
B. Extensor hallucis longus
C. Flexor hallucis longus
D. Peroneus tertius
E. Soleus

57. An anterior approach to the ankle is performed, and care is taken to identify the anterior tibial artery and deep peroneal nerve.
Proximal to the ankle joint, where would one expect to locate these two neurovascular structures?
A. Between the tendons of flexor hallucis longus and flexor digitorum longus
B. Between the tendons of extensor digitorum longus and extensor hallucis longus
C. Deep to the extensor hallucis longus tendon
D. Lateral to the extensor digitorum longus tendon
E. Lateral to the extensor hallucis longus tendon

58. The posterolateral approach is performed for a posterior malleolar ankle fracture. To expose the tibia, the surgeon retracts a deep muscle which arises from the fibula and interosseous membrane.
What is the name of this specific muscle?
A. Flexor digitorum longus
B. Flexor hallucis longus
C. Peroneus brevis
D. Peroneus longus
E. Tibialis posterior

59. A patient sustains an injury that affects just the deep peroneal nerve.
Which clinical signs best correlate with this type of injury?
A. Weakness of ankle plantar flexion and decreased sensation between the great (first) and second toes (first web space)
B. Weakness of great toe extension
C. Weakness of great toe extension and decreased sensation between the great (first) and second toes (first web space)
D. Weakness of great toe flexion
E. Weakness of great toe flexion and decreased sensation between the great (first) and second toes (first web space)

60. A dorsomedial approach to the first (great toe) metatarsophalangeal joint is carried out to perform an arthrodesis of this joint.
The nerve that is normally visible and at risk during this approach originates from which major nerve?
A. Deep peroneal (fibular) nerve
B. Saphenous nerve
C. Superficial peroneal (fibular) nerve
D. Sural nerve
E. Tibial nerve

61. **With respect to the gluteal region, which statement is INCORRECT?**
A. A positive Trendelenburg sign is noted by the pelvis sagging on the standing side
B. Gluteus maximus arises from the gluteal region of the ilium, sacrum, lumbar fascia and the sacrotuberous ligament
C. The greater sciatic foramen is formed by the greater sciatic notch and the sacrospinous ligament
D. The inferior gluteal nerve only innervates the gluteus maximus, and the blood supply to this muscle comes from both the superior and inferior gluteal arteries

E. The lesser sciatic foramen is formed by the lesser sciatic notch and the sacrotuberous ligament

62. Which of the following approaches to the knee is considered to help reduce post-operative pain and facilitate an earlier functional recovery?
A. Lateral parapatellar
B. Trivector
C. Mid-vastus
D. Subvastus
E. Medial parapatellar

Spine

63. **Which of the following is the precursor tissue to the paired segmental structures that are seen in normal vertebral development?**
A. Lateral plate mesoderm
B. Paraxial mesoderm
C. Intermediate mesoderm
D. Neural tube
E. Sclerotome

64. A transperitoneal approach is performed to approach the spine at levels L4 to S1 anteriorly.
Which vertebral level corresponds to the typical distal extent and bifurcation of the abdominal aorta?
A. T12
B. L1
C. L2
D. L3
E. L4

65. During the anterior approach to the cervical spine, a deep structure is reflected subperiosteally and laterally to the midline, exposing the anterior vertebral body.
From those listed, what is this structure?
A. Longus capitis
B. Longus colli
C. Multifidus
D. Prevertebral fascia
E. Sternocleidomastoid

66. A left-sided transthoracic approach to the thoracic spine is performed.
Which structure is most at risk during this left-sided approach?
A. Artery of Adamkiewicz
B. Azygos vein
C. Intercostal vessels
D. Lung
E. Oesophagus

67. You review a female patient following an anterior cervical discectomy and fusion. There are concerns regarding their voice, which is felt to sound low-pitched and softer in volume.
Which muscle is NOT innervated by the nerve that has been injured during this procedure?
A. Cricothyroid
B. Lateral cricoarytenoid
C. Posterior cricoarytenoid
D. Thyroarytenoid
E. Transverse and oblique arytenoids

68. An anterior retroperitoneal approach to the L3–4 level lumbar spine is performed. A structure is injured that runs just deep to the psoas fascia, on the anteromedial surface of the psoas major muscle.
Post-operatively, which of the following signs and symptoms will best correlate with this type of injury?
A. Decreased power on assessing adduction of the thigh
B. Decreased power on assessing hip flexion and knee extension
C. Decreased sensation over the anterolateral thigh
D. Decreased sensation over the upper anterior thigh and anterior scrotum (or labia majora)
E. Oliguria, flank pain and fever

69. **In the adult, which level would you typically expect the spinal cord to terminate?**
A. T12–L1
B. L1–2
C. L2–3
D. L3–4
E. L4–5

ANATOMY AND SURGICAL APPROACHES STRUCTURED SBA ANSWERS

Upper Limb

1. Answer B. **Sonic hedgehog**

Limb Development

This question relates to the pathogenesis of ulnar longitudinal deficiency. To answer this question correctly, one should be able to reach the diagnosis of ulnar longitudinal deficiency and understand the basic embryology of limb development. The following text aims to give a brief overview of limb development and how failure of this process, specifically Sonic hedgehog signalling, may lead to ulnar longitudinal deficiency.

Embryology is the area of science that is dedicated to embryogenesis and development of the foetus, which also includes the study of congenital diseases. Embryology is a potential theme during both parts of the examination, so the following text aims to introduce this topic.

The embryo represents the organism that forms when the male and female gametes fuse (fertilisation), producing a zygote, up to the point of early organ development; from week 9 onwards until birth, it is referred to as a foetus. Weeks 3–8 is the period of organogenesis, where the three germ layers that form through the process of gastrulation differentiate into early organs and tissues and is thus the main period where major congenital defects can arise. Week 9 until birth is the foetal period, which is characterised by maturation of these tissues and organs and significant growth. Gastrulation, beginning at week 3 is a process that gives rise to the trilaminar disc, consisting of the three germ layers (endoderm, mesoderm and ectoderm) from the differentiation of epiblastic cells.

The appendicular skeleton consists of the limbs, shoulders and pelvis. Limb development and patterning start at the end of the fourth developmental week, with the upper limb forming a couple of days before its distal counterpart.

The limb buds, which are the early structures of limb development, form at precise positions along the rostrocaudal (craniocaudal) axis. These limb buds are outgrowths of mesoderm into the overlying ectoderm and consist of an inner mesodermal layer of mesenchymal cells from the lateral plate and somatic mesoderms. The limb buds form ridges on the lateral body wall that causes the ectoderm to bulge out and surround this structure. Myoblasts from the myotome region of the somite eventually migrate into the limb buds and give rise to the musculature.

Forelimb (upper limb) development is initiated by the transcription factor TBX5; TBX4 determines the development of the hindlimb (lower limb) bud.

Limb bud growth is typically described as occurring along three axes, which are governed by three signalling centres. These axes are: (1) Rostrocaudal (craniocaudal), (2) Anteroposterior and (3) Dorsoventral; each of these axes are intimately linked through various signalling pathways.

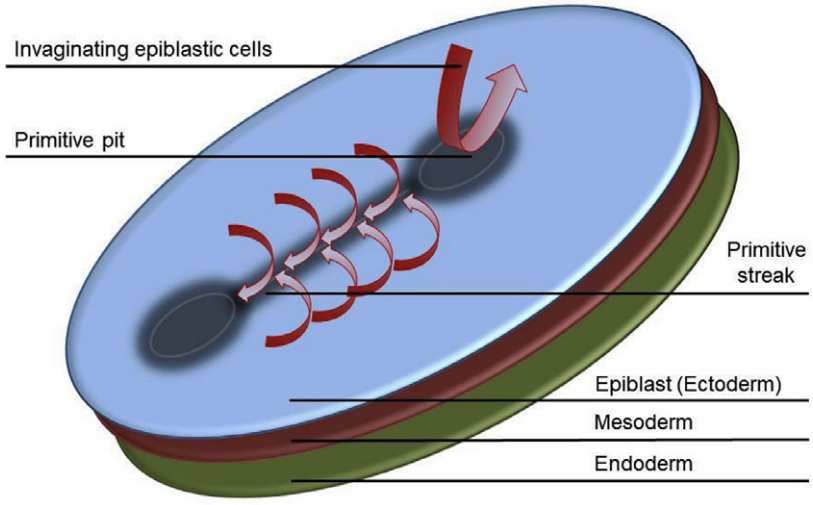


Figure 23.1 Dorsal surface of the trilaminar disc during gastrulation, showing invagination (red arrows) of the epiblastic cells through the primitive node and streak, giving rise to the mesoderm and ectoderm layers

1. Proximodistal growth

Proximodistal growth (limb length) occurs at the apicalectodermal ridge (AER), largely under the influence of fibroblast growth factors (FGFs); of note, FGF8 is felt to be an obligatory factor for normal proximodistal limb growth. Loss of the AER or FGF signalling results in limb truncation.

Initiated by either TBX5 (fore or upper limb) or TBX4 (hind or lower limb), FGF10 from the lateral plate mesoderm promotes proximodistal growth through development of the AER. The AER is a thickened ectodermal ridge that bridges the dorsal and ventral surfaces. FGF10 results in FGF8 expression from the overlying ectoderm, which then leads to a positive feedback loop relating to FGF10 and 8, where expression is maintained.

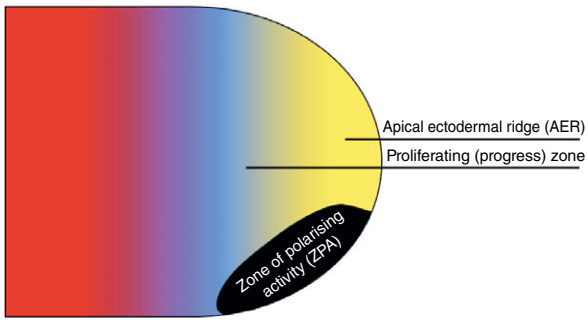


Figure 23.2 The apical ectodermal ridge (AER) releases fibroblast growth factors which induces and maintains the proliferating zone (progress zone). The progress zone is a region of undifferentiated mesenchymal tissue that results in proximal to distal growth of the limb bud; cells proximal to this zone and the AER begin to differentiate into their definitive tissues

FGF signalling from the AER ensures that there is an undifferentiated zone of proliferating mesenchymal cells adjacent to the AER, known as the progress zone, stimulating growth at this region. Mesenchymal cells that leave this progress zone differentiate first, thus differentiation of the limb progresses proximal to distal.

2. Anteroposterior growth

The second signalling centre, the zone of polarising activity (ZPA), regulates anteroposterior axis patterning. As this takes place before the normal rotation of the upper and lower limbs, the radial side of the upper limb, for example, is anterior, while the little finger and ulnar aspect is posterior. Week 7 is characterised by the 90° rotation of the upper and lower limbs in opposing directions, where the upper limb rotates laterally and the lower limb rotates medially; this results in the thumbs facing laterally and the toes medially, respectively.

The ZPA is a region of mesodermal (mesenchymal) cells in the posterior region of the AER that also travels distally as the limb grows. Through the action of retinoic acid, which is secreted by the ZPA, this causes the cells within the ZPA to produce and secrete sonic hedgehog (SHH), a cell signalling protein that is implicated in morphogenesis of the anteroposterior axis. Other than the thumb, which is independent to SHH, SHH is a key protein that is involved in the differentiation of individual digits and is dependent on both the duration and exposure to SHH. Those cells closest to the ZPA are dependent on SHH to differentiate into, for example, the ulna, little and ring fingers; whereas those furthest away and thus more anterior (which develop into the radius and thumb, for example) are least dependent on SHH signalling. Through positive feedback, SHH also acts on the AER to stimulate FGF4; FGF4 also stimulates SHH expression. Loss of SHH signalling produces the spectrum of ulnar longitudinal deficiencies that is being assessed through this single best answer question.

3. Dorsoventral growth

The third signalling centre relates to the non-AER ectoderm that produces the dorsoventral axis (dorsum of hand to palm). This is determined by WNT7A signalling in the dorsal ectoderm; WNT7A causes the upregulation and production of LMX1B and specifies cells to be dorsal and differentiate into the dorsal structures such as the skin, nails and extensor tendons. There is also a positive feedback loop where WNT7A also influences the ZPA to maintain SHH expression. Furthermore, Engrailed-1 expression (EN-1) in the ventral ectoderm limits WNT7A and thus LMX1B dorsally, leading to formation of the volar structures (palm and flexor tendons).

Digit Development

Apoptosis leads to the interdigital spaces and digits, but preceding formation of the interdigital spaces, the future digits form a precartilaginous matrix and then segmentation to the respective phalangeal regions. Apoptosis within set regions of the AER leads to the interdigital spaces; failure of this process leads to syndactyly.

Al-Qattan MM, Kozin SH. Update on embryology of the upper limb. *J Hand Surg.* 2013;**38**:1835–1844.

Oberg KC, Feenstra JM, Manske PR, Tonkin MA. Developmental biology and classification of congenital abnormalities of the hand and upper extremity. *J Hand Surg.* 2010;**35**:2066–2076.

Sadler TW. *Medical Embryology*, 14th Ed. Philadelphia, PA: Wolters Kluwer; 2019.

2. Answer D. **LMX1B**
As described earlier, this question is firstly assessing one's ability to recognise the condition that has been described, which is nail patella syndrome, and then to apply their knowledge of this condition to answer the specific question. Higher order thinking is required, which involves reaching the diagnosis based on the clinical information provided; but to answer this question, one needs to know nail patella syndrome is due to a mutation in the gene LMX1B. An overview of basic limb bud development and the role of LMX1B has been provided in the previous question. Nail patella syndrome results in hypoplastic nails and patellae, renal abnormalities and posterior iliac horns (exostoses).

Al-Qattan MM, Kozin SH. Update on embryology of the upper limb. *J Hand Surg.* 2013;**38**:1835–1844.

3. Answer B. **Hook of the hamate**
This question is assessing one's knowledge of Guyon's canal (ulnar tunnel). This fibro-osseous canal transmits the ulnar nerve and artery as they pass from the wrist to the hand.

Just proximal to the wrist, the ulnar nerve gives off a dorsal sensory branch (which supplies the dorsum of the hand and ulnar one and half fingers proximal to the nail beds) and a palmar cutaneous branch (sensory to the hypothenar region). At the wrist, the ulnar nerve and artery pass over the flexor retinaculum (transverse carpal ligament) which forms the floor of Guyon's canal. The ulnar artery is radial (lateral) to the nerve and the flexor carpi ulnaris tendon is the most ulnar (medial) structure; this tendon inserts on the pisiform. Lacerations at the wrist involving the tendon also frequently involve the artery and nerve.

The roof of Guyon's canal is formed by the volar carpal ligament, the medial (ulnar) wall by the pisiform and the lateral (radial) wall by the hook of the hamate; as previously mentioned, the flexor retinaculum (transverse carpal ligament) forms the floor.

Within the canal, the nerve divides into superficial and deep branches. The superficial branch innervates palmaris brevis and the volar skin to the small and ulnar half of the ring finger. The deep branch innervates all the intrinsic hand muscles excluding those of the thenar eminence and radial two lumbricals (recurrent motor branch of the median nerve). The intrinsic muscles supplied by the deep branch are the three hypothenar muscles (abductor digiti minimi, flexor digiti minimi brevis and opponens digiti minimi), the ulnar two lumbricals, the interossei and adductor pollicis.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

4. Answer C. **Supination weakness**
The deltopectoral approach to the shoulder (anterior approach) is often used to perform an open reduction of a dislocated shoulder; proximal humeral shaft fracture fixation; open washout of the joint and shoulder arthroplasty.

During this approach, an incision is made and developed from the coracoid process, travelling inferiorly along the deltopectoral groove. This is an internervous plane between the axillary (deltoid) and medial and lateral pectoral nerves (pectoralis major).

The deltopectoral groove is identified and the cephalic vein is generally retracted laterally, along with the deltoid; the pectoralis major is retracted medially. Deep dissection involves release of the fascia overlying the conjoint tendon (short head of biceps brachii and coracobrachialis, each innervated by the musculocutaneous nerve), followed by medial retraction of this tendon to expose the underlying subscapularis muscle and tendon. With the arm externally rotated and stay sutures applied, the subscapularis tendon is released to expose the underlying joint capsule.

The musculocutaneous nerve (a branch of the lateral cord of the brachial plexus) innervates biceps brachii, brachialis and coracobrachialis and terminates as the lateral cutaneous nerve of the forearm, emerging just lateral to the distal biceps tendon (sensory to the lateral border of the forearm). The musculocutaneous nerve is at risk during this approach during dissection and

retraction; it runs obliquely around 5–8 cm inferior to the coracoid, pierces and innervates coracobrachialis from its medial side, followed by biceps brachii and brachialis.

Injury or neuropraxia to the musculocutaneous nerve could result in weakness of elbow flexion, supination or sensory symptoms involving the lateral border of the forearm.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

Vajapey SP, Contreras ES, Cvetanovich GL, Neviaser AS. Neurologic complications in primary anatomic and reverse shoulder arthroplasty: a review. *J Clin Orthop Trauma* 2021;**20**:101475.

5. Answer C. **Internal rotation**
The deltopectoral (anterior) approach to the shoulder has been previously described. This deep anterior shoulder muscle is subscapularis. It is seen during this approach to be crossing anterior to the joint capsule to insert on the lesser tuberosity of the humerus. It helps to stabilise the shoulder, limiting external rotation and its main function is to bring about internal rotation of the humerus. Clinically, it can be isolated and tested using Gerber's lift-off test or the belly press test.

6. Answer A. **Sensory to the anterolateral forearm**
This approach is used to expose the humeral shaft, especially when exposure of the distal third is needed.

A curved incision is made along the lateral border of the biceps brachii to just above the elbow. The deep fascia is incised and the lateral borders of the biceps brachii and brachialis are identified; the biceps is retracted medially.

The lateral cutaneous nerve of the forearm (terminal branch of the musculocutaneous nerve) laterally emerges between the biceps brachii tendon and brachialis muscle; this is the sensory innervation to the anterolateral border of the forearm. This nerve is also known as the lateral antebrachial cutaneous nerve. The natural interval between brachioradialis and brachialis is then dissected and just proximal to the elbow, the radial nerve is identified between these two muscles and followed proximally. The humeral shaft is exposed by retracting the biceps and brachialis muscles medially, with the brachioradialis retracted laterally; the periosteum on the anterolateral humeral shaft is then incised and reflected to expose the bone.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

7. Answer B. **Radial nerve**
The anterior approach to the cubital fossa provides good access to the neurovascular structures, including the anterior elbow capsule. This is an internervous plane between the musculocutaneous nerve (brachialis) and radial nerve (brachioradialis) proximally. Distally, the internervous plane runs between the radial nerve again (brachioradialis) and pronator teres (median nerve).

A curved incision is made, starting on the medial side of the biceps brachii, and curving this anteriorly and then distally along the medial border of the brachioradialis muscle. The deep fascia is then incised. Care must be taken to preserve the lateral cutaneous nerve of the forearm (as previously described), which emerges laterally between the biceps brachii tendon and brachialis. The bicipital aponeurosis is released close to the biceps tendon and reflected; deep to this is the brachial artery. To expose the anterior elbow capsule, then biceps and brachialis are retracted medially, with brachioradialis retracted laterally.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

8. Answer A. **Abduction and external rotation of the arm**
This approach utilises the internervous plane between infraspinatus (suprascapular nerve) and teres minor (axillary nerve). Superficial dissection begins with an incision that runs from the posterior edge of the acromion along the spine of the scapula; the deltoid is detached from the spine of the scapula. Deeper dissection involves identifying the plane between infraspinatus and teres minor. The infraspinatus is retracted superiorly and the teres minor inferiorly to expose the posterior glenoid and neck of the scapula. The infraspinatus muscle must not be retracted too medially as this may cause significant traction to the suprascapular nerve, artery and vein.

Within the posterior triangle of the neck, the suprascapular nerve arises from the upper trunk of the brachial plexus (C5–6), coursing posteriorly and deep to trapezius, then passing through the suprascapular foramen to innervate supraspinatus, and then descending lateral to the spine of the scapula to innervate infraspinatus.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

9. Answer E. **Suprascapular nerve**

The posterior portal is a routinely used approach in shoulder arthroscopy, and the patient is normally in the 'beach chair' position. Key fixed landmarks are the acromion and coracoid process. The posterior portal is typically approached through a 'stab incision' 2cm inferior and 1cm medial to the posterolateral coroner of the acromion. This is an internervous plane between the axillary and supraclavicular nerves.

Once the incision has been made, the arthroscopic trocar is orientated in the direction of the coracoid process; this will likely pass through but be of no significant risk to the infraspinatus. It may also pass through the interval of infraspinatus and teres minor.

The axillary nerve (C5–6) is a branch of the posterior cord of the brachial plexus. This nerve, along with the posterior circumflex humeral artery and vein, passes from the axilla to the shoulder through the quadrangular space. This anatomical passage is between teres major (inferior border), teres minor (superior border), the surgical neck of the humerus (lateral) and long head of triceps brachii (medial) (Figure 23.3). On exiting this space, these neurovascular structures pass inferior to the capsule of the shoulder, and the nerve gives an articular branch to the shoulder; the axillary nerve then divides into anterior and posterior branches. The anterior branch winds around the surgical neck of the humerus and innervates the deltoid, but also provides cutaneous innervation to the anterolateral shoulder; the posterior branch innervates the teres minor and deltoid, then wraps around the posterior border of deltoid to end in the lateral cutaneous nerve of the arm. During posterior portal placement, the axillary nerve may be injured if the portal is sited too inferior.

The suprascapular nerve is a branch from the upper trunk of the brachial plexus (C5–6) and arises in the posterior triangle of the neck. It passes posterior and lateral, deep to trapezius, then through the suprascapular foramen (formed from the suprascapular notch, with the superior transverse scapular ligament) to innervate supraspinatus. It then descends lateral to the spine of the scapula (with the suprascapular artery and vein) and through the spinoglenoid fossa to innervate infraspinatus. This nerve and vessels are at risk if the portal is sited too medially.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

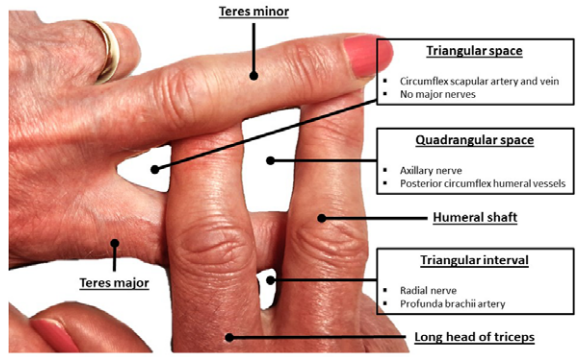


Figure 23.3 Interlock the two fingers of both hands as shown here. The two vertically orientated fingers represent the humerus and long head of triceps brachii. The two horizontally orientated fingers represent teres minor (superior) and teres major (which is inferior). Remember 'minor superior to major'

10. Answer C. **Supraspinatus**

Six muscles run from the scapula to the humerus: deltoid, the rotator cuff muscles (supraspinatus, infraspinatus, subscapularis and teres minor) and teres major.

The three posterior scapular muscles of the rotator cuff (supraspinatus, infraspinatus and teres minor) insert onto the greater tubercle of the humerus; subscapularis inserts into the lesser tubercle. Teres major inserts onto the shaft of the humerus, at the medial lip of the intertubercular sulcus.

The suprascapular nerve innervates supraspinatus and infraspinatus and arises from the superior trunk of the brachial plexus (C5 and

C6). Injury to this nerve will therefore result in loss of abduction and external rotation.

Teres minor is innervated by the posterior branch of the axillary nerve, one of the large two terminal branches of the posterior cord of the brachial plexus; the other larger terminal branch is the radial nerve. Subscapularis is innervated by a branch that arises from the posterior division of the brachial plexus, the upper and lower subscapular nerves (C5 and C6). Teres major is innervated by the lower subscapular nerve.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

11. Answer D. **C5–6**
This muscle is subclavius, and it is innervated by the nerve to subclavius (C5–6), which is one of three branches arising from the roots of the brachial plexus. The other two nerve root branches are: (1) the dorsal scapular nerve, which arises from the C5 root and innervates the rhomboids and levator scapulae and (2) the long thoracic nerve (of Bell), which innervates serratus anterior and arises from nerve roots C5–7. Subclavius arises from the first rib at the costochondral junction and inserts at the subclavian groove of the clavicle.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

12. Answer B. **Median nerve**
The roots of the brachial plexus (C5–T1) arise in the posterior triangle of the neck, between the muscles of scalenus anterior and medius. The trunks (superior, middle and inferior) also lie in the posterior triangle of the neck, while the divisions lie deep to the middle third of the clavicle and the cords are related to the second part of the axillary artery in the axilla.

Three branches arise directly from the roots: dorsal scapular nerve (C5), which innerves both rhomboids; nerve to subclavius (C5–6), and the long thoracic nerve (C5–7), which supplies serratus anterior. One branch arises from the trunks, which is the suprascapular nerve (C5–6) that innervates supraspinatus, infraspinatus and the shoulder and acromioclavicular joints.

The lateral cord gives rise to three branches (lateral pectoral nerve, musculocutaneous nerve and the lateral root of the median nerve). The musculocutaneous nerve (C5–7) has muscular and cutaneous branches, and supplies the flexors to the arm, arising high up in the axilla to initially innervate coracobrachialis before descending to supply biceps brachii and brachialis. The lateral root of the median nerve (C5–7) combines with the medial root (continuation of the medial cord) of the median nerve lateral and anterior to the axillary artery, forming the median nerve (Figure 23.4).

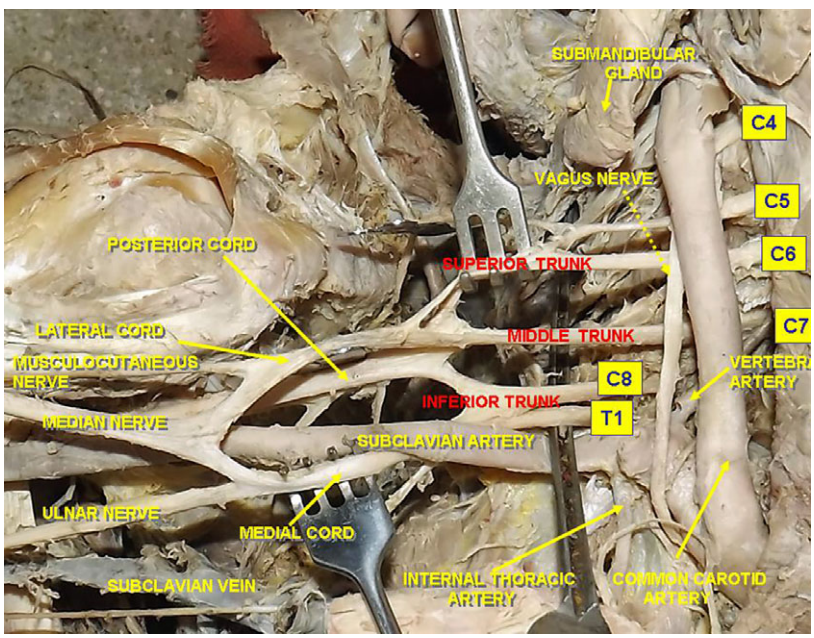


Figure 23.4 Brachial plexus. Anatomist90. Creative Commons CC0 licence

The axillary nerve (C5–6), which is a branch of the posterior cord, passes posteriorly from the axilla towards the shoulder, traversing through the quadrangular space.

The radial nerve (C5–T1) is a continuation of the posterior cord and runs inferiorly and superficial to the latissimus dorsi tendon.

The ulnar nerve (C7–T1) arises from the medial cord and passes inferiorly and medially down the arm, lying medial to the axillary and brachial arteries.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

13. Answer B. **Pectoralis major**
The pectoral girdle comprises bony and muscular attachments to the axial skeleton. The bones are the clavicle and the scapula, which are connected to the axial skeleton by the sternoclavicular joint, and to each other by the acromioclavicular joint. The coracoclavicular ligament also stabilises these two bones, and the clavicle is anchored to the first rib by the costoclavicular ligament.

The muscles can be described as direct and indirect attachments between the axial skeleton and pectoral girdle.

Direct muscles insert into the clavicle or scapula: pectoralis minor (medial pectoral nerve), subclavius (nerve to subclavius), trapezius (spinal accessory nerve, and proprioceptive fibres from the cervical plexus C3–4), rhomboid major and minor (dorsal scapular nerve), levator scapulae (dorsal scapular nerve, and C3–4 cervical plexus fibres) and serratus anterior (long thoracic nerve of Bell).

The indirect muscles attach to the proximal humerus and consist of pectoralis major (medial and lateral pectoral nerve) and latissimus dorsi (thoracodorsal nerve).

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

14. Answer E. **Thoracodorsal nerve**
Five branches arise from the posterior cord of the brachial plexus: upper (subscapularis) and lower (subscapularis and teres major) subscapular nerves (C5–6); thoracodorsal (latissimus dorsi) nerve (C6–8); axillary nerve (C5–6), and the radial nerve (C5–T1).

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

15. Answer A. **Zone I**
This corresponds to flexor zone I and this specific injury is colloquially known as Jersey finger. There are five flexor zones.

Zone I is distal to the insertion of flexor digitorum superficialis and represents just the flexor digitorum profundus tendon. Zone II is from the proximal aspect of the A1 pulley (distal palmar crease) to the insertion of flexor digitorum superficialis (middle three-fifths of the middle phalanx); at zone II, the flexor digitorum superficialis splits to form Camper's chiasm, around the flexor digitorum profundus tendon. Zone III is from the distal extent of the carpal tunnel to the proximal aspect of the A1 pulley. Zone IV is within the carpal tunnel. Zone V extends from the forearm to the proximal carpal tunnel (distal palmar crease) (Figure 23.5).

Wolfe S, Hotchkiss R, Green, D. *Green's Operative Hand Surgery*, 6th Ed. Philadelphia, PA: Elsevier Churchill Livingstone; 2011.

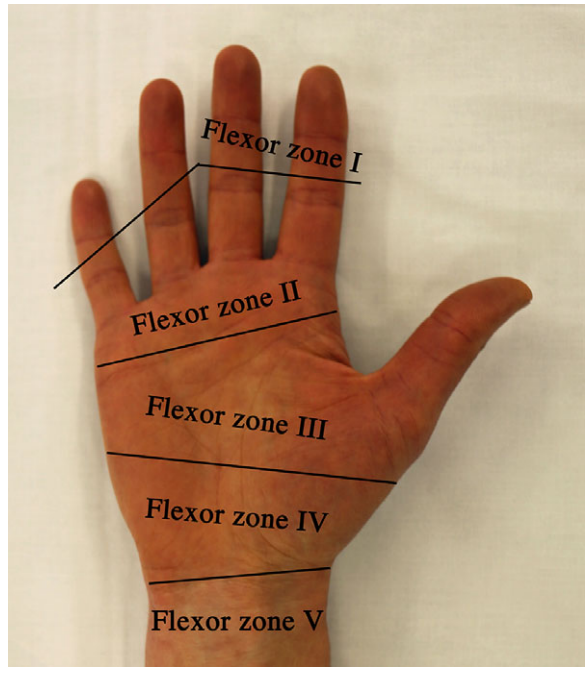


Figure 23.5 Zone classification of flexor tendon injuries

16. Answer E. **C5–7**
The long thoracic nerve (of Bell) arises from the ventral rami of nerve roots C5–7, innervating serratus anterior. Injury to this nerve causes the medial border of the scapula to move laterally and posteriorly from the thoracic wall.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

17. Answer D. **C5–7**
The musculocutaneous nerve (C5–7) is one of three branches of the lateral cord; the other two are the lateral pectoral nerve and the lateral root of the median nerve. The musculocutaneous nerve has muscular branches to the flexors of the arm (coracobrachialis, biceps brachii and brachialis) and a cutaneous branch to the forearm (lateral cutaneous nerve of the forearm). The lateral cutaneous nerve of the forearm passes lateral to the biceps tendon at the elbow, and supplies sensation to the radial border of the skin from the elbow to wrist by both anterior and posterior branches.

C1–3 combine to form the ansa cervicalis, which is a component of the cervical plexus that innervates the following infrahyoid muscles except thyrohyoid (C1): omohyoid, sternohyoid and sternothyroid.

C3–5 are branches of the cervical plexus that combine to form the phrenic nerve, with innervation primarily from C4, providing motor innervation to the diaphragm.

C8–T1 are the nerve root derivates of the medial cord branches (medial pectoral nerve, medial root of the median nerve, medial cutaneous nerve of the arm, medial cutaneous nerve of the forearm and the ulnar nerve).

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

18. Answer B. **Brachial artery**
The cubital fossa is the triangular depression on the anterior elbow, represented medially by the pronator teres, laterally by the brachioradialis and superiorly limited by the medial and lateral epicondyles of the humerus. The roof of the cubital fossa is formed by the deep fascia of the forearm, reinforced by the bicipital aponeurosis medially, and the skin as the most superficial. The floor is formed proximally by brachialis and distally by supinator.

The contents of the cubital fossa, from medial to lateral are the median nerve, brachial artery (the artery is palpable medial to the biceps brachii tendon), biceps brachii tendon, radial nerve (deep to brachioradialis and so not strictly within the fossa, which divides into its superficial and deep branches).

Superficially, in the subcutaneous tissue and anterior to the bicipital aponeurosis, lies the median cubital vein and the medial and lateral cutaneous nerves of the forearm.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

19. Answer C. **Flexor pollicis longus**
The flexor muscles, which are divided into three layers, are in the anterior compartment of the forearm. They are separated from the extensor compartment by the radius, ulna and the connecting interosseous membrane.

The superficial group is made of four muscles that arise from the common flexor origin at the medial epicondyle of the humerus and cross the elbow joint (the deep group do not cross this joint). This superficial group consists of pronator teres, flexor carpi radialis, palmaris longus and flexor carpi ulnaris (Figure 23.6). The intermediate group comprises one muscle only, the flexor digitorum superficialis. The three muscles of the deep group are: flexor digitorum profundus, flexor pollicis longus and pronator quadratus.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

20. Answer B. **Posterior interosseous nerve**
This approach exposes the length of the radius, and although the extent of the incision depends on the region of the radius to be exposed, the full incision extends just lateral to the biceps brachii tendon to the radial styloid.

Superficial dissection incises through the superficial fascia of the forearm and then the interval between brachioradialis and flexor carpi

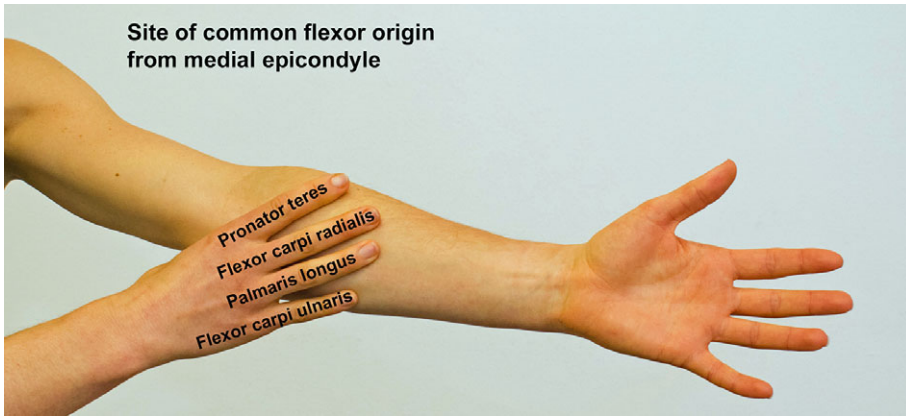


Figure 23.6 Common flexor origin

radialis. Dissection then depends on which region of the radius is being exposed. Proximally, a plane should be developed between pronator teres and brachioradialis; the superficial branch of the radial nerve should be protected and can be identified deep to brachioradialis. Brachioradialis should be reflected radially (lateral). Superficial dissection distally involves developing a plane between brachioradialis and flexor carpi radialis.

Deeper dissection likewise depends on the region being exposed. For the proximal third of the radius, the bursa is incised just lateral to the biceps brachii tendon, exposing the proximal shaft that is covered by supinator, being mindful for the radial artery during this dissection. The posterior interosseous nerve is at risk during this approach proximally and is formed when the deep branch of the radial nerve pierces the supinator to pass from the cubital fossa to the posterior compartment of the forearm; when it leaves the supinator muscle, it strictly becomes the posterior interosseous nerve. During proximal dissection, this nerve is protected by ensuring the forearm is fully supinated, and the radius is exposed by incising the supinator at its insertion into the radius, reflecting the muscle from the bone medial to lateral, and retracting the supinator muscle radially (laterally) to clear and protect the nerve.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

21. Answer C. **Posterior interosseous nerve**
The posterior interosseous nerve is a continuation of the deep branch of the radial nerve as it passes through and exits the supinator muscle; it is prone to injury during fractures and surgery of the proximal radial shaft (Figure 23.7). This nerve innervates extensor digitorum, extensor digiti minimi and extensor carpi

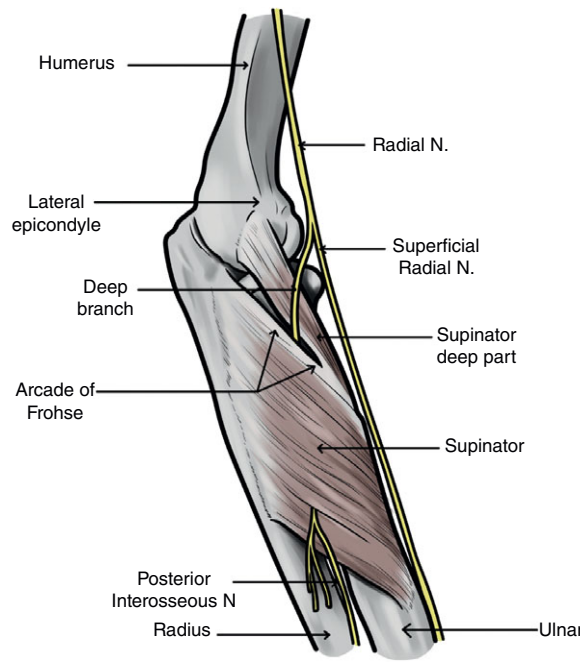


Figure 23.7 Posterior interosseous nerve and relationship to supinator muscle

ulnaris, extensor pollicis brevis and longus, extensor indicis and abductor pollicis longus. Extensor carpi radialis longus and brachioradialis are supplied by the radial nerve; extensor carpi radialis brevis and supinator are usually innervated by the deep branch of the radial nerve.

Sinnatamby C. *Last's Anatomy*, 12th *E*d. Edinburgh: Churchill Livingstone; 2011.

22. Answer C. **Palmar cutaneous branch of the median nerve**

The palmar cutaneous branch of the median nerve arises superficial to the flexor retinaculum, between the tendons of flexor carpi radialis and palmaris longus (Figure 23.8).

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

23. Answer A. **Abductor pollicis brevis**

The median nerve usually gives rise to its recurrent motor branch distal to the flexor retinaculum (carpal tunnel), where it innervates the thenar muscles. Variations in this can occur, where this branch may penetrate through the flexor retinaculum (Figure 23.9).

Distal to the carpal tunnel, the median nerve divides into a medial branch that splits into two (the first branch is sensory to the skin of the radial half of the ring finger, the middle finger, and the ulnar side of the index finger; the second branch innervates the second lumbrical). The lateral branch is motor to the first lumbrical and sensory to the palmar surface and distal dorsal thumb and the radial side of the index finger.

The recurrent motor branch of the median nerve supplies the thenar muscles. The thenar eminence comprises three muscles arising from the flexor retinaculum: abductor pollicis brevis is the most radial, followed by flexor pollicis brevis and opponens pollicis. Each of these muscles is innervated by the recurrent motor branch of the median nerve, but flexor pollicis brevis may be innervated by branches of the ulnar nerve, median nerve, or combinations of both.

Abductor pollicis longus is innervated by the posterior interosseous nerve (from the deep branch of the radial nerve).

Adductor pollicis and opponens digiti minimi are hypothenar muscles, innervated by the deep branch of the ulnar nerve.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics.* Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

24. Answer C. **Zone III**

This corresponds to flexor zone III, which is in the palm, extending from the distal flexor retinaculum to the A1 pulley.

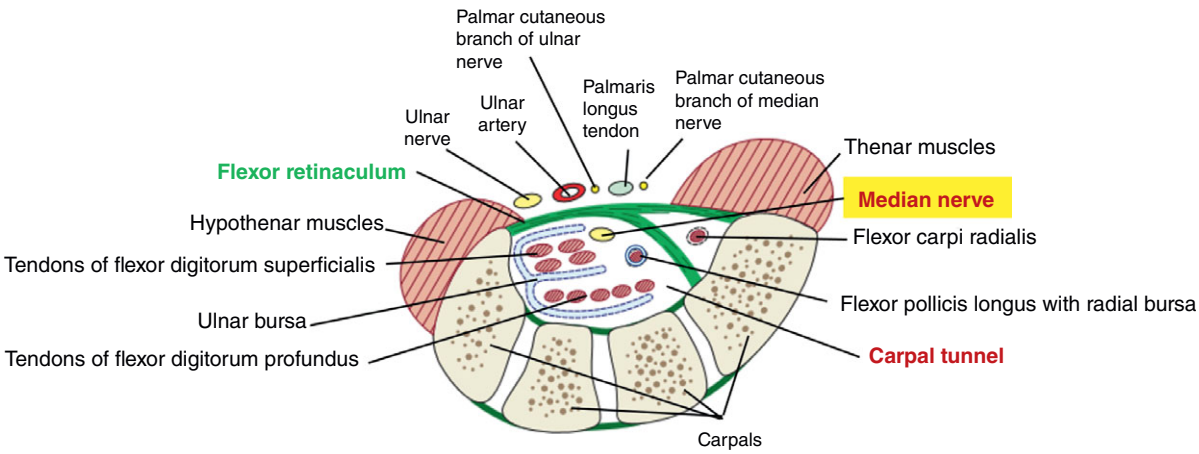


Figure 23.8 Cross section at the wrist and carpal tunnel

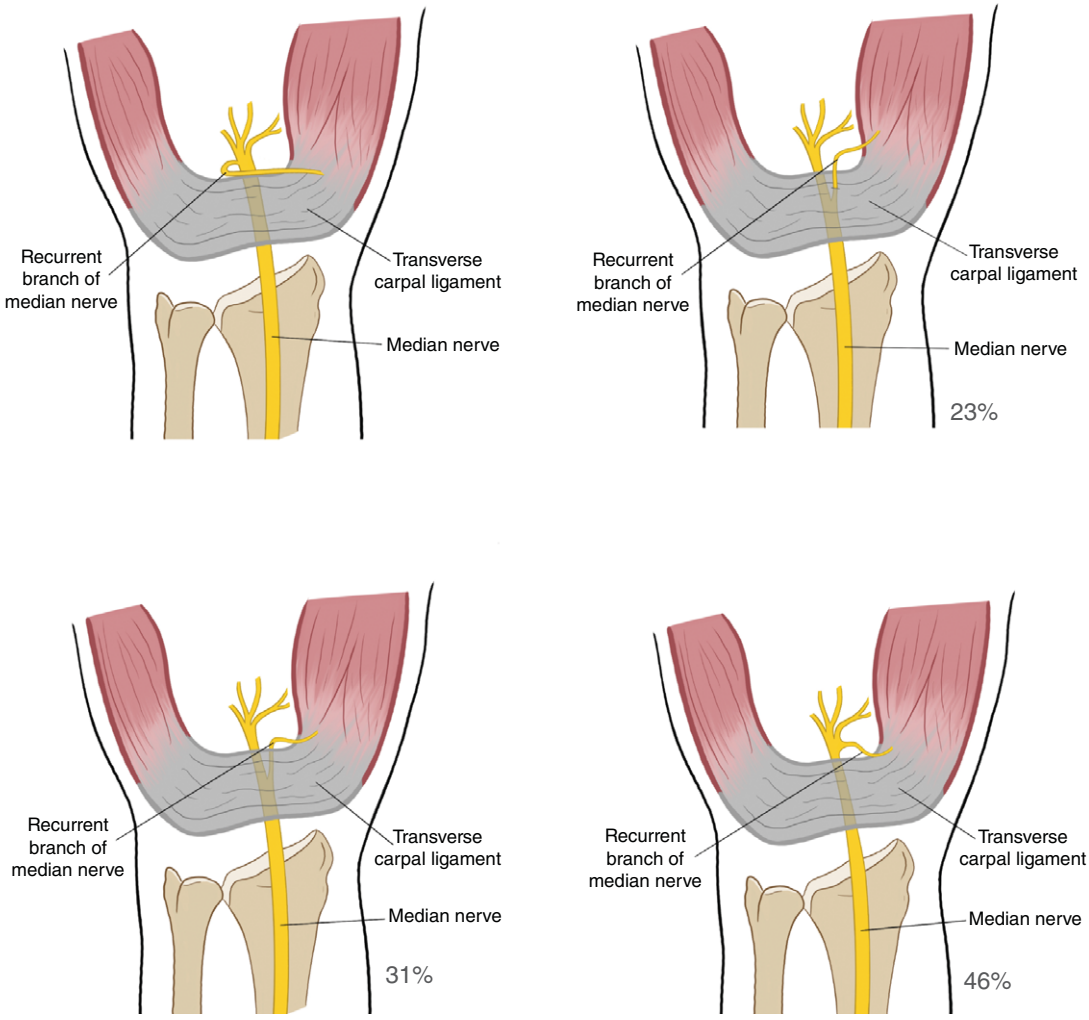


Figure 23.9 Variations in a transligament recurrent motor branch median nerve

Wolfe S. Hotchkiss R, Green D. *Green's Operative Hand Surgery*, 6th Ed. Philadelphia, PA: Elsevier Churchill Livingstone; 2011.

25. Answer A. **Extensor pollicis longus**
The forearm consists of an anterior (flexor) and posterior (extensor) compartment, separated from each other by the radius, ulna and intervening interosseous membrane (Figure 23.10).

The anterior compartment is subdivided into superficial and deep layers. The superficial layer muscles are all innervated by the median nerve except flexor carpi ulnaris.

The following five muscles make up the superficial anterior compartment: pronator teres, flexor carpi radialis, flexor digitorum superficialis (some texts describe this as being within the intermediate compartment), palmaris longus and flexor carpi ulnaris.

The deep group contains the following three muscles: flexor pollicis longus, flexor digitorum profundus and pronator quadratus; the median nerve innervates these muscles except for the ulnar half of flexor digitorum profundus, which is innervated by the ulnar nerve.

The posterior compartment (extensor group) is likewise divided into superficial and deep layers and are all supplied by the radial nerve. The superficial layer comprises seven muscles: brachioradialis, extensor carpi radialis longus

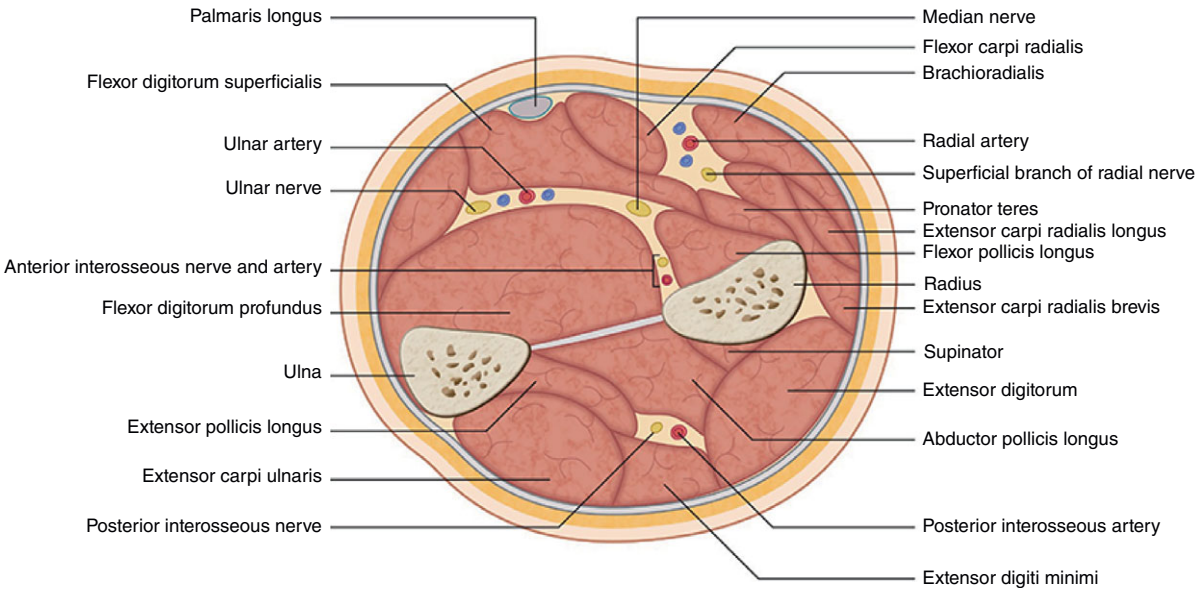


Figure 23.10 Cross section at the midforearm

and brevis, extensor digitorum, extensor digiti minimi, extensor carpi ulnaris and anconeus. There are five deep posterior compartment muscles: supinator, abductor pollicis longus, extensor pollicis longus and brevis and extensor indicis.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingston; 2011.

26. Answer E. **Supinator**
The posterior interosseous nerve is a continuation of the deep branch of the radial nerve as it passes through and exits the supinator muscle; it is prone to injury during fractures and surgery of the proximal radial shaft.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

27. Answer C. **Compartment 3**
There are six extensor compartments at the wrist (Table 23.1). This case has rupture to the tendon within the third extensor compartment, the extensor pollicis longus tendon.

Wolfe S, Hotchkiss R, Green D. *Green's Operative Hand Surgery*, 6th Ed. Philadelphia, PA: Elsevier Churchill Livingstone; 2011.

Table 23.1 Extensor compartments of the wrist

Compartment	Tendon	Pathology
1	Extensor pollicis brevis and abductor pollicis longus	De Quervain's tenosynovitis
2	Extensor carpi radialis longus and brevis	Intersection syndrome
3	Extensor pollicis longus	Traumatic rupture
4	Extensor indicis proprius and extensor digitorum communis	Extensor tenosynovitis
5	Extensor digiti minimi	Vaughan–Jackson syndrome
6	Extensor carpi ulnaris	Extensor carpi ulnaris instability

28. Answer C. **Ring finger lumbrical and ulnar nerve**
Flexor zone III extends from the distal aspect of the flexor retinaculum (distal extent of the carpal

tunnel) to the A1 pulley. The lumbricals flex the digits at the metacarpophalangeal joints and extend the interphalangeal joints. They originate from the tendons of the flexor digitorum profundus and travel to their insertion on the dorsal side of the proximal phalanx, inserting into the lateral (radial) surface of the extensor expansion.

The ring and little finger lumbricals are bipennate muscles. The ring finger lumbrical arises from the middle and ring finger profundus tendons; the little finger lumbrical originates from the ring and little finger profundus tendons. The radial two lumbricals are innervated by the median nerve and the ring and little finger lumbricals are supplied by the deep branch of the ulnar nerve.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

29. Answer C. **A3**
All five digits have on their volar surface an osseofibrous tunnel, the flexor sheath, extending from the metacarpal heads to the distal phalanges. For the thumb, this sheath contains the tendon of flexor pollicis longus, and for the remaining digits the two flexor tendons for each finger: flexor digitorum superficialis and profundus. This flexor sheath, which reduces friction and flexor tendon bowstringing, is reinforced at various points by annular (A) and cruciate pulleys (C). The fingers have five annular pulleys (A1–5) and three cruciate pulleys (C1–3), while the thumb has two annular pulleys and one oblique pulley.

For the fingers, the A1 pulley is anterior to the metacarpophalangeal joint; the middle third of the proximal phalanx is the location for the A2 pulley; the A3 pulley overlies the proximal interphalangeal joint; the A4 pulley is situated at the middle third of the middle phalanx, and the A5 pulley is at the volar surface of the distal interphalangeal joint. The cruciate pulleys lie between the annular pulleys, with C1 distal to A2, C2 between A3 and A4 and C3 just distal to A4. The A2 and A4 pulleys prevent tendon bowstringing. For the thumb, the A1 pulley is likewise anterior to the metacarpophalangeal joint, but the A2 pulley is just proximal to the interphalangeal joint; an oblique pulley lies over the middle third of the proximal phalanx and prevents bowstringing of the flexor pollicis longus tendon.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

30. Answer C. **Cranial nerve VII**
For this approach, the sternal notch is the most medial landmark if this incision length is necessary and extends longitudinally over the surface of the clavicle. Superficially, dissection is through skin and the platysma muscle before reaching the clavicle. The platysma is innervated from the cervical branch of the facial nerve (cranial nerve VII) and is a muscle of facial expression.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

31. Answer E. **Musculocutaneous nerve**
The deltopectoral approach is usually performed for an anatomical shoulder replacement. During this approach, which follows the deltopectoral groove, it begins at the coracoid process and extends inferiorly along this groove. The deltopectoral fascia is incised and the pectoralis major muscle is retracted medially and deltoid laterally, and the cephalic vein is identified and retracted, usually laterally. From the coracoid process are the conjoined tendons of coracobrachialis and short head of biceps brachii, as well as the origin of pectoralis minor. Deeper dissection involves incising the clavipectoral fascia lateral to the conjoined tendons to expose the subscapularis tendon and to allow for medial retraction of the conjoined tendons. When incising the clavipectoral fascia and retracting the conjoined tendons medially, the surgeon should be mindful that the musculocutaneous nerve pierces the coracobrachialis muscle medially, just below the coracoid.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

32. Answer A. **Anterior circumflex humeral artery**
With the arm abducted on an arm board, this approach extends from the coracoid process,

distally down the deltopectoral groove and the arm, following the lateral border of biceps brachii. Superficially and proximally, the cephalic vein is identified and the pectoralis major and deltoid are retracted, and dissection is continued distally down to the deltoid tuberosity. The deep fascia is incised, and the interval between biceps brachii and brachialis is identified. Proximally, the humeral shaft is exposed by incising the periosteum lateral to the long head of biceps brachii. The anterior circumflex humeral artery, which originates from the third part of the axillary artery, crosses medially to laterally and should be identified and ligated.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

33. Answer A. **Anaesthesia of the lateral (radial) surface of the forearm**
A curved incision is made over the anterior elbow, beginning proximally and medially to biceps brachii, curving over the flexion crease, and extending distally down the medial border of brachioradialis. Superficially, during incision of the deep fascia, the lateral cutaneous nerve of the forearm (a branch of the musculocutaneous nerve) should be identified, usually by exploring the interval between brachialis and the tendon of biceps brachii. This nerve will be seen travelling from medial to lateral, between the biceps tendon and brachialis. It divides into anterior and posterior branches to supply the skin along the radial border of the forearm.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

34. Answer A. **Deep branch of the radial nerve**
At the cubital fossa, the radial nerve divides into superficial and deep branches. The deep branch of the radial nerve pierces the supinator to pass from the cubital fossa to the posterior compartment of the forearm; when this nerve leaves the supinator, it becomes the posterior interosseous nerve.

Moore K, Dalley A. *Clinically Oriented Anatomy*. Philadelphia, PA: Lippincott Williams & Wilkins; 1999.

35. Answer E. **The tendons of FDS to the index and little fingers are superficial to the FDS tendons of the middle and ring fingers**
The carpal tunnel is the osseofibrous canal at the volar wrist, which has the flexor retinaculum as its roof and the carpal bones as the floor. The flexor retinaculum extends from the hook of hamate and pisiform to the scaphoid tubercle and ridge of the trapezium. Ten structures travel through the carpal tunnel: the median nerve, the eight flexor tendons of the index to little fingers (flexor digitorum superficialis and profundus) and the flexor pollicis longus tendon of the thumb. The flexor digitorum superficialis (FDS) tendons are in two layers; the middle and ring finger FDS tendons lie superficial to those of the index and little fingers, and the four profundus tendons are deep to these.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

36. Answer E. **Superficial branch of the radial nerve**
The anatomical snuffbox is a depression that lies on the dorsoradial surface of the hand. The borders of this concavity are the extensor pollicis longus tendon (EPL) on the ulnar side, and the extensor pollicis brevis (EPB) and abductor pollicis longus (APL) tendons radially. The roof of the snuffbox is covered by fascia and skin, and the floor consists of the scaphoid, trapezium and base of the first (thumb) metacarpal distally.

The dorsolateral approach to the scaphoid involves identifying these structures within the anatomical snuffbox and incising the fascia in the centre, taking care to identify and preserve the superficial branch of the radial nerve which lies superficial to the EPL tendon; this branch can be clinically palpated against the EPL tendon. These tendons are retracted, taking EPL dorsally.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

37. Answer B. **A2 and A4**
The annular pulleys (A) reinforce the flexor sheath, reducing the risk of flexor tendon bowstringing and reduced flexion. A1 is anterior to the metacarpophalangeal joint (MCPJ), A2 at the middle third of the proximal phalanx, A3 at the proximal interphalangeal joint, A4 at the middle third of the middle phalanx, and the A5 pulley is

sited at the distal interphalangeal joint. A2 and A4 are crucial to preventing tendon bowstringing and insert at the periosteum of the proximal phalanx and the middle phalanx, respectively. The thumb has an A1 pulley anterior to the MCPJ and an A2 pulley just proximal to the interphalangeal joint; an oblique is at the middle third of the proximal phalanx.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

38. Answer E. **Nail plate, sterile matrix and hyponychium**

The nail serves as protection to the fingertip and facilitates in tactile sensation and thermoregulation.

The perionychium represents the soft tissue of the nail and comprises the eponychium, paronychium, nail fold, nailbed and hyponychium.

The nailbed is the soft tissue deep to the nail plate and covers the distal phalanx; it is divided into germinal and sterile matrix components. The germinal matrix is proximal and begins under the nail fold and ends at the lunula and produces most of the nail plate. The sterile matrix is distal to the lunula and helps to keep the nail plate tethered to the bed.

The nail fold is the most proximal part region of the perionychium and consists of ventral and dorsal floors, where the ventral floor contains the germinal matrix. The eponychium is the skin which covers the proximal extent of the nail, superficial to the dorsal floor, extending from the proximal nail fold; distal to the eponychium to the nail is the cuticle.

The paronychium represents the folds of skin on the radial and ulnar borders of the nail. The lunula is a white crescent shape of tissue just distal to the eponychium that represents the distal extent of the germinal matrix. The hyponychium is the distal margin between the skin and sterile matrix of the nailbed.

Wolfe S, Hotchkiss R, Green D. *Green's Operative Hand Surgery*, 6th Ed. Philadelphia, PA: Elsevier Churchill Livingstone; 2011.

39. Answer A. **Adductor pollicis**

Froment's test assesses ulnar nerve function and is performed by asking the patient to grasp a piece of paper. When there is an ulnar nerve palsy, this test demonstrates weakness to the adductor pollicis and first dorsal interosseous muscles (supplied by the deep branch of the ulnar nerve, but the lesion may be proximal to this nerve's origin). Froment's sign is therefore the compensatory action of flexor pollicis longus (FPL) to achieve this grip, a muscle which is innerved by the anterior interosseous branch of the median nerve.

Solomon L, Warwick D, Nayagam S, Apley A. *Apley's System of Orthopaedics and Fractures.* London: Hodder Arnold; 2010.

Wolfe S, Hotchkiss R, Green D. *Green's Operative Hand Surgery*, 6th Ed. Philadelphia, PA: Elsevier Churchill Livingstone; 2011.

40. Answer E. **Extensor pollicis longus**

The tendon of extensor pollicis longus runs just ulnar to the dorsal tubercle of the radius, a palpable prominence which is also known as Lister's tubercle, named after the eminent surgeon Joseph Lister. The extensor pollicis longus tendon inserts into the base of the distal phalanx, and as it passes from the forearm to its insertion, it crosses the wrist at the ulnar border of the dorsal tubercle of the radius and obliquely changes direction to form the ulnar border of the anatomical snuffbox (the radial borders are formed by extensor pollicis brevis and abductor pollicis longus). The tendon of extensor carpi radialis brevis runs just radial to Lister's tubercle. Spontaneous rupture of this tendon may occur following a fracture to the distal radius, which can result from necrosis.

There are six extensor compartments at the wrist (see Table 23.1).

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

Lower Limb

41. Answer C. **Hypertrophic zone**

The clinical features that are presented in this question are pathognomonic for a slipped upper femoral epiphysis (SUFE).

This condition has a higher incidence in adolescent males and is rare before the age of 10. It is characterised by mechanical weakness and slippage of the proximal femoral physis, specifically through the hypertrophic zone. Children with renal

osteodystrophy are also at risk of developing a SUFE, though when this occurs, it is usually through the secondary spongiosa and not the hypertrophic zone of the physis. This slippage results in anterior and superior displacement of the metaphysis relative to the femoral head epiphysis.

This mechanical failure of the physis can result from abnormal loads through a normal physis or normal physiological loads through an abnormally weak physis.

A typical clinical presentation for SUFE may be an adolescent male with atraumatic groin, thigh or knee pain. The leg may be shortened and externally rotated, with limited passive flexion and internal rotation; the hip may externally rotate as it is flexed (obligate external rotation). Radiologically, Klein's line passes along the superior cortex of the femoral neck, which should also intersect the epiphysis. Trethowan's sign is when this line passes above the epiphysis due to anterior and superior slippage of the metaphysis relative to the epiphysis.

Rathi RA and Khan T. Slipped upper femoral epiphysis. *Orthop Trauma* 2016:**30**: 482–491.

42. Answer A. **Superior gluteal nerve**

The posterior approach to the hip is frequently performed in both primary and revision surgery. The incision is centred over the posterior aspect of the greater trochanter, where proximally it curves to run with the gluteus maximus fibres, and distally along the femoral shaft. Superficially, the fascia lata is incised over the femoral shaft, and proximally, the gluteus maximus fibres are bluntly split. A Charnley retractor is then inserted between the split gluteus maximus fibres and fascia lata, being mindful to the sciatic nerve whilst this is applied. This exposes the posterolateral hip joint, covered by the overlying short external rotators; the hip is internally rotated to stretch these muscles and to also help move the sciatic nerve away from the dissection. The hip joint is exposed by releasing the short external rotators close to their main insertion on the medial surface of the greater trochanter; this release usually begins at the interval between gluteus medius and piriformis.

The short external rotators relate to five individual muscles on the posterolateral aspect of the hip. From superior to inferior, these are: (1) Piriformis, (2) Superior gemellus, (3) Obturator internus, (4) Inferior gemellus and (5) Quadratus femoris. Neurovascular structures pass from the pelvis to the gluteal region through the greater sciatic foramen, either above or below piriformis, which also passes through this foramen (Figure 23.11).

Figure 23.11 Anatomy gluteal region

1 Gluteus medius
2 Superior gluteal nerve and vessels
3 Piriformis
4 Sacrotuberous ligament
5 Inferior gluteal nerve and vessels
6 Sciatic nerve
7 Obturator internus
8 Ischial tuberosity
9 Posterior cutaneous nerve of the thigh
10 Quadratus femoris
11 Gluteus maximus (reflected)
12 Hamstring part of adductor magnus
13 Short head of biceps femoris
14 Semimembranosus
15 Semitendinosus
16 Long head of biceps femoris
17 Vastus lateralis
18 Tibial nerve and popliteal vessels
19 Common peroneal nerve
20 Medial head of gastrocnemius
21 Lateral head of gastrocnemius

The superior gluteal nerve and vessels emerge above piriformis. The following structures travel to the gluteal region below piriformis: (1) Inferior gluteal nerve and vessels, (2) Nerve to obturator internus, (3) Sciatic nerve, (4) Posterior femoral cutaneous nerve, (5) Pudendal nerve and vessels and (6) The nerve to quadratus femoris.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

43. Answer B. **Superficial peroneal nerve**
This question is assessing one's knowledge of the anterior compartment of the leg; however, also knowing how to perform a four-compartment fasciotomy may also help to focus on this compartment's contents.

The anterolateral approach decompresses the anterior and lateral compartments; the posteromedial approach decompresses the posterior superficial and deep compartments.

For the anterolateral approach, a long incision is made around 2cm lateral to the tibial crest. The anterior intermuscular septum is identified within the deep crural fascia of the leg. The anterior compartment is decompressed by releasing the fascia ~1cm anterior to the intermuscular septum; the lateral compartment is decompressed by making a further incision in the fascia ~1 cm posterior to the anterior intermuscular septum.

The anterior compartment consists of four muscles: tibialis anterior, extensor hallucis longus, extensor digitorum longus and peroneus tertius. It also contains the deep peroneal nerve and anterior tibial vessels. The lateral compartment contains two muscles: peroneus brevis and longus; it also contains the superficial peroneal nerve.

The posteromedial approach is made around 2cm posterior to the posteromedial tibial cortex. The deep fascia is released to decompress the superficial deep compartment. Be mindful to protect the saphenous vein and nerve. The deep posterior compartment is decompressed by releasing the soleus bridge to its origin at the tibia; the fascia is then released longitudinally just posterior to the tibia.

The superficial posterior compartment consists of gastrocnemius (medial and lateral heads), plantaris and soleus. The deep posterior compartment contains the following four muscles: flexor digitorum longus, flexor hallucis longus, tibialis posterior and popliteus. The tibial division of the sciatic nerve is also in the deep posterior compartment, and the posterior tibial and peroneal vessels.

Singh K, Bible JE, Mir HR. Single and dual-incision fasciotomy of the lower leg. *J Bone Joint Surg Essential Techniques* 2015;**5**:e25.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

44. Answer A. **Halfway between the anterior superior iliac spine and the pubic symphysis**

45. Answer B. **Sartorius**
During this approach, the internervous plane is between the femoral nerve (sartorius) and the superior gluteal nerve (tensor fascia lata) superficially, and the femoral nerve (rectus femoris) and the superficial gluteal nerve (gluteus medius) during deeper dissection. The specific nerve described is the lateral femoral cutaneous nerve (lateral cutaneous nerve of the thigh), which is a sensory branch of the lumbar plexus (L2–3), providing cutaneous sensation primarily to the lateral thigh. This nerve emerges from behind or through the inguinal ligament just medial to the anterior superior iliac spine and enters the thigh deep to the fascia lata, eventually dividing into anterior and posterior branches. As it passes deep to the fascia lata, it crosses over the sartorius muscle; the surgeon should therefore be mindful of this nerve when incising the fascia lata to dissect the interval between tensor fascia latae and sartorius, retracting tensor fascia lata laterally and sartorius medially. Deep to these are the rectus femoris and the gluteus medius.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

46. Answer A. **Deep peroneal nerve**
This approach is made in the midline, just proximal and distal to the ankle joint. Branches of the superficial peroneal nerve are at risk during superficial dissection when superficial to the extensor retinaculum; deep to this retinaculum lie the extensor tendons. At the level of the ankle

joint, the anterior tibial artery and deep peroneal nerve are expected to be just deep to the extensor hallucis longus tendon (inserts on the dorsal surface of the distal phalanx of the great toe), which are retracted medially along with this tendon.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

47. Answer C. **Ilioinguinal nerve**
During this approach, the spermatic cord (or round ligament in the female) is mobilised. The spermatic cord (or round ligament) travels through the inguinal canal by passing from the deep to superficial inguinal rings. The spermatic cord contains the vas deferens, lymphatics (draining to the para-aortic lymph nodes), the testicular artery, artery to the vas, cremasteric artery, the pampiniform plexus of veins and three layers of fascia (internal and external spermatic fascia and the cremaster muscle). It also contains three nerves: nerve to the cremaster from the genital branch of the genitofemoral nerve and autonomic nerves. The ilioinguinal nerve also runs in the inguinal canal but is not within the cord.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

48. Answer C. **S1**
An S1 nerve root injury is a recognised complication of this procedure.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

49. Answer D. **Piriformis**
The greater sciatic foramen is formed by the greater sciatic notch and the sacrospinous ligament. The piriformis muscle, which arises from the sacrum, passes through this foramen and effectively divides the foramen into two, and then inserts onto the upper border of the greater trochanter. Several structures pass from the pelvis to the gluteal region either above or below piriformis. Above piriformis are the superior gluteal nerve and vessels. Inferior to piriformis are the inferior gluteal nerve and vessels, pudendal nerve and vessels, nerve to obturator internus, sciatic nerve, posterior femoral cutaneous nerve and the nerve to quadratus femoris.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

50. Answer E. **Transverse branch of the medial circumflex femoral artery**
The femoral head receives most of its blood supply via the trochanteric anastomosis and its nutrient arteries. This anastomosis is formed by the descending branch of the superior gluteal artery and the ascending branches of the lateral and medial circumflex femoral arteries, and a small contribution is made by the inferior gluteal artery. Nutrient arteries branch off from this anastomosis within the retinacular fibres of the capsule and pass towards the femoral head. There is a further anastomosis at the level of the lesser trochanter, the cruciate anastomosis, where the transverse branch of the medial circumflex femoral artery anastomoses with the transverse branch of the lateral circumflex femoral artery. Joining this is the ascending branch of the first perforating artery (a branch of the profunda femoris) and the descending branch of the inferior gluteal artery.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

51. Answer C. **Piriformis**
The sciatic nerve exits the pelvis through the greater sciatic foramen, passing anterior then inferior to piriformis to enter the gluteal region.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

52. Answer A. **Common peroneal nerve**
The popliteal fossa, a diamond-shaped depression of the posterior knee joint, is bordered

inferiorly by the medial and lateral heads of gastrocnemius, superolaterally by biceps femoris and superomedially by semimembranosus and, lateral to this, the semitendinosus. The roof is formed by the fascia lata (the short saphenous vein pierces this to enter the popliteal vein, and lateral to this runs the medial sural cutaneous nerve, which is a branch of the tibial nerve). The floor is formed by the femur and capsule of the knee.

Deep to the roof and passing through the fossa are the popliteal artery (the deepest structure, close to the posterior joint capsule) and vein (superficial to the artery, and deep to the tibial nerve), the tibial nerve (the most superficial structure of the main neurovascular structures, which lies in the midline of the fossa) and common peroneal nerve (most lateral structure, superficial to the posterior border of biceps femoris), and several popliteal lymph nodes. The popliteal artery (with its branches) begins from the hiatus of the adductor magnus and enters the fossa medial to the tibial nerve, but as it descends, it lies lateral to the nerve, exiting the fossa through the fibrous arch within the soleus (with the tibial nerve and popliteal vein), to become the posterior tibial artery, which ultimately divides into anterior and posterior branches.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

53. Answer C. **Great saphenous vein**
A four-compartment leg fasciotomy is best performed through anterolateral and posteromedial incisions. The anterior and lateral compartments are decompressed via the anterolateral incision, centred between the fibula and the tibial crest. The subcutaneous tissue is dissected, exposing the crural fascia. The anterior compartment is released by incising the fascia just anterior to the anterior intermuscular septum. The lateral compartment is then fully released, incising the fascia that is posterior to the anterior intermuscular septum, taking care to protect the superficial peroneal nerve. The posterior superficial and deep compartments are released through the posteromedial incision, 2cm posterior to the posterior tibial border. Superficially, the great saphenous vein and saphenous nerve are at risk. The septum between the superficial and deep compartments is exposed, the fascia is released over the deep posterior compartment proximally and distally; the fascia of the superficial posterior compartment is also released.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

54. Answer B. **Gerdy's tubercle**
Used for lateral tibial plateau fractures, this incision typically extends from the lateral border of the patellar tendon just proximal to the joint line, curving inferiorly over Gerdy's tubercle (the insertion of the iliotibial band).

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

55. Answer C. **Peroneus longus**
The superficial and deep peroneal nerves are terminal branches of the common peroneal nerve and arise within the peroneus longus muscle at the region of the fibular neck.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

56. Answer C. **Flexor hallucis longus**
Acute compartment syndrome arises when increasing intracompartmental pressure compromises the perfusion to the tissues within that compartment. Intense pain (out of proportion to the initial clinical condition) is often the first sign of acute compartment syndrome, especially when the affected muscle group is passively stretched. For this specific question, passive extension of the lesser toes stretches flexor digitorum longus, which is a member of the deep posterior department (see Table 23.2). The other two members of this deep posterior compartment are (1) Flexor hallucis longus, (2) Tibialis posterior and (3) Popliteus.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

McQueen MM, Duckworth AD. The diagnosis of acute compartment syndrome: a review. *Eur J Trauma Emerg Surg.* 2014;**40**:421–528.

Table 23.2 Muscles of the four leg compartments with corresponding nerve supply

Anterior		Superficial posterior		Deep posterior		Lateral	
Muscles	***Innervation***	***Muscles***	***Innervation***	***Muscles***	***Innervation***	***Muscles***	***Innervation***
Tibialis anterior	**Deep peroneal nerve**	Gastrocnemius	**Tibial nerve**	Flexor digitorum longus	**Tibial nerve**	Peroneus longus	**Superficial peroneal nerve**
Extensor hallucis longus		Soleus		Flexor hallucis longus		Peroneus brevis	
Extensor digitorum longus		Plantaris		Tibialis posterior			
Peroneus tertius				Popliteus			

57. Answer B. **Between the tendons of extensor digitorum longus and extensor hallucis longus**
An anterior incision is made midway between the malleoli, extending to the dorsum of the foot. The crural fascia is incised, followed by the extensor retinaculum, and the plane between the extensor hallucis longus and extensor digitorum longus is developed. Just proximal to the ankle joint, the anterior tibial artery and deep peroneal nerve are generally expected to be between the tendons of extensor digitorum longus and extensor hallucis longus, but at the ankle joint, these neurovascular structures pass deep to the extensor hallucis longus tendon.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

58. Answer B. **Flexor hallucis longus**
For this approach, a longitudinal incision is made between the Achilles tendon and lateral malleolus. The deep fascia (crural fascia) is incised and the tendons of peroneus brevis and longus are identified, along with the Achilles tendon. The peroneal retinaculum is incised, and the peroneal tendons are retracted, exposing the flexor hallucis longus muscle (FHL). FHL is retracted medially to expose the periosteum of the posterior tibia.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

59. Answer C. **Weakness of great toe extension and decreased sensation between the great (first) and second toes (first web space)**
The deep peroneal nerve innervates the four anterior compartment muscles to the leg: tibialis anterior, extensor hallucis longus, extensor digitorum longus and peroneus tertius. It is also sensory to the dorsum of the foot at the first web space.

Moore K, Dalley, A. *Clinically Oriented Anatomy.* Philadelphia, PA: Lippincott Williams & Wilkins; 1999.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

60. Answer C. **Superficial peroneal (fibular) nerve**
A dorsomedial incision is made just proximal to the interphalangeal joint, extending over the first metatarsophalangeal joint and metatarsal, ending just distal to the tarsometatarsal joint. During dissection and retraction, care should be taken to protect the dorsal digital branch of the medial cutaneous nerve, which is often retracted laterally; the medial cutaneous nerve is a sensory branch to the foot from the superficial peroneal nerve.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

61. Answer A. **A positive Trendelenburg sign is noted by the pelvis sagging on the standing side**
The gluteal region lies from the iliac crest to the gluteal fold. The sacrospinous ligament attaches to the ischial spine, forming the greater sciatic foramen from the greater sciatic notch; the lesser sciatic foramen is formed by the lesser sciatic notch and the sacrotuberous ligament. Muscles of the gluteal region include gluteus maximus (extension and external rotation), gluteus medius, minimus and tensor fasciae latae (abductors) and the deep short external rotators (piriformis, superior gemellus, obturator internus, inferior gemellus and quadratus femoris). Gluteus maximus arises from the gluteal surface of the ilium, the lumbar fascia and sacrum, and from the sacrotuberous ligament; it is innervated by the inferior gluteal nerve and receives its blood supply from the superior and inferior gluteal arteries. The Trendelenburg's test assesses the stability of the hip. Standing on both feet, the centre of gravity is midway between these points; however, when standing on one leg, the centre of gravity moves towards this side and the pelvis raises on the unsupported side. Normally, when standing on one leg (stance leg), the abductors on this weight-bearing side (medius, minimus and tensor fasciae latae) stabilise the hip; however, if there is any weakness in these muscles (trauma, poliomyelitis), the body's weight will cause the pelvis to dip on the contralateral side (Trendelenburg sign), but the weakness is on the stance side (sound side sags).

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

62. Answer D. **Subvastus**
The subvastus approach is known for its ability to give earlier recovery due to less post-operative pain and early mobilisation (due to rapid quadriceps recovery). This approach is considered as a relative contraindication for TKA in knees with limited ROM due to difficulty in exposure which can increase the risk of complications such as patellar tendon avulsion or medial collateral injury. Short stature and obesity are also relative contraindications.

An anterior midline incision with medial parapatellar arthrotomy is the most common incision for primary TKA. Technically easy to do with good exposure of the knee.

The subvastus approach leaves the extensor mechanism intact. This results in faster restoration of quadriceps strength, retains greater vascularity in the patella, increases patient satisfaction while reducing post-operative pain, and reduces the need for lateral release. Intraoperative knee visualisation is reduced compared with the medial parapatellar approach, especially in obese individuals and those who have had previous knee procedures. There is also concern about the potential for component misalignment. The muscle belly of vastus medialis is lifted off intermuscular septum.

The trivector approach is used for a minimally invasive approach to the knee. Quicker recovery with less loss of quadriceps strength but exposure less predictable. Blom et al. (2021) reported that the midvastus approach (used in 3% of cases) was associated with a 20% reduced risk of revision surgery compared with the medial parapatellar approach (used in 91.9% of cases). They recommended the use of the midvastus approach and advised surgeons to consider utilising this approach more frequently. Minimally invasive approaches did not appear to convey any clinical advantage in this study over conventional approaches for primary TKR.

Blom AW, Hunt LP, Matharu GS, Reed M, Whitehouse MR. The effect of surgical approach in total knee replacement on outcomes: an analysis of 875,166 elective operations from the National Joint Registry for England, Wales, Northern Ireland and the Isle of Man. *Knee* 2021;**31**:144–157.

Spine

63. Answer B. **Paraxial mesoderm**
The mesoderm, which is the middle layer of the trilaminar disc, is subdivided into paraxial, intermediate and lateral mesoderm. The axial skeleton (skull, vertebral column, ribs and sternum) begins to form by around the third week, where the characteristic segmentation of the vertebral

column is established early, during the embryonic period; defects during this process can lead to congenital disorders of the spine such as congenital scoliosis. The following sections will discuss somitogenesis, which is the formation of somites from the paraxial mesoderm. Somites are the precursors to the sclerotome and dermatomyotome and develop in pairs along the neural tube; ultimately, they give rise to the structures of the vertebral column, muscle and dermis.

Somitogenesis

Somitogenesis is the process of segmentation and somite development from the paraxial mesoderm, giving rise to the axial skeleton and the characteristic segmented structure of the vertebral column. The mesoderm of the trunk is subdivided into the lateral plate mesoderm, intermediate mesoderm, and the paraxial mesoderm (also known as the presomitic mesoderm); the paraxial mesoderm is the precursor to the axial skeleton and the lateral plate mesoderm gives rise to the appendicular skeleton. Somites are transient epithelial spheres that are precursors to the axial skeleton and are rhythmically developed in pairs along the anteroposterior axis and surround the neural tube and notochord at consistent intervals. The 'clock and wavefront model' explains this process of repetitive segmentation. The rate of somite development is consistent between species but varies amongst different species.

These somites extend from the occipital region caudally as paired segmental structures of tissue either side of the neural tube and notochord, and eventually differentiate to form tissues of the vertebral column, cartilage, skeletal muscle, tendons and dermis. Somites form at a predictable rate in a cranial-caudal direction. The total number and rate of somite formation is fixed but varies between species, where in humans, these form at a rate of around three per day; the first forms at around day 20, and by the fifth week, there are 42–44 pairs (4 occipital, 8 cervical, 12 thoracic, 5 lumbar, 5 sacral and 8–10 coccygeal). The first occipital and 5–7 coccygeal eventually degenerate.

The clock and wavefront model is a popular theory that explains the segmentation of paraxial mesoderm into somite pairs, where somatic pairs bud off from the paraxial mesoderm at a precise rate, and this is governed by the cyclical expression of specific signalling pathways involving Notch, WNT, b-catenin and FGF. The segmentation clock refers to the periodic expression of specific genes within the paraxial mesoderm that interacts with signalling gradients (maturation wavefront). Abnormalities in normal segmentation can lead to congenital disorders such as congenital scoliosis (most frequent congenital spinal deformity), with segmental defects visible on radiographs that may include hemivertebrae, vertebral fusions and bars.

Somite differentiation

Differentiated somites consist of two major cell types: the sclerotome and dermatomyotome. Cells within the ventromedial walls of the somites differentiate through a process of epithelial-to-mesenchymal transition (EMT), induced by noggin and sonic hedgehog signalling proteins, forming the sclerotome; the sclerotome differentiates into tissues of the vertebral column (vertebrae, intervertebral discs, and tendons), skull base and ribs. Sclerotome formation is characterised by the expression of specific transcription factors such as paired-box gene (PAX) 1 and 9 and SOX9. Those remaining cells that lie dorsolaterally remain epithelial and form the dermomyotome, which has two components: the myotome and dermatome. The myotome differentiates to produce skeletal muscle of the ventral wall and limbs; the dermatome gives rise to the dermis. Neural crest cells also differentiate into mesenchymal cells that give rise to the bones of the skull.

As previously stated, the vertebrae develop from the sclerotome, which is transient pluripotent mesenchymal tissue derived from the venteromedial region of the somite, and the paraxial mesoderm is the precursor to these tissues. During week four, sonic hedgehog signalling proteins from the floor of the neural tube and notochord stimulate the sclerotome cells of the somite to proliferate ventrally and surround the spinal cord and notochord, and merge with their counterparts from the other somite in the pair to form ultimately the vertebral body and intervertebral discs. The dorsomedial sclerotome forms the neural arches.

Sadler TW. *Medical Embryology*, 14th Ed. Philadelphia, USA: Wolters Kluwer; 2019.

Scaal M. Early development of the vertebral column. *Semin Cell Develop Biol.* 2016;**49**:83–91.

Tani S, Chung U, Hojo H. Understanding paraxial mesoderm development and sclerotome specification for skeletal repair. *Exp Mol Med.* 2020;**52**:1166–1177.

Williams S, Alkhatib B, Serra R. Development of the axial skeleton and intervertebral disc. *Curr Topics Dev Biol.* 2019;**133**:49–90.

64. Answer E. **L4**
The abdominal aorta begins behind the diaphragm at the aortic hiatus at the level of the twelfth thoracic vertebrae and ends at the level of the fourth lumbar vertebrae, bifurcating into the common iliac arteries.

65. Answer B. **Longus colli**
The sternocleidomastoid muscle is retracted laterally along with the carotid sheath and its contents (vagus nerve, carotid artery and internal jugular); the oesophagus, larynx and trachea, thyroid and strap muscles are retracted medially. Deep dissection involves incising the prevertebral fascia to expose the longus colli muscles and the anterior longitudinal ligament, which are superficial to the cervical vertebrae. The longus colli is split in the midline and is reflected laterally to the midline along with the anterior longitudinal ligament to expose the cervical vertebral body (Figure 23.13).

66. Answer A. **Artery of Adamkiewicz**
This approach is usually performed on the right side, but this depends on the indication and surgeon's preference. The lung, oesophagus and intercostal vessels are at risk of injury during either a right- or left-sided approach, while the artery of Adamkiewicz is generally found on the left side of the posterior mediastinum and the azygos vein is generally to the right.

67. Answer A. **Cricothyroid**
The anterior approach (Smith–Robinson) to the cervical spine extends superficially through superficial fascia and platysma, which is split longitudinally. The anterior border of the sternocleidomastoid is identified, and the investing layer of deep fascia is incised, retracting the muscle laterally; sternohyoid and sternothyroid, with the trachea and oesophagus retracted medially. The carotid sheath and its contents are retracted laterally by developing a plane between the carotid sheath and the thyroid, trachea and oesophagus (incising the pretracheal fascia). Deep to this plane lies the prevertebral fascia, covering the longus colli muscle, anterior longitudinal ligament and the cervical vertebrae.

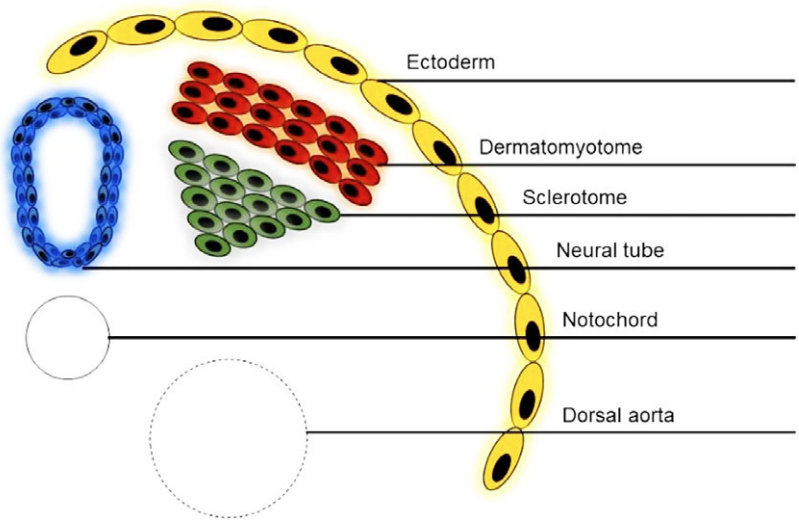


Figure 23.12 Transverse section through the embryo, showing the main regions of the somite: the sclerotome and dermatomyotome

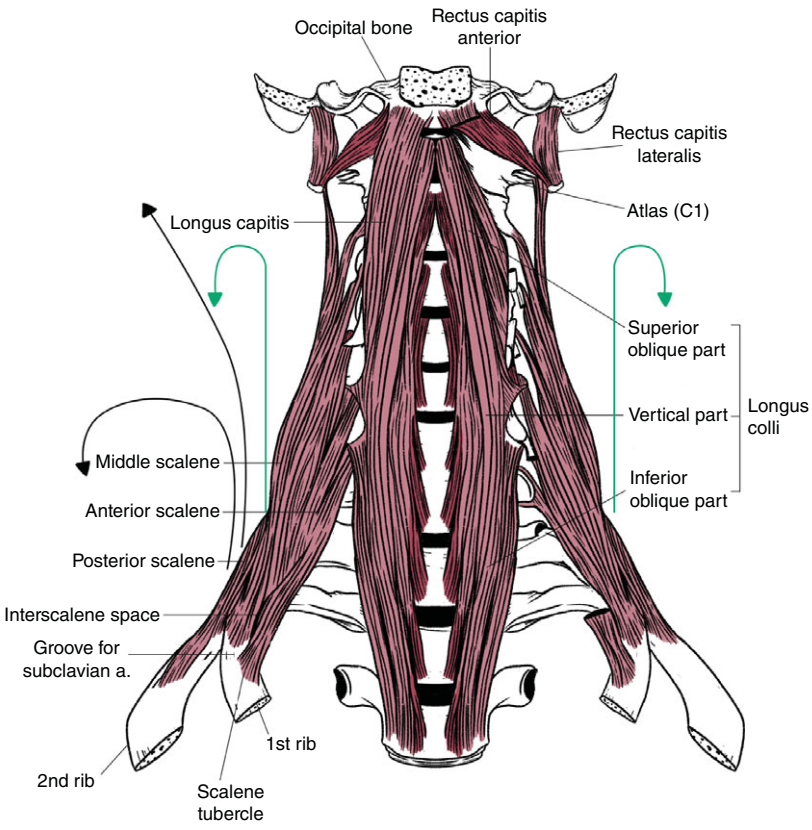


Figure 23.13 The longus colli connects the cervical spine to the thoracic spine. Of the neck flexors it is the only one that attaches to the anterior cervical spine

During this approach, the recurrent laryngeal nerve is a structure at risk, and unilateral palsy can result in hoarseness. Both nerves ascend the posterolateral border of the trachea in the tracheoesophageal groove. All intrinsic muscles of the larynx are supplied by the recurrent laryngeal nerves other than cricothyroid, which is innervated by the external laryngeal nerve, which is a further branch of the vagus nerve (CN X). The recurrent laryngeal innervates the following intrinsic laryngeal muscles: thyroarytenoid, posterior cricoarytenoid, lateral cricoarytenoid, transverse and oblique arytenoids.

68. Answer D. **Decreased sensation over the upper anterior thigh and anterior scrotum (or labia majora)**

During this approach, an oblique incision is usually made from the posterior aspect of the twelfth rib to the lateral border of the rectus abdominis. Dissection is made through the skin, subcutaneous fat and external oblique aponeurosis, followed by the external oblique, internal oblique and transversus abdominis muscles. The peritoneum and its contents are retracted medially, usually with the ipsilateral ureter, which is frequently adhered to the peritoneum. The genitofemoral nerve (L1–2), which supplies the area of skin over the upper anterior thigh and anterior scrotum or labia majora, emerges from the anterior surface of the psoas major muscle, and passes inferiorly, deep to the psoas fascia and anterior to the muscle. The ureter, which is also at risk, runs between the peritoneum (usually adhered to) and psoas fascia.

Hoppenfeld S, Boer P, Buckley R. *Surgical Exposures in Orthopaedics*, 4th Ed. Philadelphia, PA: Lippincott Williams and Wilkins; 2009.

Moore K, Dalley A. *Clinically Oriented Anatomy.* Philadelphia, PA: Lippincott Williams & Wilkins; 1999.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

69. Answer B. **L1–2**
In the fetus, the spinal cord extends from the foramen magnum to the second sacral vertebra, and at birth, the end of the spinal cord, known as the conus medullaris, is opposite the third lumbar vertebra. The final position of the conus medullaris in the adult is generally at the level of the first or second lumbar vertebrae.

Sinnatamby C. *Last's Anatomy*, 12th Ed. Edinburgh: Churchill Livingstone; 2011.

Chapter 24

Structure and Function of Connective Tissue Structured SBA

Paul Banaszkiewicz

STRUCTURE AND FUNCTION OF CONNECTIVE TISSUE STRUCTURED SBA QUESTIONS

1. **Regarding the structure of articular cartilage, which of the following is true?**
   - A. Calcified layer secures cartilage to bone
   - B. Deep radial zone collagen fibres are arranged obliquely at right angles to each other
   - C. Middle transitional zone is the thinnest layer
   - D. Superficial (tangential) zone provides good resistance to shear forces but poor tensile strength
   - E. Tidemark provides main resistance to compression

2. **The main function of articular cartilage is to do which?**
   - A. Act as a shock absorber
   - B. Allow smooth gliding movements between bones with low frictional coefficient
   - C. Facilitate the transmission of loads to the underlying subchondral bone
   - D. Minimise peak pressures on the subchondral bone
   - E. Resist the compressive forces encountered across the joint under loading conditions

3. **Which of the following correctly describes changes in articular cartilage?**
   - A. Chondrocytes are most numerous in the superficial zone
   - B. Collagen concentration increases with depth
   - C. Collagen fibres decrease in size with depth
   - D. Proteoglycan concentration decreases with depth
   - E. Water concentration increases with depth

4. **What are the options for treating a 2 × 2cm articular cartilage defect in the medial femoral condyle of a 22-year-old athletic male?**
   - A. ACI
   - B. Autologous matrix-induced chondrogenesis (AMIC)
   - C. Osteochondral allograft
   - D. Osteochondral autograft transfer system (OATS/mosaicplasty)
   - E. Microfracture

5. **Which of the following changes occurs with articular cartilage and ageing?**
   - A. Decreased permeability
   - B. Increased chondrocytes
   - C. Increased compressive strength
   - D. Increased keratin sulphate
   - E. Increased water content

6. **Regarding the collagen composition of articular cartilage, which is true?**
   - A. Type III collagen is involved in cartilage mineralisation
   - B. Type IX regulates the diameter of articular cartilage
   - C. Type VI is involved in cell–matrix interactions
   - D. Type X is found following injury
   - E. Type XI is involved in the stabilisation of the collagen II network

7. **When comparing osteoarthritis with ageing, which of the following is found?**
   - A. Collagen concentration increased in OA/decreased in ageing
   - B. Keratin sulphate increased in OA/decreased in ageing
   - C. Metabolic activity increased in OA/decreased in ageing

D. Proteoglycan synthesis decreased in OA/increased in ageing
E. Water content increased in OA/decreased in ageing

8. **In osteoarthritis when chondrocytes detect a disruption or alteration of their matrix, which of the following occurs?**
A. Chondrocytic catabolic response
B. Decreased degradation of the matrix
C. Decreased synthesis of the matrix
D. Increase in chondrocyte numbers
E. Increase in metabolic activity

9. **The biomechanical changes of articular cartilage in osteoarthritis include which?**
A. Decreased permeability
B. Decreased water content
C. Increased compressive strength
D. Increased tensile stiffness and strength
E. Loss of interstitial fluid pressure

10. **Concerning the blood supply of bone, which is correct?**
A. Nutrient artery system is low pressure
B. During early fracture healing, blood flow is centrifugal because the periosteal system is often disrupted
C. Periosteal system supplies outer two-thirds of bone
D. IM reaming devascularises the inner one-third of the cortex and delays revascularisation of the endosteal blood supply
E. Recovery of endosteal bone circulation after reaming takes around 3 months

11. **The main function of the annulus fibrosis (AF) of the intervertebral disc is which of the following?**
A. To prevent intervertebral distraction
B. To act as a shock absorber
C. To contain the axial-load-related deformation of the nucleus
D. To provide high-tensile, torsional and radial strength
E. To remain flexible enough allow motion

12. **Intervertebral disc degeneration involves which?**
A. Decreased cell density
B. Drop in nucleus pressure
C. Increased cross-linking of the disc's collagen
D. Loss of proteoglycans
E. Structural failure of the matrix

13. Which is true concerning the structure of the annulus fibrosis?
A. It contains chondrocyte like cells
B. It contains large quantities of proteoglycans
C. Lamellae are more abundant and stronger in the posterior and posterolateral aspects of the disc
D. Type I collagen and water increase in proportion from the outer annulus towards the inner annulus and transitional zone
E. Type I collagen fibres are attached to the ring apophysis

14. A patient presents to casualty with a painful left tibia. Radiographs reveal a subacute fracture (Figure 24.1). The ED registrar is concerned about the general appearance of the tibia. They suspect the patient has a bone dysplasia.
The likely diagnosis would be which of the following?

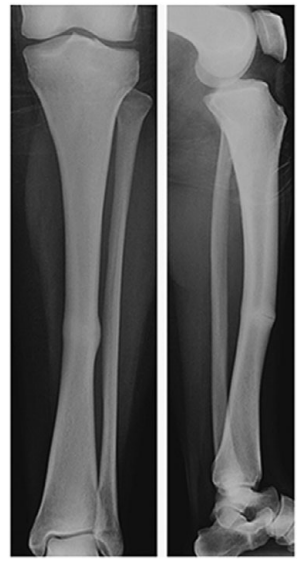


Figure 24.1 Anteroposterior (AP) and lateral radiographs left tibia demonstrating fracture

A. Osteopetrosis
B. Osteopoikilosis
C. Osteopathia striata
D. Progressive diaphyseal dysplasia
E. Pyknodysostosis

15. A 59-year-old female patient has recently been started on bisphosphonates for osteoporosis.
Regarding mechanism of action of bisphosphonates, which is true?
A. Alendronate (Fosamax) stimulates protein prenylation within the mevalonate pathway, blocking farnesyl pyrophosphate synthase enzyme
B. They are categorised into two classes based on the presence or absence of a pyrophosphate side chain
C. Didronel (etidronate) is metabolised into a non-functional adenosine triphosphate (ATP) analogue inducing apoptosis
D. Nitrogen-containing bisphosphonates have a simple mechanism of action
E. There is a loss of adenosine triphosphate (ATPase) formation, which is needed for ruffled border formation and cell survival

16. **Regarding bone remodelling, which is true?**
A. According to the Hueter–Volkmann Law, compression forces stimulate bone growth and tension forces inhibit bone formation
B. Compression side of bone is electropositive, stimulating osteoblast formation
C. During bone formation, decreased levels of osteocalcin are observed
D. Macrophages, B-cells and T-cells are involved in bone remodelling
E. Tension side of bone is electronegative, stimulating osteoclast resorption

17. A 50-year-old male with a tibial non-union after reamed IM nailing was treated with exchanging nailing and bone allograft.
Concerning the properties of allograft bone, which is correct?
A. Freeze-dried is the least immunogenic
B. Fresh has the least structural integrity
C. Osteoconduction is good
D. Osteogenic cells are fair
E. Osteoinduction is excellent

18. The mother of a 28-month-old infant is concerned that her son is not growing properly. He is a picky eater. Clinical examination reveals frontal bossing, open anterior fontanel, wide wrists, and bowlegs.
Blood tests would show which of the following?
A. Elevated calcidiol (25[OH]D_3)
B. Increased alkaline phosphate levels
C. Increased phosphate levels
D. Low calcium levels
E. Low PTH levels

19. A 26-month-old girl presented with prominent lower limb rachitic deformity, waddling gait and disproportionate short stature.
What would laboratory findings include?
A. Elevated PTH
B. Hypocalcaemia
C. Hypophosphaturia
D. Low serum alkaline phosphatase
E. Normal 25(OH)D

20. **Which is correct concerning the structure of collagen in bone?**
A. Collagen fibrils exhibit a 57nm D-period banded appearance on electron microscopy
B. Each polypeptide chain is a right-handed helix
C. It is a fibril-forming collagen
D. The structural unit is called tropocollagen, which is a trimer composed of three α1 polypeptide chains
E. The triple helix is a left-handed superhelix (i.e. the opposite way around to the polypeptide chain)

21. **Which of the following acts on the osteocyte to decrease sclerostin expression?**
A. Ankylosing spondylitis
B. Diabetes mellitus
C. Immobilisation
D. Menopause
E. Multiple myeloma

22. **What is correct concerning the structure of the annulus fibrosis?**
A. Compression damages the AF
B. Lamellae are more abundant and stronger in the posterior and lateral aspects of the disc
C. On progressing from the outer to the inner annulus, the type II collagen level declines and that of the type I increases
D. Outer AF contains chondrocytes

E. With degeneration, the inner AF undergoes an increase in collagen content with type II collagen fibrils becoming type I

23. You are about to scrub up to perform a reamed tibial nail for a displaced diaphyseal fracture. The junior orthopaedic trainee is assisting and asks you why you prefer using a reamed nail, as he read up last night that reamed nails damage the endosteal blood flow and this could interfere with bone healing.
What do you mention?
A. Blood flow is reversed with reaming from centripetal to centrifugal
B. Reamed nailing significantly reduces the risk of screw breakage
C. The risk of delayed union is significantly increased when using unreamed nails
D. Unreamed nails do not disturb the endosteal blood supply
E. With an unreamed nail, there is an increased risk of nail breakage

24. **Concerning the structure of bone, the major defining difference between cortical and cancellous bone is which of the following?**
A. Cortical bone has a basic structural unit of an osteon, whereas cancellous bone is composed of a 3D lattice of rods and plates
B. Cortical bone is dense and low porosity while cancellous bone is spongy and high porosity
C. Cortical bone is harder, stronger and stiffer than cancellous bone, which is highly vascular
D. Cortical bone is located in the diaphysis, while cancellous is located in the metaphysis or epiphysis
E. Cortical bone is subjected to bending, torsional and compressive forces, while cancellous bone is subjected to compressive forces

25. **Concerning the meniscofemoral ligaments of the knee, which is correct?**
A. Ligament of Humphrey is taut during flexion and lax during extension
B. Ligament of Wrisberg may be mistaken for the PCL during arthroscopy
C. Ligament of Wrisberg passes in front of the PCL
D. Meniscal insertion of the ligament of Humphrey commonly mimics the appearance of a tear of the posterior horn of the lateral meniscus on imaging
E. Wrisberg rips are characteristic longitudinal tears of the posterior horn of the lateral meniscus that may be seen in association with PCL tears

26. A 40-year-old male presents with non-specific bilateral hip of several weeks' duration. Blood tests including blood count and test results for C-reactive protein, rheumatoid factor, calcium, phosphate and alkaline phosphatase were all normal. Radiograph is shown in Figure 24.2.
The most likely diagnosis is which of the following?

Figure 24.2 Anteroposterior (AP) radiograph hip

A. Avascular necrosis
B. Lymphoma
C. Osteoblastic metastasis
D. Osteopoikilosis
E. Paget's disease

27. **Concerning differences in the stress–strain curve of ligaments and tendons, what is true of ligaments?**
    A. They contain small reduction dips at the end of the linear region that are specific for ligaments
    B. They recruit fibres quicker
    C. Collagen is less crimped with a smaller toe region
    D. Their ultimate tensile strength is less
    E. Their ultimate tensile strain is less

28. **What is correct below about third-class levers?**
    A. Examples include a nutcracker
    B. Fulcrum is at one end, load is in the middle and force is at the other end
    C. Load to fulcrum lever arm is shorter than the force to fulcrum lever arm
    D. Third-class levers usually have mechanical advantage
    E. When a lever's effort arm is longer than its load arm, it is said to have mechanical advantage

29. **Regarding the stress–strain curve shown in Figure 24.3, what do the labelled points represent?**

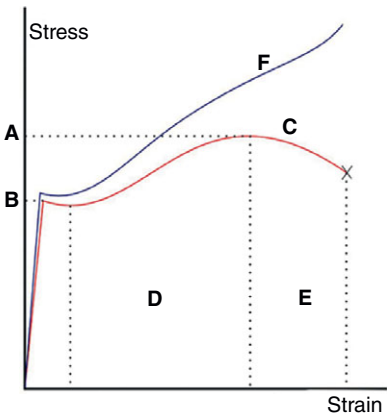


Figure 24.3 Stress–strain curve

    A. Rupture
    B. Yield point
    C. Actual stress
    D. Necking
    E. Strain-hardening

30. Regarding rate dependency loading of cortical bone (Figure 24.4), with a decreased loading rate there is which of the following?

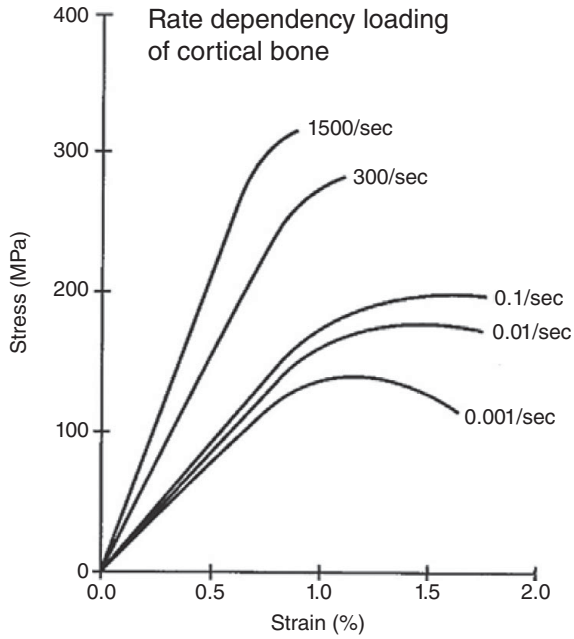


Figure 24.4 Stress–strain curve bone

    A. Increased brittleness
    B. Increased energy storage
    C. Increased rupture strain
    D. Increased rupture strength
    E. Increased stiffness

31. **The most important function of the meniscus is which of the following?**
    A. Joint stability
    B. Load transmission (bearing)
    C. Lubrication
    D. Proprioception
    E. Shock absorption

32. A 36-year-old male patient has been listed for right knee arthroscopy and medial meniscectomy.
    What is true concerning meniscal anatomy?
    A. Approximately 70% of the load in the medical compartment and 50% of the load in the lateral compartment are transmitted through the menisci

B. Horizontal cleavage tears disrupt the functional continuity of the circumferential fibres by preventing the formation of 'hoop strains'
C. There is a great variability in lateral meniscus anterior horn insertion types, but insertions of the medial meniscus are less variable and quite close
D. Removal of the medial meniscus results in a 50–70% reduction in femoral condyle contact area and a 100% increase in contact stress
E. The medial meniscus occupies a larger portion (~80%) of the articular surface than the lateral meniscus (~60%)

33. **When a sarcomere contracts:**
A. A band becomes shorter
B. H zone stays the same
C. I band stays at the same length
D. M line shortens
E. Z lines move closer together

34. **Concerning the structure of the sarcomere**
A. H zone are the regions occupied by only actin filaments
B. I bands are the regions occupied by both filaments (overlap)
C. M-line maintains the myosin filaments in a hexagonal lattice
D. Titin fibres extend from the peripheral Z-disk to the central M band
E. Z-line maintains the actin filaments in a hexagonal tetragonal lattice

35. **Concerning the stress strain curve of ligaments and tendons**
A. At high strain rates, tendons are more effective in moving large loads
B. In normal activity, most ligaments and tendons exist in the linear region
C. The toe region ends at about 4% strain when all crimpled fibres straighten
D. The toe region represents 'un-crimping' of the elastic fibrils
E. When the tendon/ligament is stretched to more than 8–10% of its original length, macroscopic failure follows

36. **Concerning visco-elastic properties:**
A. At low loads elastic behaviour dominates whilst at higher loads viscous behaviour dominates
B. Creep holds strain constant
C. Stress relaxation is an increase in deformation of a material under a constantly applied load
D. When ligaments and tendons are repetitively loaded, the stress-strain curve shifts to the left indicating that the tissues have become less stiff and more compliant
E. When subjected to increased strain rates, the linear portion of the stress strain curve becomes steeper, indicating greater stiffness of the tissues and more energy storage therefore requiring more force to rupture

37. **Sensory antidromic versus orthodromic recording.**
A. Amplitude is higher in orthodromic stimulation
B. Antidromic – stimulating away from the sensory receptor
C. Latency and conduction velocity should be identical with either method
D. Orthodromic technique is superior – higher amplitude
E. Orthodromic– stimulating towards the sensory receptor

STRUCTURE AND FUNCTION OF CONNECTIVE TISSUE STRUCTURED SBA ANSWERS

1. Answer A. **Calcified layer secures cartilage to bone**

This SBA is testing knowledge of the basic structure of articular cartilage. Although more of a type 1 SBA, this is basic science material of articular cartilage that candidates should know. Articular cartilage is a highly organised anisotropic tissue composed of four different zones (1) superficial (tangential) or gliding zone (10–20% of total cartilage volume), (2) middle or transitional zone (40–60%), (3) deep or radial zone (30–40%) and (4) the calcified zone.

Each of these zones possesses unique structural, functional and mechanical properties.

The deep radial zone has collagen fibres vertically arranged (perpendicular to articular cartilage) crossing the tide mark, anchored to the calcified zone.

The tidemark provides resistance to shear.

There are distinct subpopulations of chondrocytes in the different zones of cartilage whose properties differ in terms of their size, shape, metabolism and response to cytokines. Middle transitional zone has round random chondrocyte cells.

Superficial zone provides good resistance to shear forces due to tangential arrangement of collagen and greatest tensile strength.

The calcified layer plays an integral role in securing the cartilage to bone, by anchoring the collagen fibrils of the deep zone to subchondral bone. In this zone, the cell population is scarce, and chondrocytes are hypertrophic.

Where possible, think in terms of relating structure to function.

2. Answer B. **Allow smooth gliding movements between bones with low frictional coefficient**

The main functions of articular cartilage in synovial joints are to provide a low friction surface for motion and resist tensile, shear and compressive forces.

The principal function of articular cartilage is to allow smooth gliding movements between bones with a low frictional coefficient. It provides a smooth surface compatible with frictionless motion.

Most textbooks describe articular cartilage as acting as a shock absorber. Be careful, as this is controversial and disputed in the literature.[1] Better to say articular cartilage is load absorbing, as this is slightly less provocative. It is very thin, and its capacity is negligible compared to the surrounding muscles and bone. Think of articular cartilage as a fluid-filled, wear-resistant surface. It reduces the friction coefficient to 0.0025 better than the best-performing artificial joint by a factor of at least 30. The other options, while correct, are of less importance.

Comment: We have included this SBA as we think it is a useful learning question with some good learning points. However, this SBA would be likely to be rejected because the correct answer theme is out of synch with the other four themes, which deal with loads and weight distribution. This could be guessed as the correct answer by some streetwise candidates. Also, when we trialled this question, it was regarded as being a fairly easy question to answer for almost all candidates.

If we were to rewrite the question it would be:

The main function of articular cartilage is to

A. Act as a shock absorber
B. Facilitate the transmission of loads to the underlying subchondral bone
C. Minimise peak pressures on the subchondral bone
D. Resist the compressive forces encountered across the joint under loading conditions
E. To resist tensile, shear and compressive forces

Answer E. **To resist tensile, shear and compressive forces**

To summarise, the main functions of articular cartilage in synovial joints are to provide a low friction surface for motion and resist tensile, shear and compressive forces.

3. Answer A. **Chondrocytes are most numerous in the superficial zone**

This is another SBA concerned with articular cartilage structure. Answers B, C, D and E are incorrect. It is important to have an idea of the changes in composition of articular cartilage through the different layers. Think in terms of cells (chondrocytes), collagen, proteoglycans and water content.

The collagen fibrils in the deep layer are larger and oriented perpendicularly to the surface, this layer has been thought to provide the greatest resistance to compressive forces.

The calcified layer contains a small volume of cells embedded in a calcified matrix and thus shows very low metabolic activity. These cells synthesise type X collagen, which forms a meshwork and is associated with cartilage calcification.

The relative water concentration decreases from about 80% at the superficial zone to 65% in the deep zone.

The superficial layer contains a relatively high number of flattened chondrocytes. In the intermediate zone, the chondrocytes are spherical and at low density. At the deep zone, chondrocytes are typically arranged in columnar orientation, parallel to the collagen fibres and perpendicular to the joint line.

As one moves down the articular cartilage layers, think in terms of the compositional, structural and functional changes that are occurring.

Of note is that the water content is lowest in the deep radial zone, although the proteoglycan concentration is highest.

Only around 40% of the total possible amount of water is bound to proteoglycans, the rest prevented so by the resistance provided by the collagen meshwork.

Proteoglycans within the matrix are only partially hydrated (around 40%) and exert a constant pressure to expand and attract more water, restrained only by the collagen fibril meshwork. If this meshwork is disrupted through injury, the matrix swells as proteoglycans expand, increasing the concentration of water and reducing the concentration of proteoglycans.

4. Answer D. **Osteochondral autograft transfer system (OATS/mosaicplasty)**
This SBA is linking basic science to clinical application. Contained lesions $<2cm^2$ should be treated by microfracture. Microfracture enhances migration of mesenchymal stem cells (MSCs) from bone marrow bleeding to the site of a cartilage defect. It often results in the formation of fibrocartilage that is biochemically and biomechanically inferior to hyaline articular cartilage. There is a progressive decrease in clinical benefit after 2 years, especially for large defects or those involving the PFJ.

AMIC combines microfracture with the application of a biological scaffold acting as a collagen, cell-free matrix that covers the produced blood clot, permitting the containment and ingrowing of MSCs to differentiate into the chondrogenic lineage. This is a promising technique with emerging evidence but needs additional non-biased, high-powered, randomised controlled clinical trials to provide better long-term clinical evidence to define possible indications for use.

With ACI, a full-thickness sample from a low-weight-bearing region of the joint is collected by biopsy punch during a first arthroscopic operation to provide a chondrocyte population that is then expanded in vitro, yielding ~12–48 million cells. During a second operation, the chondrocytes are implanted into the debrided cartilage defect and covered by a membrane. It is an effective and durable treatment for large ($>4cm^2$) knee cartilage lesions.

5. Answer D. **Increased keratin sulphate**
This SBA tests knowledge of age-related changes in articular cartilage. This is level 1 knowledge testing of straightforward bread-and-butter FRCS (Tr&Orth) basic science material. It is particularly difficult at times to construct level 2 basic science questions and is especially true with anatomy and surgical approaches type questions.

With ageing, there is disruption of the collagen–proteoglycan matrix. Leeching out of the proteoglycan leads to increased permeability and increased stiffness. Increased permeability leads to loss of lubricant.

It is generally assumed that with increasing age there are reduced chondrocyte numbers present. Although there are zonal changes in the distribution of chondrocytes, the total remains essentially unchanged. Chondrocytes begin to dissipate in the superficial region, whereas in the deeper layers there are an increased number of cells.

With increasing age, there is a decrease in the hydration of the matrix, with a corresponding increase in compressive stiffness.

6. Answer C. **Type VI is involved in cell–matrix interactions**
This SBA is testing a candidate's knowledge on the types of collagen fibres present in articular cartilage. There are many types of collagen fibres in AC,

the majority being type II collagen (90–95%), which provides a tensile strength to the articular cartilage.

Types II, IX and XI form a mesh that serves to trap proteogylcans providing for stiffness and strength (Table 24.1).

Table 24.1 Function of collagen in articular cartilage

Collagen type	Function
II	Forms the network of fibrils within which the proteoglycans are contained
VI	Helps chondrocytes adhere to the matrix framework. Increases in early OA
IX	Facilitates fibril interaction with the matrix proteoglycan molecules. Stabilisation collagen II network
X	Organises the collagen fibrils into a 3-dimensional hexagonal lattice. Only found near calcified zone
XI	Regulation of fibrils size
III, XII & XIV	Function in articular cartilage unknown
II, IX & XI	Form a mesh that serves to trap and constrain the proteogylcans matrix providing for stiffness and strength

Table 24.2 Ageing versus osteoarthritis

Parameter	Effect of Ageing	Effect of Osteoarthritis
Water content	Decreased	Increased
Chondrocyte number	Unchanged	No change
Chondrocyte size	Increased	No change
Collagen concentration	Relatively unchanged	Decrease in severe OA
Proteoglycan concentration	Decreased	Initially increased but with progression becomes decreased
Proteoglycan synthesis	Decreased	Increased
Proteoglycan degradation	Decreased	Increased
Chondroitin 4 sulphate	Decreased	Increased
Keratin sulphate	Increased	Decreased
Modulus of elasticity	Increased	Decreased
Metabolic activity	Unchanged	Increased

7. Answer E. **Water content increased in OA/ decreased in ageing**
The pathophysiological differences between ageing and osteoarthritis is again classic basic science FRCS (Tr&Orth) material. Perhaps it is best remembered as changes occurring with water, chondrocytes, collagen and proteoglycans. Ageing and degenerative changes (osteoarthritis) are quite distinct in articular cartilage but less so with the intervertebral disc and menisci.

With ageing, there is an age-related decline in the ability of chondrocytes to maintain the tissue. If all else fails, learn the contents of Table 24.2.

8. Answer E. **Increase in metabolic activity**
Again, classic basic science material. Again, learn the table (Table 24.2).
Initial increase in chondrocyte synthetic and proliferative activity, loss of proteoglycans and increased water content; eventual decreased synthetic activity and increased degradative enzyme activity.

The chondrocytic anabolic response eventually declines, and the imbalance between chondrocyte synthetic activity and degradative activity leads to progressive thinning and loss of articular cartilage.

9. Answer E. **Loss of interstitial fluid pressure**
Disruption of the collagen type II network results in reduced tensile stiffness and strength. There is a significant increase in water content and permeability.

There are inferior mechanical properties of articular cartilage in OA with decreased compression strength. A number of internet sources and revision notes incorrectly describe an increased mechanical strength of AC with OA.

10. Answer E. **Recovery of endosteal bone circulation after reaming takes around 3 months**
During early fracture, healing blood flow is centripetal (outside to inside) because the high-pressure nutrient artery system is often disrupted.

Reaming devascularises the inner 50–80% of the cortex and delays revascularisation of the endosteal blood supply

Nutrient artery is centrifugal high pressure

Centripetal (outside to inside) flow occurs with a completely displaced fracture and immature developing bone

11. Answer C. **To contain the axial-load-related deformation of the nucleus**
This SBA is testing the function of the annulus fibrosis. Its main function is to contain and restrain the forces acting on the nucleus pulposus. This allows for uniform distribution and transfer of compressive loads between the vertebral bodies. While it facilitates joint mobility and prevents intervertebral distraction, these are of secondary importance. Similar to articular cartilage, try to avoid using the term 'shock absorber'.

12. Answer E. **Structural failure of the matrix**
This SBA is deliberately mixing up the normal ageing changes of the IVD with IVD degeneration. The differences between the two conditions are not always clearly explained in the literature. Complicating matters, both processes share several similar features such that many textbooks describe the two (pathological) processes as one, co-existing together.

With ageing, the disc nucleus loses some of the proteoglycan molecules that bind water into the tissue. This reduces the nucleus hydration and pressure, so that the disc bulges radially with a 'middle-aged spread'. There is increased cross-linking of the disc's collagen that causes the tissue to become stiffer and more fibrous, and to develop a yellow/brown discolouration. After skeletal maturity, cell density remains constant, although more of the cells become senescent.

Intervertebral disc degeneration is characterised by structural damage to the disc matrix, combined with increased activity of matrix-degrading enzymes. This can be interpreted as attempted repair, which is largely frustrated by the low cell density and by repeated damage (Figure 24.5).

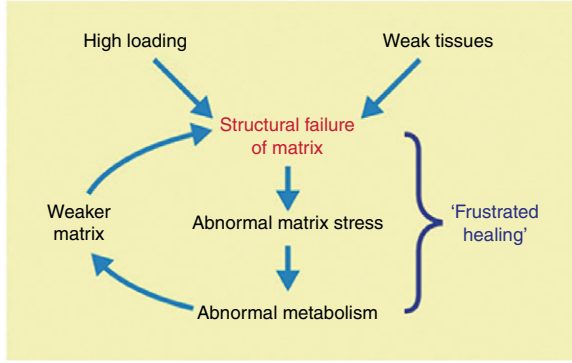


Figure 24.5 Failure can be caused by high loading of normal tissue, or normal loading of tissue that has been weakened by age and/or unfavourable genes. Damaged matrix resists mechanical loading unevenly, and abnormal matrix stresses interfere with disc cell metabolism, resulting in weakening and further structural damage. This 'vicious circle' can be characterised as 'frustrated healing' because of the inability of the relatively low population of disc cells to fully repair their extensive matrix. Torrie A, Adams MA. Basic science of spinal degeneration. *Surgery* 2015;**33**:233–237

13. Answer E. **Type I collagen fibres are attached to the ring apophysis**
Type II collagen and water increase in proportion from the outer annulus towards the inner annulus and transitional zone.

The NP contains chondrocyte-like cells, while the AF contains fibroblast-like cells.

The opposite is true in that lamellae are more abundant and stronger in the anterior and lateral aspects of the disc in comparison to those at the posterior and posterolateral aspects, where the annulus is thinner. This may have relevance, as the majority of intervertebral disc prolapses occur in the posterior/posterolateral areas.

The type II collagenous lamellae of the inner annular layers are loosely attached to the cartilaginous zone of the end plates. Avulsions of the nucleus pulposus at this level are frequent, undiagnosed traumatic lesions in children.

The collagen type I fibres in the outer and tougher part of the AF are powerfully attached to the peripheral area of the osseous end plate (through the Sharpey's fibres) but do not enter the subchondral bone. The insertion place of outer collagen type I fibres is called the ring apophysis and is a common site for peripheral rim fractures and tear.

Elastin fibres, constituting 2% of the AF dry weight, pass radially from one lamella to the

next, binding them together, and possibly helping the IVD return to its original arrangement following bending. Additionally, the lamellae are interconnected by lubricin and type VI collagen. Lubricin, known for its lubricant role within diarthrodial joints, is probably involved in the reduction of friction between adjacent lamellae.

14. Answer E. **Pyknodysostosis**
This is an SBA on sclerosing bone dysplasia. They result from some disturbance in the pathways involved in osteoblast or osteoclast regulation, leading to abnormal accumulation of bone. Radiographs obtained in patients with these disorders need to be interpreted and a reasonable differential diagnosis given.

Osteopetrosis and pyknodysostosis are disorders of the primary spongiosa. Osteopoikilosis and osteopathia striata are disorders of the secondary spongiosa. Progressive diaphyseal dysplasia is a disorder of intramembranous ossification.

The hallmark of osteopetrosis radiographically is increased density within the medullary portion of the bone with relative sparing of the cortices.

Pyknodysostosis is an autosomal-recessive trait with a mutation in the cathepsin K gene. Cathepsin K is a lysosomal cysteine proteinase that is expressed in osteoclasts and is required for the degradation of collagen.

Radiographically, there is generalised osteosclerosis similar to osteopetrosis, but with preservation of the medullary canal of long bones. Bones are brittle and prone to fracture (Figure 24.6).

Osteopoikilosis is a disorder of endochondral ossification involving the secondary spongiosa. There are focal deposits of compact lamellar bone in the spongiosa that have the appearance of an enostosis, or bone island. These bone lesions are asymptomatic.

Osteopathia striata is characterised by dense linear striations in the diaphyses and metaphyses of long and tubular bones. The striations run parallel to the long axis of the bone and are typically seen in areas of rapid growth such as the femur. It is a disorder of the secondary spongiosa, also known as Voorhoeve disease. This disorder has no known associated physical or laboratory abnormalities and is, therefore, usually discovered incidentally at radiography performed for some other reason.

Progressive diaphyseal dysplasia is a disease of intramembraneous ossification. Radiographically, there is bilateral and symmetric cortical thickening involving both the periosteal and endosteal surfaces of long bones. Narrowing of the medullary canals may occur. The tibia is the most commonly affected bone. The metaphysis and epiphysis are typically not involved, since these regions are formed by endochondral ossification. Therefore, there is often a sharp demarcation of normal bone in these regions.

Figure 24.6 Pyknodysostosis. Anteroposterior (a) and lateral (b) radiographs of the left tibia and fibula show hyperostosis with preservation of the medullary cavity. A subacute fracture is noted in the mid-diaphysis of the tibia, a common finding in patients with pyknodysostosis

15. Answer C. **Didronel (etidronate) is metabolised into a non-functional adenosine triphosphate (ATP) analogue inducing apoptosis**
This SBA reinforces revision of how bisphosphonates work. It can be an unexpected SBA or viva question.

There are two classes of bisphosphonates based on the presence or absence of a nitrogen side group: (1) nitrogen-containing and (2) non-nitrogen-containing. Each class of bisphosphonates has a different mechanism of action.

Nitrogen-containing bisphosphonates inhibit protein prenylation within the mevalonate

pathway, blocking farnesyl pyrophosphate synthase. This results in the loss of guanosine triphosphate (GTPase) formation, which is needed for ruffled border formation and cell survival. Didronel (etidronate) is a non-nitrogen-containing bisphosphonate. Non-nitrogen-containing bisphosphonates have a simpler mechanism of action and induce osteoclasts to undergo premature death and apoptosis and do so by forming a toxic non-functioning adenosine triphosphate (ATP) analogue.

16. Answer D. **Macrophages, B-cells and T-cells are involved in bone remodelling**
The site of bone remodelling contains bone cells that include osteoblasts, osteoclasts, bone-lining cells and osteocytes, which form a basic multicellular unit (BMU). In addition to these cells, immune cells including macrophages, B-cells and T-cells are also involved in bone remodelling.

There are a few details of the Hueter–Volkmann Law that candidates may be tested on. Bone remodels in small packets of cells known as BMUs. The theory suggests that mechanical forces influence longitudinal growth, while compressive forces inhibit growth. For brownie points, candidates could mention that its theory may account for some forms of scoliosis.

17. Answer A. **Freeze-dried is the least immunogenic**
It is important to know something about the biological properties of the different types of bone graft.

Allograft bone has no osteogenic cells and fair osteoconduction and osteoinduction. Freeze-dried bone is the least immunogenic but has the least structural integrity (weakest).

18. Answer B. **Increased alkaline phosphate levels**
This is nutritional rickets. Causes of rickets include vitamin D deficiency, phosphorus or calcium deficiency (rare), inadequate sunlight exposure, secondary to malabsorption syndromes (IBD, coeliac disease, cystic fibrosis (rarely)). Calcium can be low or normal depending on the severity of the condition. PTH levels are elevated.

The earliest radiological findings are limited to the distal ulnar region in infants and to the lower and upper metaphyses of the knees in older children.

19. Answer E. **Normal 25(OH)D**
X-linked hypophosphataemic rickets (XLHR) is a dominant, inherited disease caused by isolated renal phosphate wasting and impairment of vitamin D activation. It is the most common form of hereditary rickets, with incidence of 1:20 000 live births. The basis of XLHR is the inactivating mutations in the *PHEX* gene (phosphate-regulating gene) which is located in Xp22.1-22.2.

The *PHEX* gene negatively regulates FGF23 expression. FGF23 excess induces hypophosphataemia via impaired phosphate reabsorption in the renal proximal tubules and decreased phosphate absorption in the intestines.

Laboratory findings include hypophosphataemia, hyperphosphaturia, high serum level of alkaline phosphatase, normal calcaemia, 25(OH) D and PTH.

20. Answer C. **It is a fibril-forming collagen**
Collagen is type I in bone. The structural unit of type I collagen is called tropocollagen and is a trimer composed of three polypeptide chains. Two chains are α1 chains, and the third chain is α2. The three chains form a distinctive unit in which the polypeptide chains wrap around each other for most of their length, forming a tight triple helical braid.

Each polypeptide chain is a left-handed helix, but the triple helix is a right-handed superhelix (i.e. the opposite way around).

The triple helical structure is not the same as the α helix that is formed by a single polypeptide chain and is the defining feature of all collagen. There are non-helical N and C telopeptides flanking the helical region on each side as well as the N and C terminal propeptides that are cleaved during post-translational processing.

It is a fibril-forming collagen.

Several tropocollagen molecules are aggregated in an organised head-to-tail fashion into a structure called a collagen fibril. These collagen fibrils can be seen with an electron microscope and exhibit a 67nm D-period banded appearance due to staggered gaps between the heads and tails of the molecules in each row.

21. Answer A. **Ankylosing spondylitis**
Sclerostin expression is regulated by a wide variety of factors, including mechanosensation, local cytokines and endocrine factors. Increased sclerostin levels are associated with osteoblast apoptosis and decreased bone formation.

Sclerostin is a *SOST* gene product under nuanced regulatory control. It is integral to osteocyte function as a signal to damp the action of osteoblast bone deposition and to control bone metabolism. Its anti-anabolic effect on bone has rendered it an important molecule in fracture healing, osteoporosis, metastatic disease and a variety of other disorders. Development of sclerostin antibodies has shown promising results and wide applicability to a multitude of orthopaedic conditions.

Increased sclerostin levels are caused by menopause, diabetes mellitus, immobilisation, multiple myeloma and thalassaemia. Decreased sclerostin levels are associated with mechanical loading, resistance exercise, intermittent PTH, ankylosing spondylitis and Van Buchem disease.

Compton JT, Lee FY. A review of osteocyte function and the emerging importance of sclerostin. *J Bone Joint Surg Am.* 2014;**96**:1659–1668.

22. Answer E. **With degeneration, the inner AF undergoes an increase in collagen content with type II collagen fibrils becoming type I**
It is important to have an understanding of the anatomy of the IVD and relate the structure to function. This SBA is testing candidates on the structure of the AF.

Inner AF contains chondrocytes while the outer AF contains fibroblast like cells.

Compression damages the end plates.

Cadaver studies have suggested that compression damages the end plates, but not the AF.

The lamellae are more abundant and stronger in the anterior and lateral aspects of the disc in comparison to those at the posterior and posterolateral aspects, where the annulus is thinner. This may have relevance, as the majority of intervertebral disc prolapses occur in the posterior/posterolateral areas.

The inner AF undergoes an increase in collagen content, with type II collagen fibrils becoming type I.

From the outer to inner AF, there is an increase in type II collagen and decrease in type I collagen, resulting in less distinctive lamellae. Lamellae thickness varies by location (anterior/posterior/lateral) within the disc. The AF outer lamella fibres are attached to the vertebra, while the inner lamellas merge with the cartilaginous end plate.

23. Answer B. **Reamed nailing significantly reduces the risk of screw breakage**
Unreamed nails probably do disturb the endosteal blood supply but less so than a reamed nail.

The reactive increase in periosteal blood flow is less in unreamed nails and this may help explain why they may not offer as predictable or rapid a time to union as reamed nails.

Ream whenever possible, as this allows you to insert a bigger nail that is biomechanically more stable with less motion at the fracture site, generating products of reaming which may be osteoinductive.

An unreamed nail is a reasonable option in polytrauma or in a pathological fracture where the life expectancy of the patient is short.

While reaming is known to have distinct advantages in the treatment of closed tibial fractures, including a shorter time to fracture healing, there is a lower prevalence of non-union and less screw breakage. This is of particular concern in open tibial fractures, where soft tissue disruption has already compromised blood supply, which is crucial for wound healing and the prevention of infection.

Blood flow is reversed with reaming from centrifugal (inside to outside) to centripetal (outside to inside).

Johal H, Bhandari M, Tornetta P 3rd. Cochrane in CORR®: Intramedullary Nailing for tibial shaft fractures in adults [Review]. *Clin Orthop Relat Res.* 2017;**475**:585–591.

24. Answer A. **Cortical bone has a basic structural unit of an osteon, whereas cancellous bone is composed of a 3D lattice of rods and plates**
This SBA probes knowledge of the structural differences between cortical and cancellous bone. All answers are correct. Architectural characteristics differentiate the two types of bone. This

would be followed by porosity, location and description and mechanical stress.

25. Answer A. **Ligament of Humphrey is taut during flexion and lax during extension**
This is an anatomy SBA with a focus on clinical relevance.

Posteriorly, the posterior horn of the lateral meniscus may be connected to the lateral side of the medial femoral condyle by one or two meniscofemoral ligaments (MFL). The anterior MFL (ligament of Humphrey) passes in front of the PCL, the posterior MFL (ligament of Wrisberg) passes behind the PCL.

In about 70% of knees, there is either an anterior MFL (ligament of Humphrey) or posterior MFL (ligament of Wrisberg) present. In 6% of knees, both ligaments will be present.

The ligament of Humphrey is thinner (<one-third diameter PCL). It arises from the posterior horn of the lateral meniscus, runs anterior to the PCL and inserts at the distal edge of the femoral PCL attachment. This ligament may be mistaken for the PCL during arthroscopy.

The posterior MFL is usually larger than the anterior MFL (around half the diameter of the PCL). It extends from the posterior horn of the lateral meniscus to the medial femoral condyle and lies posterior to the PCL. At the femur, it inserts at the medial part of the intercondylar notch near the insertion of the posteromedial band of the PCL. This is the reason why fibres of the posterior MFL and PCL sometimes intermingle.

The MFLs play an important role as stabilisers and protectors for the posterolateral femorotibial compartment. They increase congruity between the mobile lateral meniscus and lateral femoral condyle during motion of the knee. They also carry a protective role for the posterior horn of the LM.

The MFLs have a totally different function during knee extension and flexion due to differently applied tension on the anterior and posterior MFL. The anterior MFL is taut during flexion and lax during extension, whereas the posterior MFL is taut during extension and lax during flexion.

The anterior MFL has a supplementary role to the anterior band of the PCL, whereas the posterior MFL supplements the function of the posterior band of the PCL. MFLs could act as a splint during injuries of the PCL.

The posterior MFL commonly causes a pseudotear of the posterior horn of the lateral meniscus on imaging. There is a well-known ligament of Wrisberg pseudotear, caused by the vertical/oblique signal intensity region that occurs normally at the junction of the ligament of Wrisberg with the posterior horn of the lateral meniscus.

The Wrisberg rip is a characteristic longitudinal vertical tear of the posterior horn of the lateral meniscus that may be seen in association with ACL tears. This tear type is important for two reasons. First, many people realise that meniscal tears are common in association with ACL disruption, but tears at the central portion of the posterior horn laterally are among the most frequently missed. The Wrisberg rip is one of those tears. Second, because the Wrisberg rip appears to occur only in association with ACL tears, this tear pattern may be used as a secondary sign of ACL disruption.

26. Answer D. **Osteopoikilosis**
Osteopoikilosis is a form of skeletal sclerotic dysplasia that is asymptomatic. It is a rare inherited benign condition incidentally found on skeletal X-rays. Its importance is predominantly in correct diagnosis so that it is not mistaken for pathology.

Imaging shows multiple, small ovoid sclerotic foci, which are symmetrically distributed.

On the AP pelvic radiograph, multiple small sclerotic bone islands of varying sizes are noted in the hip bones and the head, neck and proximal metaphysis of both femurs.

27. Answer E. **Their ultimate tensile strain is less**
Although the stress–strain curves of ligaments and tendons are very similar, and they are often shown graphically as one composite, there are some subtle differences. Candidates should be aware of these dissimilarities, as it is easy marks lost otherwise.

Of the values for ultimate tensile strength and strain and Young's modulus, the ultimate tensile strain is most notably different between tendons and ligaments. This may be explained by the higher proportion of collagen and lower

proportion of elastin in tendons and the more uniform arrangement of collagen fibres.

Ultimate tensile strength is generally less than for tendons, but this is variable and depends on what ligament is being tested.

Small force reduction dips are specific for both tendons and ligaments.

28. Answer E. **When a lever's effort arm is longer than its load arm, it is said to have mechanical advantage**
Load to fulcrum lever arm is longer than the force to fulcrum lever arm.

When a lever's load arm is longer than its effort arm, it is said to be at a mechanical disadvantage. It has a low load-force-to-effort ratio. Third-class levers always have a mechanical disadvantage.

29. Answer B **Yield point**
This SBA is testing point definitions on a stress–strain curve (Figure 24.7).

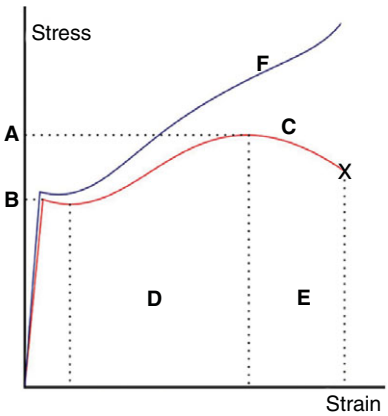


Figure 24.7 Stress-strain curve

A. Ultimate strength
B. Yield point
C. Apparent stress (red)
D. Strain-hardening
E. Necking
F. Actual stress (blue)
X. Rupture

30. Answer C. **Increased rupture strain**
As the strain rate increases, the ultimate strength increases and the ultimate strain decreases (Figure 24.8).

This is an SBA dealing with viscoelastic properties. Another time-dependent property is strain-rate sensitivity. Different tissues show different sensitivities to strain rate. For example, there may be little difference in the stress–strain behaviour of ligaments subjected to tensile tests varying in strain rate, while bone properties may change considerably.

Bone is strain rate-sensitive and tends to be more strain rate-sensitive than other biological tissues. This has implications for bone–ligament and bone–tendon injuries. The optimal strain rate for energy absorption is around 0.1–1 per second.

With an increased loading rate there is

A. Increased brittleness
B. Energy storage increased 2× (increased toughness)
C. Rupture strength increased 3×
D. Rupture strain decreased 100%
E. Stiffness increased 2×

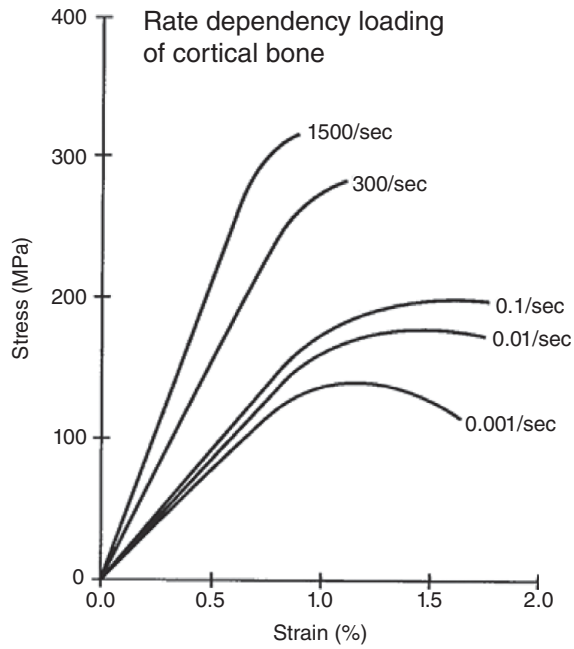


Figure 24.8 Strain-rate sensitivity of cortical bone

31. Answer B. **Load transmission (bearing)**
This is an SBA on meniscal function. It is straightforward basic science material, but it is surprising

how often candidates struggle to name more than two or three meniscal functions.

Shock absorption is usually mentioned (see below) and candidates aren't usually able to go into any great detail or depth with their answer.

The menisci are important structures in the knee joint, and their functions vary from their primary role in load transmission to more secondary roles in stabilisation, nutrition and proprioception.

They also serve to decrease contact stresses and increase contact area and congruity of the knee.

At least 50–70% of the compressive load is transmitted through the meniscus when the knee is in extension with an increase to 85% at 90° flexion.

While shock absorption is a role commonly stated in papers and textbooks describing the menisci, this function of the menisci is not intuitive. On review of the literature, there is little evidence that shock absorption is indeed a significant function of the menisci.

Mechanically, a shock absorber is defined as a device that dissipates energy to modify the response of a mechanical system to applied shock. Some believe the shock-absorbing ability of the knee is due to eccentric contractures of the muscles that surround the knee.

Get-out phrase is 'The menisci are often described as being shock absorbers in textbooks, but this is fairly controversial and disputed by some authors.'

The meniscectomised knee results in a significantly reduced contact area of 50–70% medially and 40–50% laterally.

Joint stability is enhanced by the shape of the meniscus. The concavity of the superior aspect of the meniscus and the flat surface of the inferior aspect of the meniscus enhance the congruity of the tibiofemoral joint.

Medial meniscectomy in the ACL-intact knee has little effect on anterior-posterior motion, but in the ACL-deficient knee, it results in an increase in anterior-posterior tibial translation of up to 58% at 90° of flexion.

Although it has been suggested that the meniscus has a role in joint lubrication, no studies to date have proved a direct contribution.

32. Answer D. **Removal of the medial meniscus results in a 50–70% reduction in femoral condyle contact area and a 100% increase in contact stress**

Medial meniscectomy decreases contact area 50–70% and increases contact stress 100%, whereas lateral meniscectomy decreases contact area 40–50% but dramatically increases contact stress 200–300% secondary to the relative convex surface of the medial tibial plateau. This explains why a lateral meniscectomy has a much worse outcome in terms of developing osteoarthritis than a medial meniscectomy.

The lateral meniscus occupies a larger portion (~80%) of the articular surface than the medial meniscus (~60%).

Approximately 70% of the load in the lateral compartment and 50% of the load in the medial compartment is transmitted through the menisci.

Horizontal cleavage tears may cause pain and lead to mechanical instability of a portion of the meniscus, but they will not disrupt the functional continuity of the circumferential fibres. Hence, the load-bearing functions of the meniscus should be largely preserved. Excision of meniscal tissue in this circumstance (as opposed to repairing the meniscus or even just leaving it alone) will result in loss of functional tissue, and hence the meniscal trim could be said to cause arthritis in the future. Radial or complex ragged tears classically disrupt hoop stresses in a meniscus at the time of injury. The aim of trimming such a tear is specifically to relieve the symptoms of the tear. However, if only the torn de-functioned tissue is removed, then it follows that meniscectomy per se will be unlikely to cause an increased risk of arthritis, as the damage has already been done at the time of the tear.

Excision of meniscal tissue in a radial tear will result in loss of functional tissue, and therefore the meniscal trim could be said to cause arthritis in the future.

With radial tears or ragged complex degenerative tears, the meniscal tissue is likely to have been de-functioned at the time of the actual injury.

The increased intra-articular contact stresses within the knee after meniscectomy are thought to 'overload' the articular cartilage. Associated biochemical changes include loss of proteoglycan, disaggregation of proteoglycan, an increase in synthesis of proteoglycan and an increase in hydration.

There is a great variability in medial meniscus anterior horn insertion types, but insertions of the lateral meniscus are less variable and quite close.

33. Answer E. **Z lines move closer together**
This is a level 1 basic science SBA testing factual knowledge of muscle physiology. It revises important factual information that can be tested in a basic science Part 2 viva. The sliding filament theory explains changes that occur between thick and thin filaments during contraction:
- During contracture the actins are pulled towards centre of each myosin myofilament. The sarcomeres shorten.
- H band gets smaller.
- I band get smaller.
- Zone of overlap gets larger.
- A band stays at the same length.
- Z lines move closer together.
- In a fully contracted muscle, the ends of the actin myofilaments overlap, the H zone disappears and the I band becomes very narrow.

34. Answer D. **Titin fibres extend from the peripheral Z-disk to the central M band**
More difficult than the previous SBA. Provides another opportunity to revise muscle physiology.

Titin is a structural protein that connects Z disc to M line of sarcomere, thereby helping to stabilise thick filament position; it can stretch and then spring back unharmed, and thus accounts for much of the elasticity and extensibility of myofibrils.
- A **sarcomere** is the basic unit of striated muscle tissue. It is the contractile unit of a muscle cell. It spans from one Z line (disc) to the next.
- The **Z line** represents the attachment of adjacent saromeres. Actin fibres are anchored on the 'z' line.
- The **I band** represent just actin filaments in adjacent sarcomeres where there is no overlap with myosin filaments.
- In between the I bands is the **A band** of the sarcomere. An A band contains the entire length of a thick filament (myosin) filament.

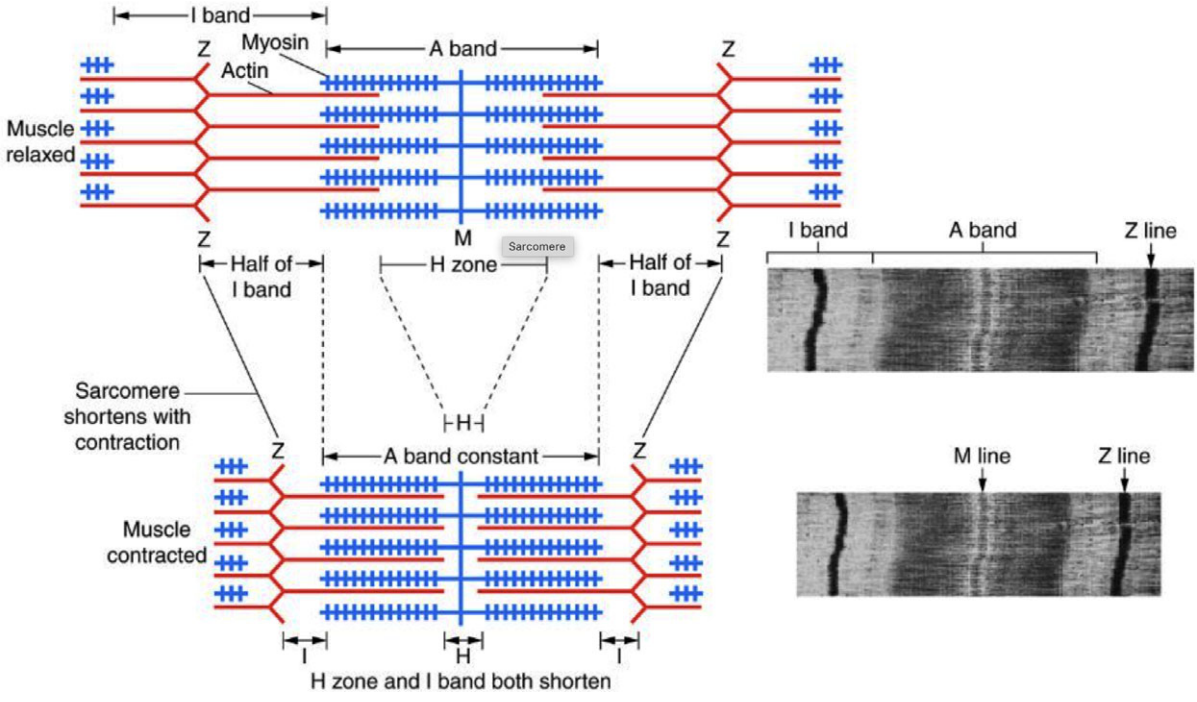


Figure 24.9 When a sarcomere contracts, both the H zone and the light I band shrink in width, while the dark A band doesn't appear to narrow. Colorado Community College System, Anatomy and Physiology, https://pressbooks.ccconline.org/bio106/chapter/muscular-levels-of-organization/ CC BY-SA 4.0, no changes made

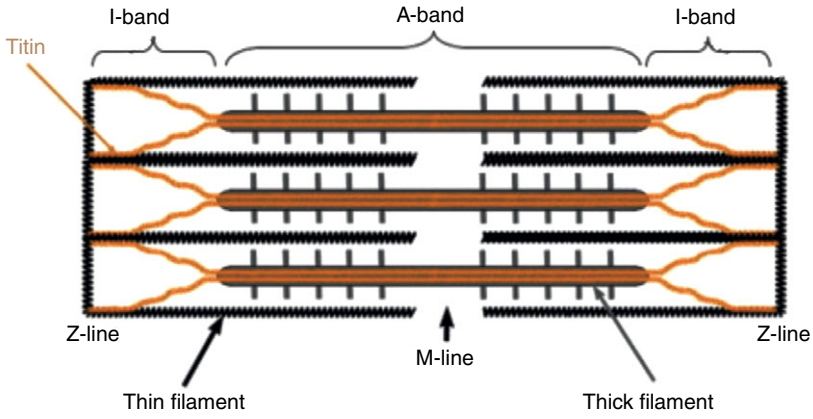


Figure 24.10 The A-band (dark band) consists mainly of thick myosin filaments (joined at the M-line), whereas the I-band (light band) is composed of thin actin filaments. Each sarcomere is flanked by a Z-disc region

It is darker on the edges where there is a double, overlapping, hexagonal array of thick filaments (mostly myosin) and thin filaments (actin plus the regulating proteins: troponin and tropomyosin). It is anisotropic.

- The **central H zone of the A band** contains only thick myosin filaments.
- The **M-line** (or M-band) maintains (anchors) the myosin filaments in a hexagonal lattice and the **Z-line** (or Z-band) maintains the actin filaments in a tetragonal lattice.
- **Titin fibres** act as a molecular spring that holds the myosin and actin filaments in place. They extend from the Z-line of the **sarcomere**, where it binds to the thick filament (myosin) system, to the M-band, where it is thought to interact with the thick filaments.
- Z-line maintains the actin filaments in a tetragonal lattice.
- M-band (M-line) maintains the myosin filaments in a hexagonal lattice

35. Answer A. **At high strain rates, tendons are more effective in moving large loads**
At high strain rates, tendons become less deformable with a high degree of stiffness and are more effective in moving large loads.

The toe region ends at about 2% strain when all crimpled fibres straighten.

In normal activity, most ligaments and tendons exist in the toe and somewhat in the linear region.

The upper limit of physiological strain for tendons and ligaments is 4–8%. Under normal physiological conditions ligaments and tendons are subjected to a stress magnitude that is around one-quarter to one-third ultimate tensile strength.

36. Answer E. **When subjected to increased strain rates, the linear portion of the stress strain curve becomes steeper, indicating greater stiffness of the tissues and more energy storage therefore requiring more force to rupture**
This is an SBA on viscoelasticity. A number of materials display viscoelastic properties. Classically ligament and tendon but also articular cartilage, bone, meniscus, intervertebral disc and cement. Viscoelastic materials exhibit stress-strain behaviour that is time and rate dependent. i.e. the material deformation depends on the load and its rate and duration of application.

A viscoelastic material displays the properties of creep, stress relaxation, hysteresis and load-dependent deformation.

At low loads viscous behaviour dominates whilst at higher loads elastic behaviour dominates. This balance allows ligaments and tendons to function within a fairly wide range of loads without damaging their fibres.

When ligaments and tendons are repetitively loaded, the stress-strain curve shifts to the right indicating that the tissues have become less stiff and more compliant.

Creep is an increase in deformation of a material under a constantly applied load. Initially, elongation under a constant load occurs quickly, however, this response slows with time. Cyclic creep occurs during cyclic dynamic

testing, where each consecutive load cycle generally causes an increase in the amount of deformation. In contrast with creep, stress relaxation holds strain constant. Stress relaxation in tendon is demonstrated when a measured load in a tendon decreases over time with a constant strain. This load initially decreases under a constant strain quickly, but the rate of change decreases over time as it approaches equilibrium.

37. Answer C. **Latency and conduction velocity should be identical with either method**
Median sensory nerve conduction studies are the most often performed electrodiagnostic tests worldwide. Routine tests in clinical practice are done using either antidromic or orthodromic techniques type of stimulation, with no universal agreement on the use of one or the other technique.

Recording the SNAP orthodromically refers to distal nerve stimulation and recording more proximally (the direction in which physiological sensory conduction occurs). Antidromic testing is the reverse.

- Antidromic – stimulating toward the sensory receptor.
- Orthodromic – stimulating away from the sensory receptor.
- Latency and conduction velocity should be identical with either method.
- Amplitude is higher in antidromic stimulation.
- Antidromic technique is superior – higher amplitude.

With the antidromic technique the stimulating electrode activates the median nerve at the wrist and the response is recorded over digital nerves of the index or middle fingers.

With the orthodromic technique stimulating electrodes are usually ring electrodes placed around the proximal and middle phalanxes of the 2nd or 3rd digits and the recording electrodes are placed on the ventral aspect of the wrist, over the median nerve, usually at about 1–2 cm proximal to the proximal wrist crease.

Note

1 Despite being widely quoted in textbooks, we wouldn't necessarily suggest mentioning that cartilage acts as a shock absorber, especially in a viva situation. 'Shock absorber' is a layman's term and shouldn't be used. 'Load-bearing structure' is more precise and less controversial. Despite best intentions in the heat of a difficult basic science viva 'shock absorber' always gets mentioned.

Chapter 25

Pathology I Structured SBA

Nicolas Wei and Adam Farrier

PATHOLOGY I STRUCTURED SBA QUESTIONS

1. The physiotherapist has left a message for you to contact them regarding the introduction of closed kinetic chain exercises for rotator cuff dysfunction.
   Examples of closed kinetic chain exercises for the upper body include:
   A. Bench press
   B. Biceps curl
   C. Deadlift
   D. Push-up
   E. Shoulder press

2. A 22-year-old male has undergone ACL reconstruction and has been referred on to physiotherapy.
   Post-operatively, when comparing open versus closed chain exercises:
   A. Open chain exercises are safer because they place less strain on the ACL graft
   B. Open chain exercises are preferred in ACL rehabilitation
   C. Open chain exercises have better knee extensor strength
   D. Open chain exercises have better pain scores
   E. Open chain exercises have improved active knee flexion

3. A semi-professional rugby player attends the specialised sports musculoskeletal outpatient clinic keen to discuss muscle physiology as part of his planned exercise training programme for the new rugby session.
   Concerning type 1 and type 2 muscle fibres:
   A. Type I fibres are divided into types Ia and Ib
   B. Type I fibres have a high strength of contraction
   C. Type I fibres tend to be smaller than type II in young adults who do not carry out strenuous activity although they increase in size with repeated physical exercise
   D. Type II fibres are more prone to anatomical changes following altered energy demands than are type I fibres
   E. Type II fibres have the smallest motor unit size

4. **Compared with tendons, ligaments have:**
   A. Greater tensile strength
   B. Higher content of collagen
   C. Higher metabolic activity
   D. Lower proteoglycan content
   E. Lower water content

5. During ACL reconstruction surgery when a surgeon is preparing the ACL graft the biomechanics of ACL graft preconditioning are discussed.
   During cyclic loading and unloading of an ACL ligament (Figure 25.1)

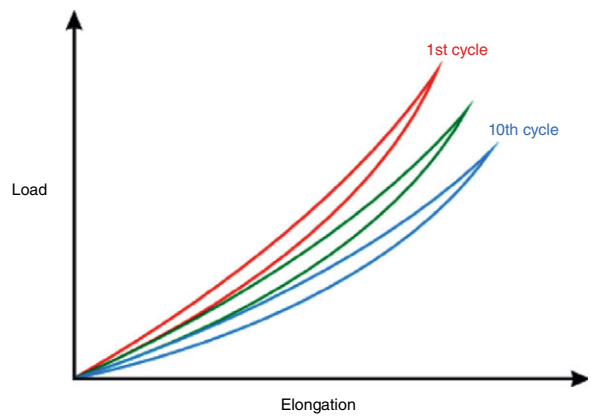


Figure 25.1 Cyclic loading and unloading ACL

A. Displays greater stiffness at the 10th cycle
B. Leads to the ligament resembling an elastic spring
C. The amount of hysteresis is increased
D. The diagram demonstrates pseudo-plasticity which represents the non-linearity of ligament stress strain behaviour
E. The stress/strain curve shifts to the left

6. A 40-year-old plumber felt a pop around his elbow whilst working 1 week ago. He presents with some swelling proximal to the elbow and has continued to work but states that his arm fatigues quickly. He is diagnosed with a distal biceps rupture.
What mechanical property predisposes the distal bicep tendon to rupture?
A. 2nd class lever at the elbow joint
B. 3rd class lever at the elbow joint
C. Antagonism from the larger triceps muscle
D. Hypovascular zone near the radial tuberosity insertion
E. Mechanical impingement of the tendon during forearm flexion

7. **Which of the following best describes the material properties of the head in the right THA seen in Figure 25.2?**

Figure 25.2 Anteroposterior (AP) radiograph pelvis

A. Brittle
B. Ductile
C. Fatigue resistant
D. Tough
E. Weak in compression

8. A 2-year-old girl presents with a 1-week history of feeling generally unwell. This was preceded by a sore throat and her parents are concerned as she is not improving and has become withdrawn. She is reporting discomfort in her right shoulder and a decision is made to aspirate the joint.
Which organism is likely the culprit given the clinical scenario?
A. *Escherichia coli*
B. *Kingella kingae*
C. *Salmonella*
D. *Staphylococcus aureus*
E. *Streptococcus pyrogenes*

9. During fasciectomy for Dupuytren's contracture affecting the MCPJ and PIPJ, the neurovascular bundle is noted to be in the centre of the wound.
What are the components of the pathological structure responsible for this?
A. Central cord
B. Central cord, Lateral digital sheath, Spiral band and Grayson's ligament
C. Pretendinous band, Lateral digital sheath and Cleland's ligament
D. Pretendinous band, Lateral digital sheath, Spiral band and Grayson's ligament
E. Pretendinous band, Spiral band and Lateral cord

10. A 12-year-old boy presents with leg pain of 2 months. Radiographs show periosteal reaction and histology reports uniform small round blue cells.
Choose the most likely genetic defect associated with this condition.
A. Mutation in epidermal growth factor protein (erbB-2) coding gene
B. Mutation of retinoblastoma protein (pRB-1) coding gene
C. Mutation of tumour protein 54 (p53) coding gene
D. Translocation t(11:22)
E. Translocation t(2:13)

11. You review a 19-year-old male patient in outpatients who has suffered progressive muscle weakness and has been declining recently. He has a waddling gait and positive Gower's sign. He

walks on his tiptoes and you note calf enlargement.

Which initial investigation is the most appropriate for your suspected diagnosis?

A. Creatine kinase
B. EMG
C. Genetic testing
D. MRI calf
E. Muscle biopsy and immunohistochemistry

12. You are counselling a 57-year-old man about hybrid hip arthroplasty. He questions how the uncemented cup will be held in the acetabulum.

Which characteristic property of hydroxyapatite (HA) coated acetabulum component enables bone to grow onto the surface of the implant?

A. Osteoconductive
B. Osteogenic
C. Osteoinductive
D. Osteointegrative
E. Transfixative

13. A 76-year-old post-menopausal lady with a fragility fracture attends your fracture clinic for follow up. She has had previous bisphosphonate treatment discontinued due to an intolerance but since her recent fracture the osteoporosis nurse recommended that she starts on denosumab.

The osteoprotective effects of denosumab are due to its analogous function to:

A. Nuclear factor kappa light chain enhancer of activated B cells (NF-kB)
B. Osteoprotegerin (OPG)
C. Parathyroid hormone
D. Receptor activator of nuclear factor-kapp B – ligand (RANKL)
E. Tumour necrosis factor-α (TNF-α)

14. Synovial fluid is an ultrafiltrate of blood plasma proteins and hyaluronan formed by type B synovial cells.

Which mechanical property does synovial fluid exhibit?

A. Dilatant
B. Generalised Newtonian fluid
C. Rheopexy
D. Shear-thickening
E. Thixotropy

15. During the design process for an osteosynthesis device a novel material is considered.

A material that undergoes elastic deformation, but no plastic deformation is termed:

A. Anisotropic
B. Brittle
C. Ductile
D. Stiff
E. Viscoelastic

16. **Following a total hip arthroplasty, which of the following will reduce the joint reaction force?**

A. A bag full of shopping in the contralateral hand
B. Instruct the patient to use a walking stick in the ipsilateral hand
C. Placing the acetabular component in a more lateral position
D. Placing the femoral component in varus
E. Using a cemented implant

17. A 28-year-old cyclist undergoes cannulated screw fixation for an intracapsular neck of femur fracture.

The pull-out strength of a cannulated cancellous screw is most affected by the screw's:

A. Head diameter
B. Inner diameter
C. Outer diameter
D. Pitch
E. Thread angle

18. **Applying an external fixation for ankle fracture dislocation; which of the following has the greatest effect on the rigidity of the construct?**

A. The diameter of the 1st metatarsal pin
B. The diameter of the tibial pin
C. The distance between calcaneal pin and tibial pin
D. The distance from tibial bone to clamp
E. The distance of calcaneum clamp to tibia clamp

19. On assessing a patient with a suspected brachial plexus injury, it is noticed that there is numbness on the radial border of the volar aspect of the forearm.

Of the following structures which one is least likely to be involved?

A. C6 root
B. Lateral cord

C. Musculocutaneous nerve
D. Radial nerve
E. Upper trunk

20. A 23-year-old man is being examined at a follow-up clinic one year after an RTA, where he sustained multiple fractures to his right leg. On examination, he is complaining of pain on light touch to his right leg in certain areas.
This can be described as:
A. Allodynia
B. Complex regional pain syndrome
C. Dysaesthesia
D. Hyperalgesia
E. Neuralgia

21. A 24-year-old polytrauma patient came off his motorcycle at high speed. He is seen in the ED resus area with the right arm rigidly held in an abducted position above his head (Figure 25.3).

Figure 25.3 Clinical picture polytrauma patient

What is his most likely injury?
A. Axillary nerve injury
B. Brachial plexus injury
C. Proximal humerus surgical neck fracture
D. Scapula fracture
E. Vascular injury

22. A 40-year-old male patient presents with a 6-month history of back pain. On examination he has some flattening of his lumbar spine and slight thoracic kyphosis. Plain radiographs demonstrate marginal syndesmophytes.
With regards to the underlying diagnosis which of the following findings on clinical examination is most likely to be present?
A. A 5cm increase with Schober's test
B. Chest expansion of 5cm
C. Fixed flexion deformity hip
D. Occiput to wall distance of 3cm
E. Reduced tragus to wall distance

23. A 36-year-old female chef sustains an iatrogenic injury to her median nerve during routine carpal tunnel decompression.
Following nerve transection, the cellular event signalling the start of regeneration is the:
A. Axonal sprouting
B. Degradation of myelin sheath
C. Formation of Büngner bands
D. Phagocytosis
E. Schwann cell proliferation

24. Concerning the diagram shown in Figure 25.4.
A. Direction vertical component tells us whether the body is accelerating or decelerating forwards
B. During the contact phase vertical component of GFR is less than body weight
C. Initially at foot contact the GRF points forward
D. Line at the extreme left hand represents the GRF when the toe leaves the ground
E. Line at the extreme right hand represents the GRF the moment the foot touches the ground

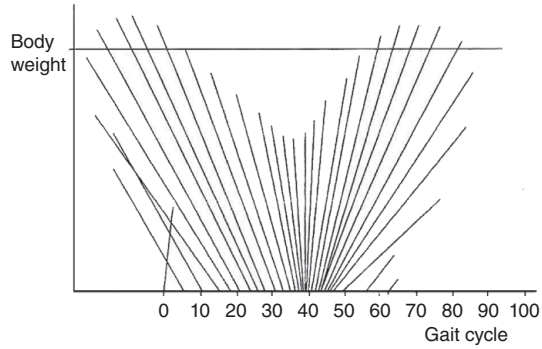


Figure 25.4 Gait cycle and body weight

25. **Concerning the diagram shown in Figure 25.5. During the middle of stance phase:**
    A. GRF acts diagonally backwards and upwards, from the heel
    B. GRF increases in magnitude, acting forwards and upwards
    C. GRF remains < body weight and therefore the CoM is lifted up slightly
    D. Line of action becomes more nearly vertical and therefore the braking/slowing effect disappears
    E. Point of action moves backwards from the heel

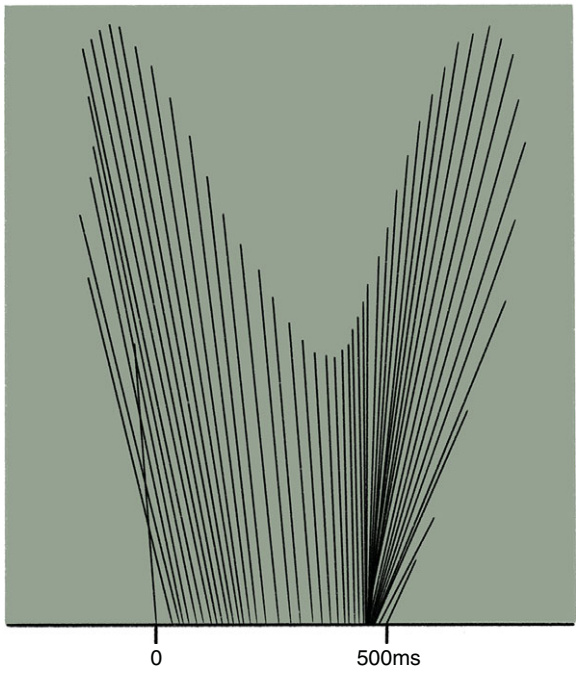


Figure 25.5 Stance phase

26. Concerning this diagram showing the corresponding sagittal plane angles at the hip, knee and ankle joints during the gait cycle in a normal adult (Figure 24.6).
    Match the correct letter to the correct part of the gait cycle.
    A. A FA = feet adjacent
    B. C TV = tibia vertical
    C. D OI = opposite initial contact
    D. E TO = toe-off
    E. F HR = heel rise

27. With regards to the ionic mechanism at work with nerve action potentials, which of the following statements indicates what happens when a nerve is refractory?
    A. Potassium channels remain open, sodium channels closed
    B. Sodium channels remain open, potassium channels closed
    C. Sodium and potassium channels close
    D. Sodium and potassium channels remain open
    E. Sodium-potassium pump activated

28. **Concerning the neuromuscular junction (motor end plate), which of the following statements is most accurate?**
    A. Botox blocks AC receptors at the motor end plates
    B. Malignant hyperthermia is a life-threatening clinical syndrome of hypermetabolism involving skeletal muscle due to an allergy
    C. Neostigmine is an antidote for non-depolarising blockers
    D. Succinylcholine blocks the effect of AC at the neuromuscular junction
    E. With myasthenia gravis the release of AC from the end plate is blocked

29. **Concerning the obturator artery**
    A. An aberrant obturator artery (AOA) is more commonly encountered on the right hemi-pelvis than left
    B. An aberrant obturator artery (AOA) is seen more frequently in females
    C. An aberrant obturator artery (AOA) usually arises from the internal iliac artery
    D. Has the greatest frequency of variation among the external iliac branches
    E. This is a standard branch of the external iliac artery (EIA)

30. When investigating the causative organism in an infected THA which would be your preferred method?
    A. Intraoperative frozen section
    B. Intraoperative Gram stain
    C. Percutaneous aspiration and culture
    D. Polymerase chain reaction
    E. Tissue culture of intraoperative biopsies

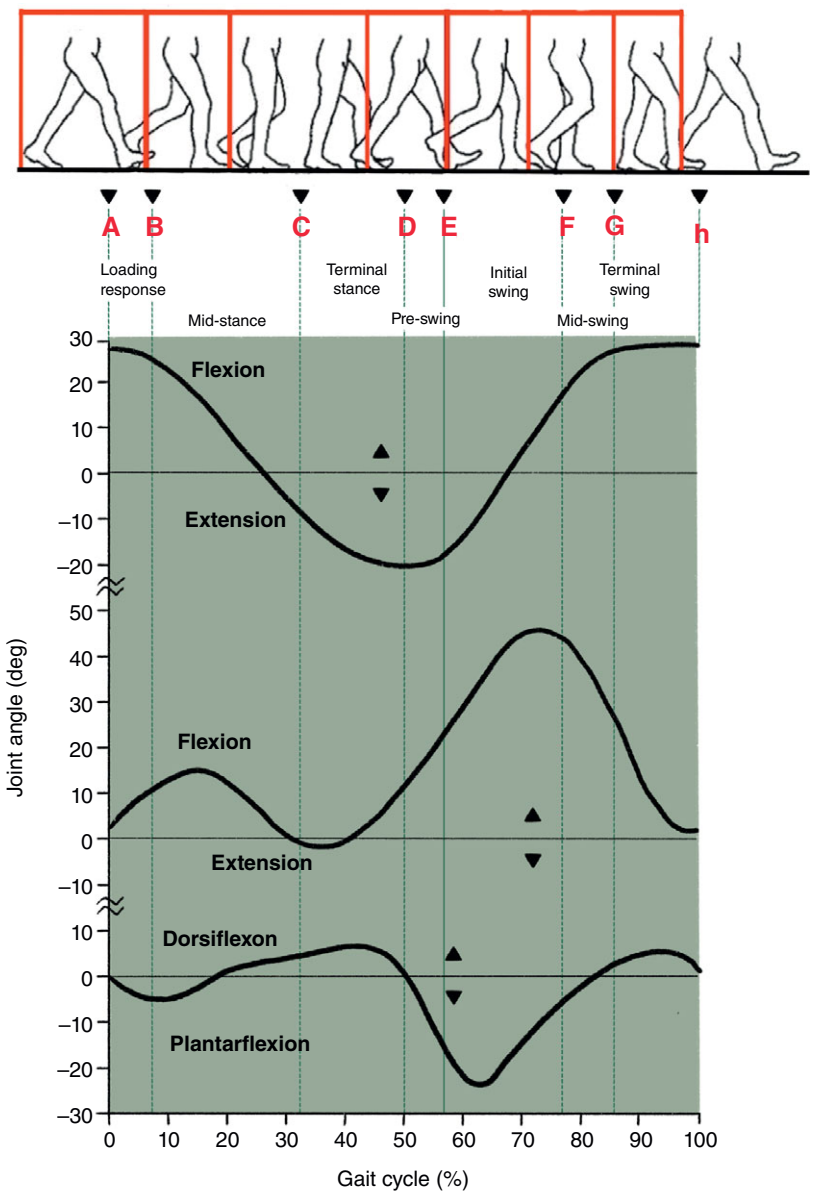


Figure 25.6 Sagittal plane motion patterns of the hip, knee and ankle during the gait cycle

31. A 28-year-old man who recently immigrated from the Middle East presents to the ED with a 9-month history of pain and swelling in his left ankle. He had a prolonged stay in hospital as a child because of an infection in his left lower extremity. On examination he was afebrile, left calf was atrophied, with swelling posterior to both malleoli and hyperpigmentation of the skin around the medial malleolus (Figure 25.7a). He had limited left ankle active and passive range of movement. Radiography showed a solitary radiolucent lesion (Figure 25.7b).

The most likely diagnosis is:

A. Brodie abscess
B. Chondroblastoma
C. Ewing sarcoma
D. Giant cell tumour
E. Osteoid osteoma

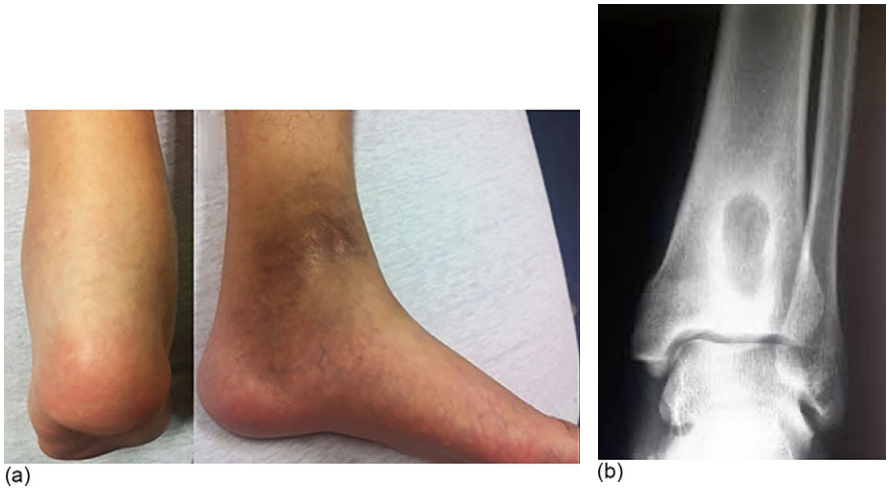


Figure 25.7 (a) Clinical photograph and (b) anteroposterior (AP) radiograph left ankle

32. A 63-year-old female has been listed for THA. She has been seen in the high-risk clinic as she has known risk factors for THA complications, including tobacco use, poor diabetic control, low albumin (<3.5g/dl) and high BMI (>40kg/m^2).
The risk factor most associated with re-admission post-operative complications were:

A. Anaemia
B. Diabetes
C. High BMI
D. Low albumin
E. Tobacco use

PATHOLOGY I STRUCTURED SBA ANSWERS

1. Answer D. **Push-ups**
   Closed chain exercises refer to exercises where the hand or foot is fixed in place and cannot move. The distal joint remains in constant contact with an immobile surface, for example the floor or platform of a machine, and the body moves around it. In contrast, open chain exercises refer to those performed where the hand or foot is free to move.

   Push-up is an upper body closed chain exercise as the hands remain in constant contact with the floor during the exercise. Bench press, biceps curl and triceps extension are upper body open chain exercises as the body is stationary while the hands are free to move with the machine/ barbell. Deadlift is a lower body closed chain exercise as the feet are in constant with the floor and the exercise primarily involves hip extension.

2. Answer C. **Open chain exercises have better knee extensor strength**
   There is no consensus on the superiority of closed chain versus open chain exercises following anterior cruciate ligament (ACL) reconstruction. Many surgeons feel intuitively that the ACL graft is more likely to be stretched with open chain exercises as the tibia is acting as a large lever and pulling on the graft. Therefore, most prefer closed chain exercises in the first 6 weeks following reconstruction as it is thought to put less strain on the graft and be safer. Closed chain exercise means the most distal part of that limb is anchored to an immobile surface. It allows for co-contraction of muscles (simultaneous activation of antagonist muscles – quadriceps and hamstrings) around a joint and decreases the shearing forces that occur with open chain exercises.

   A systematic review and meta-analysis by Jewiss et al. (2017) could not make a case of superiority for either open or closed chain exercises after ACL reconstruction. They reported some evidence that open chain exercises were better for improving knee extensor strength and some evidence for better active knee flexion in closed chain activities. There was insufficient evidence to discern between the two for joint laxity and patellofemoral joint pain scores.

   Jewiss D, Ostman C, Smart N. Open versus closed kinetic chain exercises following an anterior cruciate ligament reconstruction: a systematic review and meta-analysis. *J Sports Med*. 2017;**2017**:4721548.

3. Answer D. **Type II fibres are more prone to anatomical changes following altered energy demands than are type I fibres**
   This question tests your knowledge on muscle fibre types.

   Type I fibres are slow, small diameter, oxidative fibres with high fatigue resistance, low contraction speed and low contraction strength. They have a high concentration of mitochondria and myoglobin (contributes to red colour).

Table 25.1 Muscle fibre types

Characteristic	Type I	Type IIa	Type IIb
Other names	Red, slow twitch, slow oxidative	White, fast twitch, fast oxidative, glycolytic	Fast glycolytic
Speed of contraction	Slow	Fast	Fast
Strength of contraction	Low	High	High
Fatigability	Fatigue resistant	Fatigable	Most fatigable
Aerobic capacity	High	Medium	Low
Anaerobic capacity	Low	Medium	High
Motor unit size	Small	Larger	Largest
Mitochondria	Numerous	Numerous	Sparse

Type II fibres are divided into IIa and IIb. Type IIa fibres are large diameter with a mixture of glycolytic (anaerobic) and oxidative fibres (aerobic). They show an intermediate twitch time and high contraction strength. Type IIb are large diameter, fast glycolytic fibres. They have the largest motor unit and therefore the highest contraction strength. They also have the fastest contraction speed but are the most susceptible to fatigue. They have low concentrations of mitochondria and myoglobin (contributes to white colour).

Cross-sectional area of muscle fibres is generally larger in males than females. The size of the three muscle fibre types also differ between the sexes: type IIA>I>IIB for males and I>IIA>IIB for females.

Muscle fibres can change in size as well as type in response to altered energy demands. Muscle fibre conversions between Type IIa and IIb are most common. Type I to Type II conversion is possible in those patients with spinal cord injuries or who are severely deconditioned.

Scott W, Stevens J, Binder-Macleod SA. Human skeletal muscle fiber type classifications. *Phys Ther*. 2001;**81**:1810–1816.

Simon S. *Orthopaedic Basic Science*, p. 100. Rosemont, IL: American Academy of Orthopaedic Surgeons; 1994.

Staron RS et al. Fiber type composition of the vastus lateralis muscle of young men and women. *J Histochem Cytochem*. 2000;**48**:623–629.

4. Answer C. **Higher metabolic activity**
Although ligaments and tendons are broadly similar structures, they have their differences in composition and function. The slight differences in composition between ligaments and tendons is another classic SBA question.

Compared with tendons, ligaments have:

- Lower tensile strength
- Lower collagen content
- Less parallel arrangement of collagen (composed of functional bands, which come under tension at different joint positions)
- More proteoglycan and thus higher water content
- More elastin
- Higher metabolic activity

Table 25.2 Comparison of tendons and ligaments

	Ligaments	Tendons
% of collagen	Lower	Higher
% of ground substance	Higher	Lower
Organisation	More random	Organised
Metabolic activity	Higher	Lower
Orientation	Weaving pattern	Long axis direction

Table 25.3 Comparison of composition between tendon and ligament

Component	Ligament	Tendon
Cellular material		
Fibroblasts	20%	20%
Extracellular material (matrix)		
Water	60–80%	60–80%
Solids	20–40%	20–40%
Collagen	70–80%	Slightly higher
Type 1	90%	95–99%
Type 3	10%	1–5%
Ground substance	20–30%	Slightly less
Elastin	Up to 2× collagen	Scarce

5. Answer B. **Leads to the ligament resembling an elastic spring**
This is a higher order SBA dealing with the stress/strain curve of ligaments, hysteresis and cyclic loading.

During cyclic loading and unloading, the stress/strain curve shifts to the right. After 10 repetitions, the curve becomes reproducible. The amount of hysteresis under cyclic loading is reduced.

Hysteresis refers to a change in the stress-strain curve of a material during loading and unloading. When loading and unloading is repeated several times i.e. cyclic loading, different curves are obtained. However, after about 10 cycles, the curves do not change significantly. In other words, the amount of

hysteresis under cyclic loading is reduced (right-shift) and the stress-strain curve becomes reproducible. This process is preconditioning and this behaviour is called pseudo-elasticity to represent the non-linearity of ligament/tendon stress strain behaviour. Note that the option provided states pseudo-plasticity which is not the correct term. With preconditioning, the internal rearrangement of the ligament structure during the conditioning load-unload cycles leads to it working more efficiently, closer to an elastic spring with less viscous losses.

Robi K, Jakob N, Matevz K, Matjaz V. The physiology of sports injuries and repair processes. In Hamlin M, Draper N, Kathiravel Y, eds. *Current Issues in Sports and Exercise Medicine*, 43–86. London: IntechOpen; 2013.

6. Answer B. **3rd class lever at the elbow joint**
The hypovascular zone near the radial tuberosity insertion is a recognised risk factor for distal biceps tendon rupture, however this is not the correct option. The devil is in the detail, and the question is specifically asking for a mechanical property. Mechanical impingement and irritation of the tendon during forearm rotation (not flexion) has also been suggested. Seiler et al. (1995) reported a 50% reduction in proximal radioulnar joint space at the radial tuberosity when going from full supination to pronation. Antagonism from the comparatively bigger triceps muscle is not a risk factor and serves as a distractor. This leaves the class of lever options remaining and requires knowledge that the biceps is a 3rd class lever. This means that the effort is placed between the fulcrum and load; the fulcrum-to-load lever arm is longer than the fulcrum-to-effort lever arm. This configuration gives it the poorest mechanical advantage of the 3 lever classes and predisposes the tendon to rupture.

Seiler JG 3rd, Parker LM, Chamberland PD, Sherbourne GM, Carpenter WA. The distal biceps tendon. Two potential mechanisms involved in its rupture: arterial supply and mechanical impingement. *J Shoulder Elbow Surg.* 1995;**4**:149–156.

7. **Answer: A. Brittle**
The figure shows bilateral total hip arthroplasty – uncemented on the right and cemented on the left. The right THA uses a ceramic head which has the following properties: biocompatible, high stiffness (high Young's modulus of elasticity), brittle, excellent wettability, low coefficient of friction, strong under compression and weak under tension. Hardness is often mentioned and this is a surface property.

Beckmann NA et al. Long-term durability of alumina ceramic heads in THA. *BMC Musculoskelet Disord.* 2015;**16**:249.

8. Answer B. ***Kingella kingae***
Kingella kingae is a Gram-negative organism typically found in the oral cavity. It belongs to the 'HACEK' group of organisms, classically associated with bacterial endocarditis. It is, however, becoming increasingly recognised as a causative organism in paediatric joint infections. It presents with a more indolent course with less pronounced features of septic arthritis. A preceding upper respiratory tract infection is characteristic. Khattak et al. (2021) reported that it was the most common organism to be positive on PCR but negative on cultures for confirmed cases of paediatric septic arthritis. It most frequently affected the knee, shoulder and hip and in children under the age of 4.

Staphyloccocus aureus is the most common organism implicated in adult septic arthritis. It and streptococcus pyogenes would present with the typical acutely swollen, painful joint in the systemically unwell patient. *Escherichia coli* is a rare cause of septic arthritis in the non-immunocompromised patient. *Salmonella* is an organism often associated with sickle cell anaemia.

Khattak M et al. *Kingella kingae* septic arthritis. *Bone Joint J.* 2021;**103-B**(3):584–588.

9. Answer D. **Pretendinous band, Lateral digital sheath, Spiral band and Grayson's ligament**
Cords are pathological structures whereas bands are a normal part of anatomy. To identify the components, you first need to know that the structure that displaces the neurovascular bundle centrally is the spiral cord. This pathological structure has four components (bands): pretendinous band, spiral band, lateral digital sheath, and Grayson's ligament.

It is worth noting that Cleland's ligament is spared in Dupuytren's contracture which helps eliminate it from the list of options presented. Additionally, pathological cords are formed from normal fascial bands. Therefore, options which include a cord as a component can be excluded.

10. Answer D. **Translocation t(11:22)**
The salient features of the scenario are the presence of small round blue cells on histology and periosteal reaction on X-rays. Although rhabdomyosarcoma and retinoblastoma also have small round blue cells on histology, the presence of a periosteal reaction (onion skinning/Codman triangle) is most consistent with Ewing's sarcoma. Translocations t(11:22) and t(2:13) result in Ewing's sarcoma and rhabdomyosarcoma, respectively. Rhabdomyosarcoma is a soft tissue sarcoma and commonly affects the head and neck and genitourinary system. Mutations in pRB-1 lead to the development of retinoblastoma and typically presentation is in children under the age of 5 with clinical features such as strabismus or leukocoria. Mutations in erbB-2 and p53 are implicated in numerous malignancies (breast, gastrointestinal, ovarian, lung) which the clinical scenario does not allude to.

Small round blue cells (SRBC) are used to describe a group of malignant neoplasm that share characteristic histology appearance: size, shape and staining (blue on routine haematoxylin and eosin [H&E] stain). The mnemonic LERN'M can be used to remember the common malignancies: Lymphoma, Ewing's sarcoma, Rhadomyosarcoma, Neuroblastoma, Myeloma. Lymphoma and myeloma can present with periosteal reaction on radiographs but again occur in an older population.

11. Answer A. **Creatine kinase**
Gower's sign indicates weakness of the pelvic girdle and is historically associated with Duchenne muscular dystrophy (DMD). The progressive muscle weakness and calf enlargement supports this, but the older age of the patient also needs considering. In DMD, the patient loses independent ambulation by age 10 and usually succumbs to cardiorespiratory conditions by age 20. Becker muscular dystrophy (BMD) is the most likely diagnosis as patients have the same examination findings but present later, progress slower and survive longer. Both conditions are X-linked recessive and result from a mutation in the dystrophin gene (Xp21.2). In Becker muscular dystrophy, there is a reduction in dystrophin protein whereas in DMD, there is absence of it. This is reflected in onset and progression. Dystrophin plays a role in the muscle fibre membrane where it links the F-actin of the inner structural cytoskeleton to extracellular matrix proteins. Reduction/absence leads to injury to the cell membrane and oozing of creatine kinase from damaged muscle cells.

The question asks for the best initial investigation which would be creatine kinase (CK). A diagnosis is suggested when levels are elevated (20–100 times normal range) and would be confirmed using genetic testing and/or muscle biopsy and immunohistochemistry. Genetic testing is normally used to confirm the diagnosis but in cases where a pathogenic variant of the DMD gene is not identified, muscle biopsy and immunohistochemistry is needed. It would show reduced/absent dystrophin protein on staining and areas of necrosis and connective tissue infiltration as muscle is replaced by fibrofatty tissue.

EMG studies would demonstrate features of myopathy and MRI would show fatty atrophy in the gastrocnemius and semimembranosus. These two tests support but not alone confirm the diagnosis.

LaPelusa A, Kentris M. *Muscular Dystrophy*. Treasure Island, FL: StatPearls Publishing; 2023. https://www.ncbi.nlm.nih.gov/books/NBK560582/#.

12. Answer A. **Osteoconductive**
This is a case of knowing your biomaterials and bone graft properties. Osteointegration is the intended outcome of uncemented arthroplasty components and not a property of HA. It is a direct structural and functional connection between ordered, living bone and the surface of a load-carrying implant, critical for implant stability and considered a prerequisite for implant loading.

Osteoconduction is the process by which bone grows onto a surface. Osteoconductive materials serve as a scaffold onto which bone cells (osteoblasts and osteoclasts) can attach, migrate, grow and/or divide. HA is a calcium phosphate compound often used as an adjuvant surface coating owing to its osteoconductive properties. It promotes bone on-growth by providing bone with its mineral phase substrate.

Osteogenic materials contain immature precursor cells capable of differentiating and creating new bone. Osteoinductive materials stimulate these immature cells to develop into preosteoblasts. Transfixation is a type of wire fixation property.

Albrektsson T, Johansson C. Osteoinduction, osteoconduction and osseointegration. *Eur Spine J.* 2001;10(Suppl. 2):S96–S101.

Parithimarkalaignan S, Padmanabhan TV. Osseointegration: an update. *J Indian Prosthodont Soc.* 2013;**13**:2–6.

13. Answer B. **Osteoprotegerin (OPG)**

The RANKL-RANK signalling activates downstream signalling pathways needed for osteoclast development. RANKL (Receptor Activator of NF-κB Ligand) is a cytokine involved in the resorptive processes of both osteoporosis and metastatic bone disease and is produced by osteoblasts. It binds to Receptor Activator of Nuclear Factor Kappa B (RANK) on nascent osteoclasts, promoting their maturation, survival and proliferation, and hence the resorption of bone.

Osteoprotegrin (OPG) is also produced by osteoblasts and is a physiological antagonist to RANKL. It protects bone from excessive resorption by binding to RANKL and preventing it from binding to RANK. Denosumab is a human monoclonal antibody targeted against RANKL and thus has an analogous function to OPG.

PTH is a hormone that stimulates osteoclast formation by binding to its receptor on osteoblasts, and stimulating the production of RANKL and inhibiting the expression of OPG. TNF-α increases bone resorption through increasing RANKL expression.

Boyce BF, Xing L. Functions of RANKL/RANK/OPG in bone modeling and remodeling. *Arch Biochem Biophys.* 2008;**473**:139–146.

Farrier AJ et al. New anti-resorptives and antibody mediated anti-resorptive therapy. *Bone Joint J.* 2016;**98-B**:160–165.

Huang JC et al. PTH differentially regulates expression of RANKL and OPG. *J Bone Miner Res.* 2004;**19**:235–244.

14. Answer E. **Thixotropy**

This question requires prerequisite knowledge that synovial fluid is a non-Newtonian fluid. In a generalised Newtonian fluid, viscosity is constant i.e. there is a linear relationship between shear stress and shear rate. In non-Newtonian fluid, this does not hold true and there is a change in the viscosity (shear stress) based on the rate at which force is applied (shear rate).

Dilatant, pseudoplastic, rheopexy and thixotropy are all non-Newtonian fluid properties.

- Dilatant (shear thickening): an increase in viscosity as shear rate is increased. It is time independent.

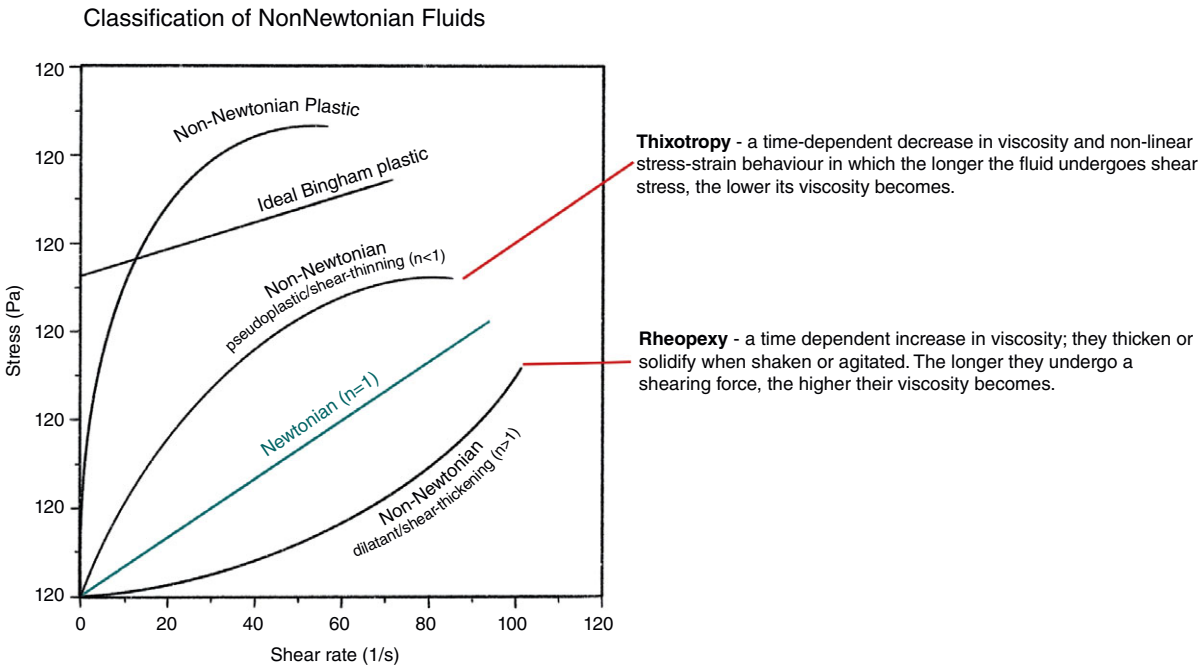


Figure 25.8 Classification of non-Newtonian fluids

- Pseudoplastic (shear thinning): a decrease in viscosity as shear rate is increased. It is time independent.
- Rheopexy: an increase in viscosity over time, at a constant shear rate i.e. the longer the fluid is sheared, the more viscous it becomes. It thickens or solidifies.
- Thixotropy is the opposite and the longer the fluid is sheared at a constant rate, the less viscous it becomes.

The non-Newtonian properties of synovial fluid are that it exhibits pseudoplasticity and thixotropy.

15. Answer B. **Brittle**
Here we visualise a stress-strain curve with a very limited plastic zone before failure. The elastic region would be comparatively large. This describes a brittle material; one that displays elastic behaviour for the most part before failure. A ductile material, on the other hand, can sustain a large amount of plastic deformation under tensile stress before failure. A stiff material is one that has a high Young's modulus and changes its shape only slightly under elastic loads. Anisotropy means the material has different properties (usually strength) depending on the direction a load is applied to it. A viscoelastic material is one that displays creep, stress relaxation and hysteresis.

16. Answer D. **Placing the femoral component in varus**
Joint reaction force (JRF) is the resultant force needed to balance the hip abductor and body weight moment arms. Changes in abductor force and/or body weight influences JRF. Using a cemented implant does not affect JRF. It is worthwhile splitting moment arms into clockwise and anti-clockwise moments. For a right hip, the body weight moment would be clockwise and the abductor force moment would be anti-clockwise. Carrying a shopping bag in the ipsilateral side would contribute to the anti-clockwise moment and in order to maintain an equilibrium, the anti-clockwise abductor force required is reduced. This reduces the JFR. Similarly, using a stick on the contralateral side again contributes to the anti-clockwise moment, resulting in a reduced JFR. The first two answers provided swap the placement of the stick and bag. They now contribute to the clockwise moment and in doing so, the abductor force required to achieve equilibrium is now greater and thus the resultant is JRF is increased.

Placing the acetabular component in a more lateral position lateralises the centre of rotation. Doing this increases the distance component of the bodyweight moment and decreases the distance component of the abductor force moment. The bodyweight moment increases and to achieve equilibrium, a greater abductor force is needed. Increasing the abductor force increases the joint reaction force.

Through a process of elimination, placing the femoral component in varus is the correct answer. By placing the femoral component into varus, the distance component of the abductor

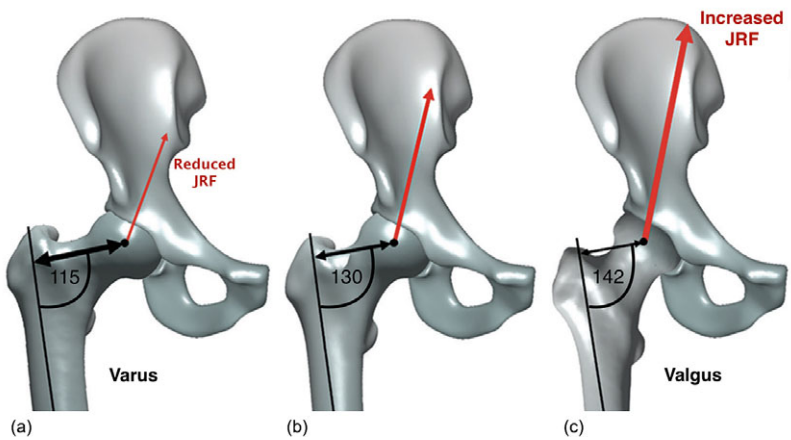


Figure 25.9 Impact of neck-shaft angle on the femoral offset and hip joint reaction force. An increased neck-shaft angle results in a decrease in femoral offset and increase in hip joint reaction force. (a) Varus hip configuration of 115°, (b) mean Caucasian hip configuration with neck-shaft angle of 130°, (c) valgus hip configuration of 142°

moment increases. The abductor force required is reduced and thus the JRF is decreased.

Houcke JV, Khanduja V, Pattyn C, Audenaert E. The history of biomechanics in total hip arthroplasty. *Indian J Orthop.* 2017;**51**:359–367.

17. Answer C. **Outer diameter**

Cancellous screws are designed to have greater thread depth and decreased thread cross-sectional thickness in comparison to cortical screws. A greater thread depth is achieved by increasing the difference between inner (core) and outer (thread) screw diameters. This provides more holding power in porous materials such as cancellous bone. Cannulated screws have a reduced thread depth so have a lower pull-out strength. When forces acting along the axis of the screw exceed its pull-out strength, the screw will shear out of the screw hole, removing sheared bone with it between the threads.

Pull-out strength is mostly controlled by the outer diameter of the screw, followed by the length of engagement of the thread, the shear strength of the material into which the screw is embedded and thread shape (which accounts for screw thread depth and pitch). The outer diameter and length of screw thread engagement can be thought of as an outer cylinder. The greater the area of this outer cylinder, the greater the force is required to shear it out of the bone (Force = Stress $\times$ area). Biomechanical studies of vertebral fixation systems have reported 37–47% increase in pull-out strength when comparing screws with 6.0mm to 5.0mm outer diameters.

Chapman JR et al. Factors affecting the pull-out strength of cancellous bone screws. *J Biomech Eng.* 1996;**118**:391–398.

Fakhouri SF et al. Biomechanical study of the pullout resistance in screws of a vertebral fixation system. *Adv Mech Engin.* 2011;**3**.

18. Answer B. **The diameter of the tibial pin**

The diameter of the pin has the greatest impact on construct rigidity. The stiffness of a rod to bending and twisting is proportional to the radius to the fourth power. For a rod, bending stiffness relates to its second moment of inertia ($I = \frac{1}{4}\pi R^4$) and torsional stiffness relates to its polar moments of inertia ($J = \pi R^4/2$).

Increasing the pin diameter and therefore stiffness also can reduce the stresses at the bone-pin interface. In practice it is advisable to keep pin sizes to within a third of the diameter of the bone to reduce the risk of fracture on removal.

Whilst on the topic of pins and external fixation, interference is another term of interest. It is a measure of the 'grip' the pin has in the bone and traditionally, it is at its maximum at the time of pin insertion and may decrease gradually as the fixator is loaded. Therefore, maximising interference at the beginning serves to promote bone hold for longer.

Giotakis N, Narayan B. Stability with unilateral external fixation in the tibia. *Strategies Trauma Limb Reconstr.* 2007;**2**:13–20.

19. Answer D. **Radial nerve**

The key to this question is identifying that the deficit is purely sensory and the area affected is the territory of the lateral cutaneous nerve of the forearm; this nerve is a continuation of the musculocutaneous nerve. Now we can eliminate options by going through the course of the musculocutaneous nerve. It arises from the C5–7 nerve roots. Contributions from the upper (C5, 6) and middle (C7) trunks give rise to the lateral cord which lead to the formation of the musculocutaneous nerve.

This leaves the radial nerve as the only remaining option which is the correct answer. In the arm, the radial nerve gives sensory supply to the anterior and posterior aspects of the lateral arm, via the lower lateral cutaneous nerve of the arm and posterior cutaneous nerve of the arm. In the forearm, it supplies the posterior aspect via the posterior cutaneous nerve of the forearm.

20. Answer A. **Allodynia**

This is a case of knowing your definitions. Allodynia is the perception of pain from a stimulus that does not normally cause pain (non-noxious stimuli). For example, the touch of a cotton bud on the skin causing pain. Hyperalgesia is an exaggerated response to a normally painful stimulus (noxious stimuli). It

differs from allodynia but the two can often co-exist. Dysaesthesia is an unpleasant and/or abnormal sensation that can occur spontaneously or in response to a stimuli. It often has a burning, tingling or numbing quality. There are many causes of dysaesthesia, both peripherally (neuropathies, neuroma, nerve trauma) and centrally (multiple sclerosis). Neuralgia is severe pain in the distribution of a nerve or group of nerves. It can be sharp, stabbing or shooting in nature and triggered by movement, touch or even changes in temperature. Examples include trigeminal neuralgia and postherpetic neuralgia.

Complex regional pain syndrome (CRPS) is a chronic pain condition characterised by spontaneous and evoked regional pain, usually beginning in a distal extremity. The pain is disproportionate in magnitude and/or duration expected for the amount of tissue trauma. It differs from other chronic pain conditions due to the presence of prominent autonomic and inflammatory changes in the affected area. It is characterised by pain (allodynia and hyperalgesia), erythema, oedema, stiffness, hyperhidrosis and altered skin temperature. Motor dysfunction can also be present. The Budapest criteria divides the signs and symptoms into sensory, vasomotor, sudomotor and motor categories. This option is a distractor in the clinical scenario.

Jensen TS, Finnerup NB. Allodynia and hyperalgesia in neuropathic pain: clinical manifestations and mechanisms. *Lancet Neurol.* 2014;**13**:924–935.

21. Answer A. **Axillary nerve injury**
The abnormal posturing of the arm in hyperabduction above the head and high energy transfer mechanism describes an inferior shoulder dislocation. This injury is very rare but easy to identify owing to a characteristic 'salute' position. The humeral head may be palpable or visible in the axillary fossa. It results from either a direct axial load on an abducted arm that forces the humeral head inferior to the glenoid or a hyperabduction force on an abducted arm that levers the humeral neck against the acromion and forces the head inferiorly. It is commonly associated with neurovascular injury, rotator cuff injury, tears in the capsule, and proximal humerus fractures. A literature review by Manon et al. (1990) reported that 80% had an associated greater tuberosity fracture or rotator cuff tear, 60% had a neurological deficit with the most common being to the axillary nerve and 3.3% demonstrated vascular compromise. Vascular injury was more common in patients over 50 years of age, largely due to pre-existing atherosclerosis.

Mallon WJ, Bassett FH 3rd, Goldner RD. Luxatio erecta: the inferior glenohumeral dislocation. *J Orthop Trauma* 1990;**4**:19–24.

22. Answer D. **Occiput to wall distance of 3cm**
The presentation fits with a diagnosis ankylosing spondylitis (AS). This is a seronegative spondyloarthropathy that leads to progressive cervical and thoracic kyphosis and the 'bamboo' spine (fusion of vertebral bodies with syndesmophytes). It typically presents in a patient under the age of 40 with sacroiliac joint involvement before progressing onto the spine. Early signs include tenderness over the sacroiliac joints, positive sacroiliac joint provocation tests (e.g. FABER) and decreased range of movement of the lumbar spine.

From the options presented above, an increased occiput to wall distance of 3cm is most likely to be present and is associated with progressive kyphosis. The normal range is 0–2cm. An increased tragus to wall distance (greater than 10cm) is also likely to be present. It is a similar measurement to occipital to wall distance. Cervical kyphotic deformity can be debilitating with symptoms ranging from mechanical neck pain, radiculopathy and myelopathy to impaired swallowing and horizontal gaze.

Chest expansion of 5cm or more is considered normal. In AS, it is reduced owing to restriction in chest wall movement. Chest expansion is measured circumferentially at the level of the 4th intercostal space and is taken as the difference between maximal inspiration and expiration measurements.

Schober's test would be reduced, less than 5cm increase with forward flexion, and indicates loss of lumbar flexion.

A fixed flexion deformity of the hip is a distractor option as it is non-specific. It can

however be seen in patients with AS. Early in the disease the patient stands with a slightly flexed hip and knee to remain upright. Later, the hips may develop a fixed flexion deformity and together with the loss of compensation from the lumbar spine, the patient may assume a stooped posture. This loss of compensatory lumbar spine movement must also be kept in mind when interpreting the findings of the Thomas test as the patient may be unable to fully flatten the lumbar spine on the couch when assessing for fixed flexion deformity of the hip.

An option not included but worth knowing is the Chin-Brow Vertical Angle (CBVA). It is the angle between the vertical and a line connecting the brow and chin. It measures horizontal gaze which is essential in day-to-day functioning. It is a parameter often used in spinal deformity correction. An ideal target range for CBVA has not been formally defined but Scheer et al. (2013) suggested a range between −10° and +10°.

Scheer JK et al. Cervical spine alignment, sagittal deformity, and clinical implications: a review. *J Neurosurg Spine* 2013;**19**:141–159.

23. Answer E. **Schwann cell proliferation**
This stem alludes to neurotmesis. When a nerve is transected the communication between the cell body and the segment distal to the site of injury is disrupted. This distal segment undergoes Wallerian degeneration; a series of changes that occur in the axon, Schwann cells and macrophages that result in the clearing of axonal debris and creation of an environment conducive to axonal regeneration. Schwann cells dedifferentiate and work together with macrophages to phagocytose and clear myelin debris. Dedifferientated Schwann cells then proliferate on endoneurial tubes and this signals the start of regeneration. These Schwann cells form bands of Büngner that provide pathways for regenerating axon sprout. Some degeneration also occurs in the proximal segment but usually only to the nearest node of Ranvier. The neuron cell body located in this segment then prepares to regenerate and is signalled by chromatolysis in the nucleus. In chromatolysis, the nucleus relocates to the periphery of the cell body and the rough endoplasmic reticulum (Nissl substance) fragments and disperses. The main function of Nissl substance is the synthesis of proteins such as enzymes, neurotransmitters, ion channels and structural proteins needed for normal nerve function. This displacement of the nucleus and dispersal of Nissl substance reflects a shift in function from neurotransmission to nerve regeneration.

24. Answer C. **Initially at foot contact the GRF points forward**
This SBA sets out to test basic knowledge of a Pedotti diagram. Some candidates will have no clue about what a Pedotti diagram is whilst other candidates will only know superficial details. Pedotti diagrams are asked in SBAs and also the basic science vivas but it is an obscure topic not always covered well in mainstream textbooks.

A Pedotti diagram, also known as a Butterfly diagram, is a way to represent GRF acting on the foot during normal gait. It has also been used to identify abnormal forces acting on the foot in pathological gaits. It is a plot of the ground reaction vectors and is made up of successive representations, usually at 10 ms intervals, of the magnitude, direction and point of application of the ground reaction force vector. The vectors move across the diagram from left to right and create a shape that resembles the wings of a butterfly.

The line at the extreme left-hand end represents the force vector at the moment the foot touches the ground. The line at the extreme right-hand end represents the GRF when the toe leaves the ground.

As a subject walks, their centre of pressure moves forward, starting at a heel, assuming that the initial contact was made by the heel, and then progressing towards the ball and the toe. Vector lines incorporate three aspects of the force they represent: magnitude (= length of line), point of action and direction of action.

Initially GRF acts diagonally backwards and upwards, from the heel. The horizontal component acts backwards, and the vertical component is greater than that of body weight. The envelope of all vectors presents a pattern characterised by two maxima and one minimum.

Initially, when the foot contacts the ground, the first few vectors are pointing forwards while absorbing the shock due to the heel strike. This is not often shown on Pedotti diagrams or mentioned and is the sting in the tail for this SBA.

Immediately, at the beginning of stance, GRF vectors are inclined backwards, contrary to the direction of movement, producing body deceleration. In the later stages, the leg pushes the ground down and backwards, and the GRF pushes the entire body up and forward and the vector inclination faces the movement, according to Newton's third law of motion.

Munoz JC, Represas G, del Mar Vales Flores M, Cassibba R. FF graphs and ground reaction force. American Society of Biomechanics 36th Annual Meeting Conference Paper August 2012.

25. Answer D. **Line of action becomes more nearly vertical and therefore the braking/slowing effect disappears**

The previous SBA sets out to test the basic principles of a Pedotti diagram. This SBA follows on and is more difficult as it deliberately sets out to mix up the various parts of the Pedotti diagram to test a candidate's in-depth knowledge.

1. At the beginning of stance, the GRF acts diagonally backwards and upwards, from the heel. The horizontal component acts backwards, and the vertical component is greater than that of body weight. GRF at this moment therefore:
   - Stops the 'controlled downwards fall' of the body.
   - Exerts a braking, or slowing, effect on forward movement.
2. During the middle of the stance phase the GRF:
   - Remains > body weight and therefore the CoM is lifted up slightly in midstance.
   - Point of action moves forward from the heel.
   - Line of action becomes more nearly vertical and therefore the braking/slowing effect disappears.
3. After the midpoint of the stance phase the vertical component of GRF falls (< body weight) as the leg passes the vertical position and the CoM moves downwards.
4. At the end of the stance phase, the GRF increases in magnitude again, acting forwards and upwards. This gives the necessary propulsive force to stop downwards movement of the CoM, and to keep the body moving forwards.

We have also conveniently ignored mentioning that initially when the foot contacts the ground, the first few vectors are pointing forwards while absorbing the shock due to the heel strike (see previous SBA).

26. Answer D. **E TO = toe-off**

Figure 25.10 is a classic diagram that candidates need to be able to explain. This is well known to appear in the basic science viva.

The following terms are used to identify major events during the gait cycle:

An IC = initial contact

B OT = opposite toe-off

C HR = heel rise

D OI = opposite initial contact

E TO = toe-off

F FA = feet adjacent

G TV = tibia vertical

H IC = initial contact

These seven events subdivide the gait cycle into seven periods, four of which occur in the stance phase, when the foot is on the ground, and three in the swing phase, when the foot is moving forward through the air.

The stance phase lasts from initial contact to toe off. It is subdivided into:

1. Loading response
2. Mid-stance
3. Terminal stance
4. Pre-swing

The swing phase lasts from toe off to the next initial contact. It is subdivided into:

1. Initial swing
2. Mid-swing
3. Terminal swing

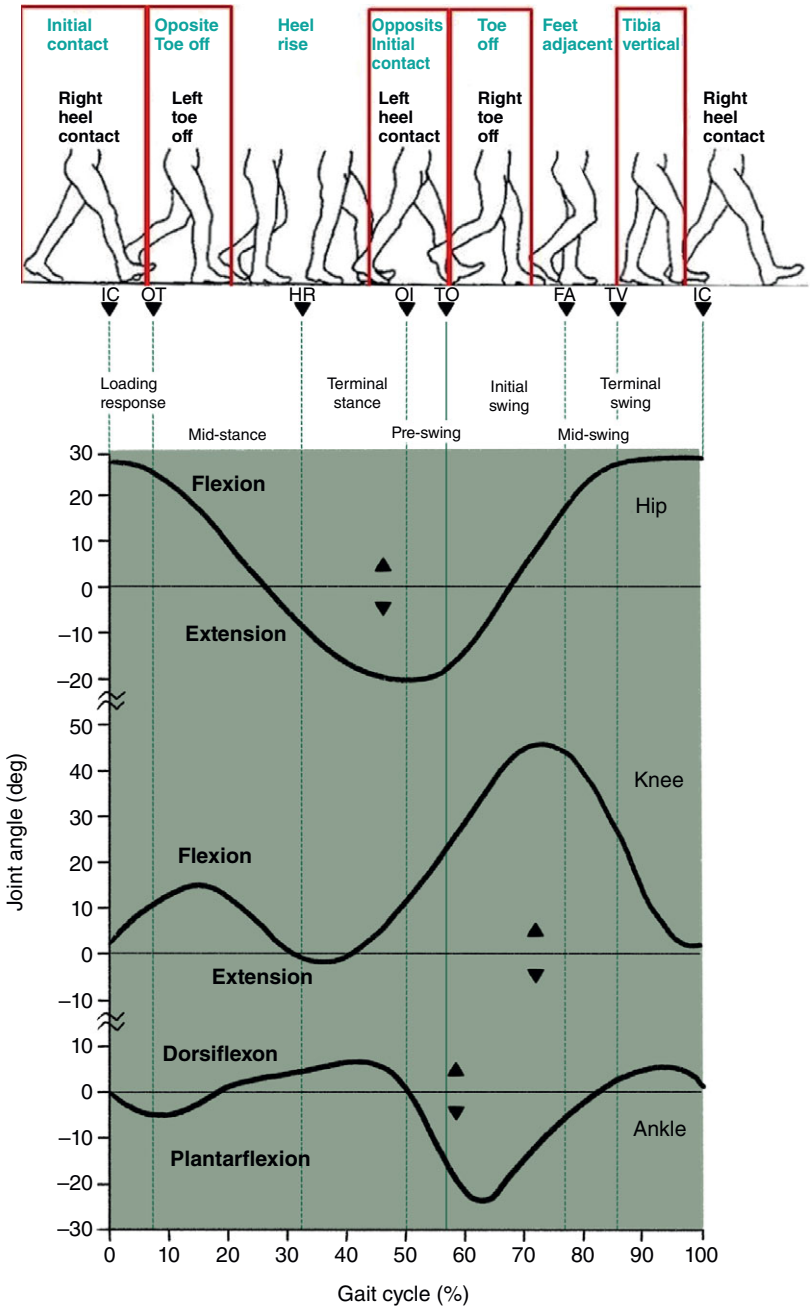


Figure 25.10 Sagittal plane joint angles (degrees) during a single gait cycle of right hip

27. Answer A. **Potassium channels remain open, sodium channels closed**
This SBA tests knowledge of nerve action potentials. The formation of an AP can be divided into five steps.

1. **Resting state.** A neuron at rest is negatively charged because the inside of a cell is approximately 70 millivolts more negative than the outside. In the resting state the activation gates on the Na^+ and K^+ channels

are closed and the membranes resting potential is maintained.

2. **Depolarisation**. A stimulus opens the activation gate on some Na^+ channels. Na^+ influx through those channels depolarises the membrane. If the depolarisation reaches the threshold, it triggers an action potential.
3. **Rising phase of the action potential.** Depolarisation opens the activation gates on most Na^+ channels while the K^+ channels activation gates remain closed. Na+ influx makes the inside of the membrane positive with respect to the outside.
4. **Falling phase of the action potential.** At the peak action potential, K^+ channels open and K^+ begins to leave the cell. At the same time the inactivation gates on most Na^+ close, blocking Na^+ influx. The activation gates on most K+ channels open, permitting K^+ efflux which again makes the inside of the cell negative.
5. **Undershoot.** Diffusion of K^+ out of the cell hyperpolarises the cell, making the membrane potential more negative than the cells normal resting potential. At this point, the sodium channels return to their resting state, ready to open again if the membrane potential again exceeds the threshold potential. Eventually, the extra K^+ ions diffuse out of the cell through the potassium leakage channels, bringing the cell from its hyperpolarised state back to its resting membrane potential.

The negative charge within the cell is created by the cell membrane being more permeable to K^+ movement than Na^+ movement. The difference in the number of positively charged potassium ions (K^+) inside and outside the cell dominates the resting membrane potential.

The actions of the sodium-potassium pump help to maintain the resting potential, once it is established.

28. Answer C. **Neostigmine is an antidote for non-depolarising blockers**

This is a basic SBA question on the neuromuscular junction, neuromuscular blocking agents and associated pathology.

The motor end plate is a specialised synapse formed between the axon terminalis of a motor neuron and motor end plate of skeletal muscle fibre. An action potential arrives and stimulates the release of ACh from the pre-synaptic membrane into the synaptic cleft. The ACh diffuses across and then binds with post-synaptic

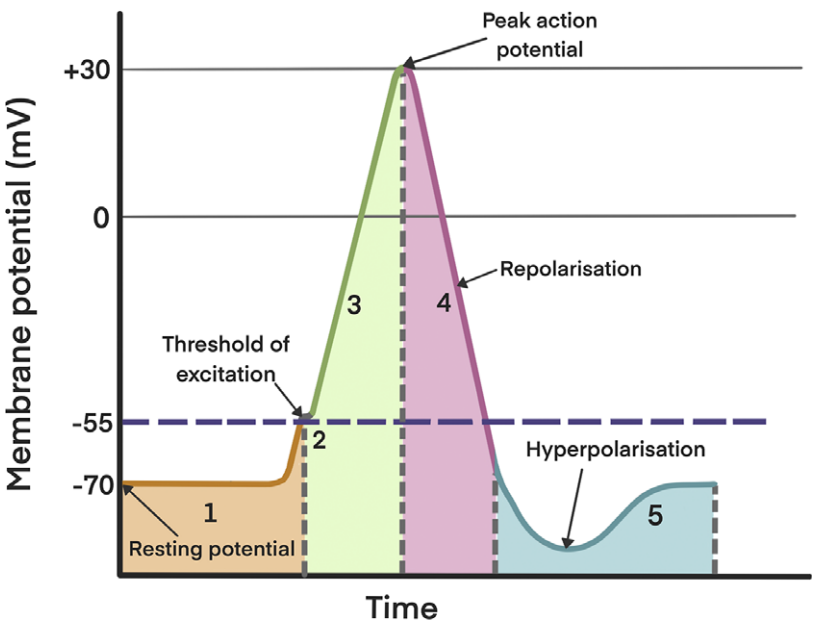


Figure 25.11 Nerve action potential

membrane nicotinic ACh receptors and leads to the depolarisation of the motor end plate.

Neostigmine is the correct answer through a process of elimination. It inhibits acetylcholinesterase, therefore increasing the concentration and duration of action of ACh at the neuromuscular junction. It is an antidote for non-depolarising neuromuscular blocking agents, such as atracurium. Non-depolarising agents are competitive antagonists that compete with and block the binding of ACh with nicotinic ACh receptors at the post-synaptic membrane.

Succinylcholine is a depolarising agent that mimics the effect of ACh at the post-synaptic membrane. It is an ACh receptor agonist that causes prolonged depolarisation which in turn prevents repolarisation. This causes muscle fasciculations and then paralysis. Botox prevents spasticity by blocking the release of ACh at the pre-synaptic membrane, not at motor end plates.

Myasthenia gravis is an autoimmune disease where antibodies attack nicotinic ACh receptors. Malignant hyperthermia is not an allergy, but an inherited disorder triggered in susceptible individuals.

Neostigmine inhibits cholinesterase and is an antidote for non-depolarising blockers.

Cholinesterase inhibitors inhibit acetylcholinesterase enzyme from breaking down Ach thereby increasing the level and duration of action of neurotransmitter acetylcholine.

Botox blocks the release of acetylcholine at the pre-synaptic membrane preventing spasticity.

29. Answer A. **An aberrant obturator artery (AOA) is more commonly encountered on the right hemipelvis than left**

The obturator artery (OA) is usually a branch of the anterior division of internal iliac artery (ADIIA) with a high degree of variability. Knowing the various OA variants is essential for pelvic procedures that require adequate ligation of blood vessels. Such varied origins may be a substantial cause of haemorrhages which are difficult to address in the cases of acute pelvic fractures.

The most common origin of a variant obturator artery is the inferior epigastric artery.

The variation of obturator arteries in males is almost twice that of females.

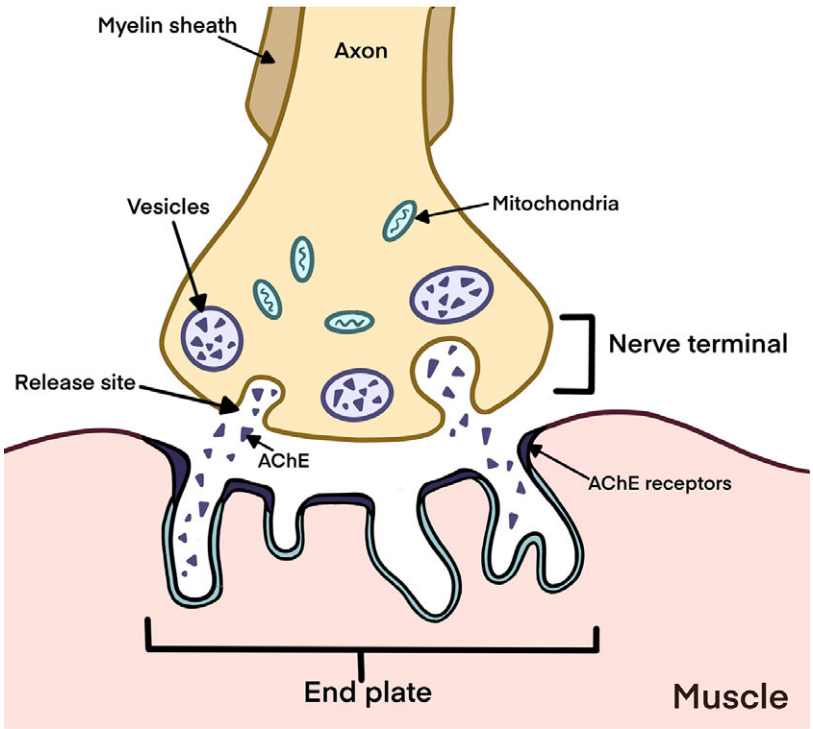


Figure 25.12 Neostigmine inhibits the hydrolysis of acetylcholine by competing with acetylcholine for attachment to acetylcholinesterase at sites of cholinergic transmission. It enhances cholinergic action by facilitating the transmission of impulses across neuromuscular junctions

The right hemi-pelvis has a higher incidence of a variant obturator artery when compared with the left hemi-pelvis.

The obturator artery (OA), a standard branch of the anterior division of the internal iliac artery (ADIIA), has the greatest frequency of variation among the IIA branches.

An aberrant obturator artery (AOA) or variant obturator artery (VOA) is a pelvic arterial variant in which the OA arise from the iliac artery and its derivatives other than ADIIA.

An aberrant obturator artery (AOA) usually arises directly from the external iliac artery (EIA) or branched from the external iliac artery with the inferior epigastric artery. Select case studies have identified it in as many as 31.4% of individuals. Other alternative AOA origins include common iliac artery, inferior gluteal artery (IGA), internal pudendal artery (IPA), shared trunk for IGA and IPA and the iliolumbar artery (ILA).

The **corona mortis** is not strictly an aberrant obturator artery. It should be considered a common vascular variant between the external iliac or its branch which is the inferior epigastric and the obturator artery. It is a collateral circulation between the internal iliac and the external iliac.

Corona mortis (CMOR), meaning 'the crown of death', involves vascular communication(s) between the obturator artery and external iliac artery (EIA) or inferior epigastric artery (IEA) vessels. It can be unilateral or bilateral, and there seems to be no significant difference in its incidence between males and females. This vascular variant earns its name due to the significant risk of death raised by its injury, which can lead to substantial haemorrhage and difficult haemostasis.

Raniga SB, Mittal AK, Bernstein M, Skalski MR, Al-Hadidi AM. Multidetector CT in vascular injuries resulting from pelvic fractures: a primer for diagnostic radiologists. *Radiographics* 2019;**39**:2111–2129.

Sume BW, Abay Mulu A. Anatomical variations of obturator artery and its clinical significances: a systematic review and meta-analysis. *Transl Res Anat.* 2023;**30**:100237.

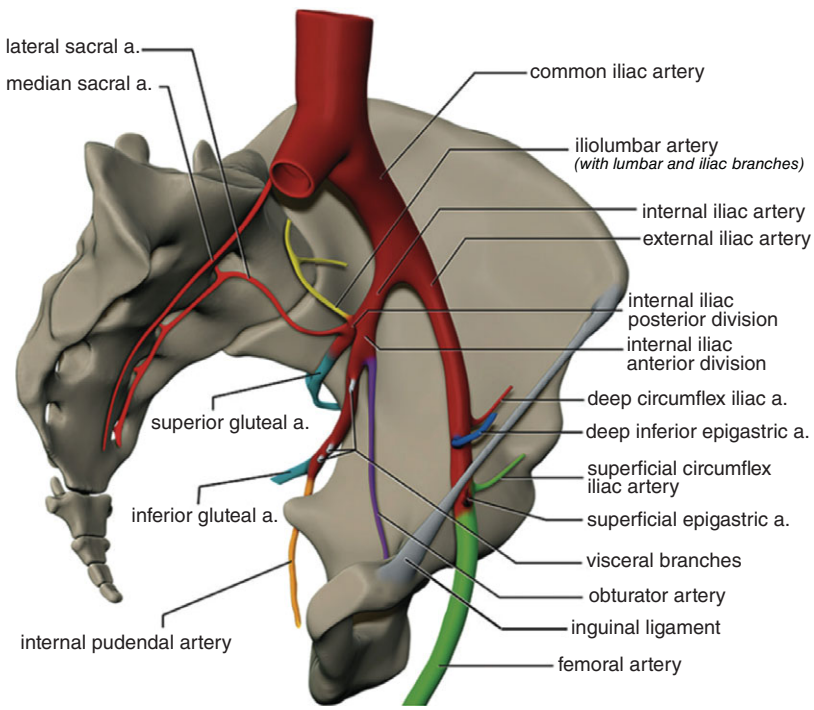


Figure 25.13 Internal iliac artery and its important branches: the lateral sacral arteries, iliolumbar artery, superior gluteal artery, inferior gluteal artery, internal pudendal artery, and obturator artery

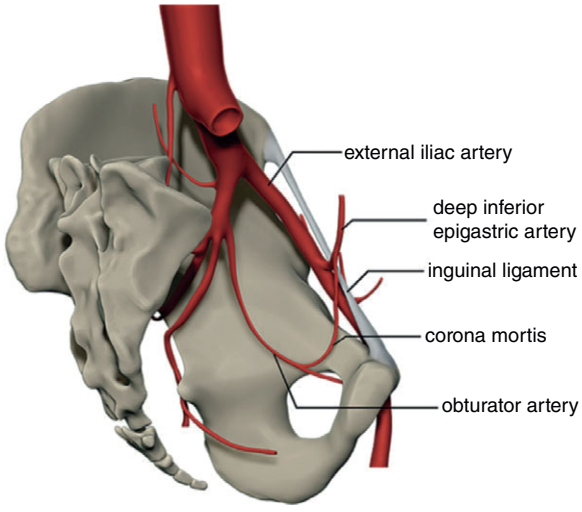


Figure 25.14 Corona mortis. Illustration shows an aberrant anastomotic connection from the obturator artery to the inferior epigastric artery

30. Answer E. **Tissue culture of intraoperative biopsies**

There is no single test that can reliably and reproducibly predict infection. Therefore, a combination of clinical assessment, biochemical testing and diagnostic imaging should be utilised. ESR and CRP are key tests that should always be analysed in assessment for PJI. However, these markers can be affected by age and medical comorbidities. An ESR >30mm/h and a CRP >10mg/l have been shown to represent elevated levels. If both the ESR and CRP are normal, the probability of infection has been shown to be 3%.

Joint aspiration is an invasive diagnostic method and often used as the first step in suspected PJI cases. Currently, various synovial fluid tests have been applied in the clinical diagnosis of PJI. Antibiotics should be withheld for a minimum of 2 weeks before aspiration. The analysis of the synovial fluid typically includes synovial WBC and synovial PMN%. In acute infections, a synovial WBC of 20,000 cells/ml and synovial PMN% of 89% are considered threshold values. These figures do differ in the context of chronic infection. The aspirate should be sent for enriched cultures and antimicrobial sensitivity.

The MSIS consensus meeting stressed several points regarding intraoperative biopsies. Each tissue sample is taken with separate, sterile instruments. They also stated that at least three, but no more than five samples should be taken and incubated in both aerobic and anaerobic environments. The use of sterile broth containing Ballotini beads can increase the pick-up of low-grade organisms (83% sensitivity compared with 38% sensitivity with direct culture plates).

After the surgeon places the sample in the sterile broth pot, it can be shaken enabling the Ballotini beads to dislodge the bacteria from the tissue samples, enhancing the chance of a positive culture, without risking contamination by multiple laboratory steps.

The benefit of obtaining multiple samples for culture is not only to increase the yield of difficult to identify organisms but also to be able to decide when a bacteria is more likely to be a contaminant or not. For example, if three of five specimens culture an identical organism, there is a 96% chance that this is the true causative organism, compared with a 25% chance with two positive identical samples.

In recent years, polymerase chain reaction (PCR) has also been used in the diagnosis of PJI. A recent meta-analysis of PJI diagnosed by synovial fluid PCR concluded that the diagnostic capability of synovial fluid PCR is not superior to that of synovial fluid culture.

Tissue samples have been shown to have superior sensitivity and specificity. Sampling of joint fluid through aspiration has variable results with a wide range of reported sensitivities (50–93%) and specificities (82–97%). The diagnostic accuracy of synovial fluid culture is lower than intraoperative tests of periprosthetic tissue and sonication fluid culture from biofilms. Furthermore, joint fluid collection is limited in the case of dry tap.

Gram staining of synovial fluid has shown a poor sensitivity (~30%) in diagnosing *S. aureus* PJI, and therefore, its clinical utility appears to be low.

Fink B et al. The value of synovial biopsy, joint aspiration and C-reactive protein in the diagnosis of late peri-prosthetic infection of total knee replacements. *J Bone Joint Surg Br.* 2008;**90**:874–878.

Walker LC et al. The importance of multisite intraoperative tissue sampling in the diagnosis of hip and knee periprosthetic joint

infection – results from a single centre study. *J Bone Joint Infect*. 2020;**5**:151–159.

31. Answer A. **Brodie abscess**

Brodie abscess is a subacute form of haematogenous osteomyelitis that accounts for 2.5–42% of primary bone infections. In general, patients are younger than 25 years of age and present with joint pain and localised swelling. Signs and symptoms of systemic disease are frequently absent. *Staphylococcus aureus* (30–60%), *Pseudomonas* (5%), *Klebsiella* (5%) and coagulase negative *Staphylococcus* (5%) are causative organisms. However, 20% of cultures are negative for these organisms. Radiographically, an intramedullary area of central lucency with sclerotic margins is characteristic.

In addition to systemic antibiotics, surgical debridement is usually required, with bone grafting if a large cavity requires stabilisation.

With an osteoid osteoma look for the nidus on radiographs.

The SBA could be rewritten with only 1–2 sentences of detail and with the emphasis of the diagnosis placed on the radiograph.

32. Answer D. **Low albumin**

Obesity, diabetes, tobacco use, opioid use, anaemia, malnutrition, poor dentition and vitamin D deficiency have all been identified as MRFs that should be addressed prior to arthroplasty.

Statz et al. (2021) found that the risk factor that was most highly correlated with postoperative readmission was albumin <3.5g/dl (OR: 2.173, 95% CI: 1.865–2.532, $P<0.0001$), followed by ≥ 40kg/m^2 (OR: 1.79, 95% CI: 1.439–2.226, $P<0.0001$), tobacco use (OR: 1.389, 95% CI: 1.13–1.706, $P = 0.0003$) and diabetes (OR: 1.225, 95% CI: 1.057–1.419, $P<0.0001$). Patients that were not optimised preoperatively were more likely to be readmitted post-operatively than patients who were optimised preoperatively (7.0% vs 4.3%, r, $P<0.0001$).

Documented modifiable risk factors for TJA include diabetes control, elevated basal metabolic index (BMI), smoking or tobacco use, anaemia, methicillin-resistant *Staphylococcus aureus* colonisation status and malnutrition. The authors of this study reported in a large database that malnutrition, defined as hypoalbuminaemia (<3.5), was the strongest risk factor for all complications evaluated.

Statz JM, Odum SM, Johnson NR, Otero JE. Failure to medically optimise before total hip arthroplasty: which modifiable risk factor is the most dangerous? *Arthroplast Today* 2021;**10**:18–23.

Chapter 26

Pathology II Structured SBA

Rory Morrison and Rajesh Kakwani

PATHOLOGY II STRUCTURED SBA QUESTIONS

1. **What type of afferent peripheral nerve fibre is responsible for transmitting vibration sense to the spinal cord?**
   A. Aα (A alpha)
   B. Aβ (A beta)
   C. Aγ (A gamma)
   D. Aδ (A delta)
   E. C

2. **Which of the following is not part of the Kocher criteria for differentiating septic arthritis of the hip?**
   A. C-reactive protein
   B. Erythrocyte sedimentation rate
   C. Fever
   D. Non-weight bearing
   E. White cell count

3. **Septic arthritis may be caused by contiguous spread from osteomyelitis, typically due to an intra-articular metaphysis. Which of the following DOES NOT have an intra-articular metaphysis?**
   A. Ankle
   B. Elbow
   C. Hip
   D. Knee
   E. Shoulder

4. **The most common organism responsible for septic arthritis in patients with sickle cell disease is which of the following?**
   A. *Escherichia coli*
   B. *Pseudomonas aeruginosa*
   C. *Salmonella*
   D. *Staphylococcus aureus*
   E. *Streptococcus*

5. A 5-year-old boy presents with a painful hip and unable to weight bear. His temperature is 38.8°C, his CRP is 120 and his ESR is 40. He is taken to theatre for an open arthrotomy due to concern about a septic hip.
   Which is the best approach to the hip for this patient?
   A. Arthroscopic approach
   B. Hardinge approach
   C. Medial approach
   D. Posterior approach
   E. Smith-Petersen approach

6. A farmer slips and falls awkwardly, sustaining an open tibial shaft fracture. The paramedics manage to retrieve him from his farmyard and bring him to a major trauma centre hospital within an hour of injury.
   Which of the following is the best management?
   A. IV co-amoxiclav, debridement and closure within 72 hours
   B. IV co-amoxiclav, debridement within 12 hours
   C. IV co-amoxiclav, debridement within 24 hours
   D. IV co-amoxiclav, debridement within 6 hours
   E. IV co-amoxiclav, immediate debridement

7. **Concerning Brodie abscess, which of the following is true?**
   A. A well-circumscribed cavity that is surrounded by a halo of sclerosis is typical for a Brodie abscess
   B. Brodie abscess typically occurs in the diaphysis of the bone

C. *Pseudomonas* are typically found in a Brodie abscess
D. Systemic reaction is proportional to the size of the abscess
E. Treatment is with antibiotic therapy

8. A 4-year-old girl presents with a 24-hour history of inability to weight bear with pain in the right hip. She is afebrile but looks flushed. Her leg is 'rotated' out to the side on the bed, and she is hesitant to move it. Blood tests show a WCC of 13, CRP of 5 and ESR of 50.
What is the best form of management?
A. Admit for observation
B. Hip arthrotomy with debridement and washout
C. MRI of the hip
D. Start IV antibiotics and monitor response
E. US of the hip

9. A microbiology report for a fluid sample obtained from a native joint aspiration concludes that 'acid-fast bacilli are seen as bright red'.
Which of the following is the most likely organism?
A. *Aspergillus* sp.
B. *Candida albicans*
C. *Mycobacterium bovis*
D. *Mycobacterium tuberculosis*
E. *Staphylococcus aureus*

10. Which of the following is incorrect?
A. Mycobacteria are seen as bright red with Ziehl–Neelsen stain
B. *Mycobacterium tuberculosis* are acid-fast bacilli
C. *Mycobacterium tuberculosis* are obligate aerobes
D. Short-duration chemotherapeutic treatment is required to minimise the risk of developing resistance
E. The most likely cause of TB is *Mycobacterium tuberculosis*

11. A 60-year-old patient with back pain has an MRI scan suggesting tuberculous spondylodiscitis. Routine microbiology culture tests are negative. There is no concern about malignancy.
Which of the following is correct?
A. *Mycobacterium* TB appears as bright red colonies on Löwenstein–Jensen culture medium
B. Obligate anaerobic, acid-fast bacilli would be seen in TB
C. TB of the spine is the least common form of musculoskeletal TB
D. The presence of skip lesions on the MRI suggests this is not TB
E. Venous impregnation is the most likely route of spread

12. A 19-year-old man is brought to fracture clinic with a 5th metacarpal neck fracture. There is associated swelling, no rotational deformity and a small wound over the knuckle. He admits to having punched somebody.
Which of the following is the best management?
A. Buddy-strapping little and ring fingers
B. Complete short-arm cast
C. Low threshold for operative exploration and washout
D. Reduction of the fracture using Jahss technique
E. Ulnar gutter splint for support

13. A patient presents to the minor injuries unit with a wound to the hand, sustained when she was trying to cut an avocado. It is a simple wound that can be closed directly and there is no tendon or neurovascular damage.
Which of the following is incorrect?
A. If this woman has completed her primary immunisation, but boosters were incomplete, she requires a further booster dose
B. If this woman has not been immunised, then human tetanus immunoglobulin should be administered
C. If this woman has not been immunised, then tetanus vaccine should be administered
D. If this woman has been fully immunised, then she requires no further treatment for this wound
E. If this woman has been fully immunised, then she would only require further treatment if this was a high-risk tetanus-prone wound

14. A patient has a femoral fracture around the stem of a hip replacement. There is good bone stock, but the prosthesis looks loose.
How would you classify this fracture according to the Vancouver classification?

A. A
B. B1
C. B2
D. B3
E. C

15. You are asked how you would manage a patient with a Vancouver type A periprosthetic hip fracture, with 1cm displacement of the fracture fragments.
Which of the following is the best response?
A. Fixation with locking plate only
B. Protected weight bearing
C. Revision of the stem with additional bone graft
D. Revision of the stem with additional cerclage wires
E. Revision of the stem with no need for additional cerclage wires

16. A patient has previously undergone a total hip replacement but falls and sustains a Vancouver B2 periprosthetic fracture. They are medically fit to undergo anaesthesia.
Which of the following is the best management option?
A. Fixation with cerclage wires
B. Protected weight bearing
C. Revision of the stem with additional bone graft
D. Revision of the stem with fixation of the fracture
E. Revision of the stem with no need for additional fixation

17. Concerning the management of periprosthetic fractures of the hip.
Which of the following is incorrect?
A. Vancouver A fractures can be managed non-operatively
B. Vancouver B1 fractures may be reclassified to B2 fractures intraoperatively
C. Vancouver B1 fractures require a revision stem bypassing the fracture site, along with fixation of the fracture
D. Vancouver B2 fractures require a revision stem bypassing the fracture site, along with fixation of the fracture
E. Vancouver B3 fractures require revision of the femoral stem with allograft, or proximal femoral replacement

18. **Which of the following is deemed to be the greatest cause of wear leading to aseptic loosening of an implant?**
A. Irregular particles $<0.1\mu m$ in size
B. Irregular particles $0.1–10\mu m$ in size
C. Irregular particles $>10\mu m$ in size
D. Spherical particles $<0.1\mu m$ in size
E. Spherical particles $0.1–10\mu m$ in size

19. **Stem-cement fretting is an example of which mode of wear?**
A. Mode 1
B. Mode 2
C. Mode 3
D. Mode 4
E. Mode 5

20. **Which of the following best describes adhesive wear?**
A. Delamination secondary to repetitive stressing
B. Formation of a junction between two surfaces leading to shearing
C. The asperities in the harder surface cutting grooves into the softer surface
D. The presence of galvanic currents between two materials
E. The presence of polyethylene wear debris in between the normal articulation

21. A radiograph of a cemented hip stem shows sclerosis and thickening of the cortex medially and laterally at the level of the tip of the stem.
Which type of stem loosening is most likely to be the cause?
A. Calcar pivot
B. Cantilever bending
C. Medial stem pivot
D. Pistoning of the stem within the bone
E. Pistoning of the stem within the cement

22. **Which of the following is the typical cause of polyethylene wear in a total hip arthroplasty?**
A. Abrasive wear
B. Crevice corrosion
C. Fatigue delamination
D. Galvanic corrosion
E. Oxidative wear

23. **Which is correct concerning cementing around a THA?**
    A. Barrack grade A indicates radiolucency >50% of the bone–cement interface
    B. DeLee and Charnley zone 1 is inferomedial
    C. DeLee and Charnley zone 3 is the most common area for osteolysis
    D. Gruen zone 1 loosening occurs at the lesser trochanter
    E. Gruen zone 5 occurs at the tip of the stem

24. You are reviewing the MRI hip scan of one of your patients who has presented with hip pain, and the report mentions a 'double-line sign'.
    Which of the following is the most likely diagnosis?
    A. Avascular necrosis
    B. Osteoarthritis
    C. Septic arthritis with underlying osteomyelitis
    D. TB affecting the hip
    E. Undisplaced subcapital fracture

25. A 60-year-old man presents with progressive painful pes planus. Radiographs show the deformity is due to collapse of the navicular.
    Which of the following is the most likely diagnosis?
    A. Freiberg's disease
    B. Kienböck's disease
    C. Kohler's disease
    D. Müller–Weiss syndrome
    E. Sever's disease

26. A 58-year-old woman presents with fairly acute onset knee pain but denies any history of trauma or previous knee problems. There are no concerning features of infection. She has plain radiographs and an MRI of the knee. T2-weighted images show bone oedema, particularly in the medial femoral condyle.
    Which is the most likely diagnosis?
    A. Lateral meniscal tear
    B. Osteoarthritis flare
    C. Osteochondral defect
    D. Spontaneous osteonecrosis of the knee
    E. Traumatic fracture

27. A 75-year-old female with a history of polymyalgia rheumatica presents with a short history of acute hip pain. She denies any trauma. Radiographs show Steinberg stage V osteonecrosis, and a Kerboul angle of >200°.
    Which of the following is the best form of management?
    A. Cemented total hip replacement
    B. Decompression and fibula bone graft
    C. Non-operative management
    D. Rotational osteotomy
    E. Uncemented total hip replacement

28. **Concerning the management of osteonecrosis of the hip, which of the following is the best option?**
    A. A Kerboul angle of >200° is associated with a favourable outcome with joint-sparing procedures
    B. Femoral head decompression is the mainstay of treatment for Ficat stage IV cases
    C. Rotational transtrochanteric osteotomy (Sugioka) moves the affected part of the femoral head laterally, inferiorly and posteriorly
    D. Steroid-induced osteonecrosis should be managed by osteotomy
    E. Total hip arthroplasty is best for younger patients with stage IV disease

29. A patient presents to your clinic with an acute history of hip pain, and radiographs show osteopenia and sclerosis of the femoral head, which remains spherical.
    What stage of osteonecrosis is present according to the Ficat classification?
    A. 0
    B. I
    C. II
    D. III
    E. IV

30. **Which of the following is the most common cause of osteonecrosis of the hip?**
    A. Alcohol
    B. Caisson disease
    C. Gaucher disease
    D. Idiopathic primary
    E. Steroid-induced

31. **Which of the following is the most common organism causing prosthetic joint infection?**

A. *E. coli*
B. Group B *streptococci*
C. *Propionibacterium acnes*
D. *Pseudomonas* spp.
E. *S. epidermidis*

32. Which of the following is not of use in the diagnosis of prosthetic joint infection?
A. CRP
B. ESR
C. IL-6
D. Intraoperative Gram stain
E. Intraoperative histopathology

33. Which of the following facultative, anaerobic Gram-positive rods is an organism commonly isolated from an infected shoulder arthroplasty?
A. *Cutibacterium acnes*
B. Group B *Streptococcus*
C. *Staphylococcus aureus*
D. *Staphylococcus epidermidis*
E. *Streptococcus pneumoniae*

34. A patient presents to hospital with a 1-week history of a painful knee, with associated swelling, erythema and warmth. They had a TKR 2 years ago, with no post-operative complications. Radiographs show well-fixed implants. An aspiration performed on admission to hospital is growing *S. epidermidis*.
Which of the following is the best form of management?
A. Arthroscopic washout
B. Debridement, antibiotics and implant retention
C. Intravenous antibiotics
D. Single-stage revision
E. Two-stage revision

35. Teicoplanin is commonly used as antibiotic prophylaxis for arthroplasty cases.
How does teicoplanin work?
A. Inhibits beta-lactam
B. Inhibits DNA gyrase
C. Inhibits peptidoglycan polymerisation
D. Inhibits ribosomal protein synthesis
E. Inhibits RNA polymerase

36. With regard to trying to reduce infections following arthroplasty surgery, which of the following is INCORRECT?
A. HEPA can help reduce colony-forming units to $<10/m^3$ in theatre
B. Intravenous glycopeptides are the treatment of choice for MRSA infection
C. Iodophors are inactivated by blood, faeces and pus
D. Screening for MRSA has no benefit on infection rate
E. The skin preparations chlorhexidine and povidone-iodine reduced bacterial counts by 99% and 97%, respectively, following use

37. Which of the following is not used as a diagnostic criterion for periprosthetic infection?
A. A sinus tract communicating with the joint
B. Elevated CRP and ESR
C. Elevated serum WCC
D. Positive histological analysis of periprosthetic tissue
E. Two positive prosthetic cultures with identical organisms

38. Antibiotic-loaded bone cement can be used for spacers for patients undergoing a two-stage revision for infection.
Which of the following is correct?
A. Antibiotic elution is highest for the first 2 weeks following implantation
B. Commercially available antibiotic cement should be used for cement spacers
C. Penicillin is commonly added to the cement, just before mixing
D. Powdered antibiotics should be used and added before mixing
E. The addition of antibiotics to cement has no effect on cement strength

39. A patient is having their first of a two-stage revision TKR for infection.
Which of the following is the best answer?
A. Handmade antibiotic cement spacers have a lower infection eradication rate than industry-made spacers
B. Heat-sensitive antibiotics should only be used in cement spacers
C. Non-articulating cement spacers should be used in patients with bone loss or lack of soft tissue constraint

D. One or two deep tissue samples are required for microbiology culture, to help guide further management
E. Synovial analysis reveals PMN% of 75%, which is diagnostic for infection

40. **Which of the following patients would benefit from debridement and exchange of the femoral head, with post-operative antibiotic therapy?**
A. Four-week history of increasing pain in the hip, normal CRP and ESR, two joint aspirations are negative for growth, radiographs show evidence of aseptic loosening
B. One-week history of increasing pain in the hip, with a raised CRP and ESR; aspiration results are not yet known
C. Seven-week history of increasing pain in the hip, with a raised CRP and ESR; radiographs are satisfactory, culture results show *S. aureus*
D. Three-week history of increasing pain in the hip, with a raised CRP and ESR; radiographs shown changes in DeLee and Charnley zone 3
E. Two-week history of increasing pain in the hip, with a raised CRP and ESR; radiographs are satisfactory, culture results show *S. aureus*

41. A patient with COPD, rheumatoid arthritis and polymyalgia rheumatica is on the ward recovering from hip fracture fixation earlier that day. You are called to see the patient as they are confused, hypotensive, tachycardic and hypoglycaemic.
Please choose the best response from the following.
A. Catecholamines are produced in the adrenal cortex
B. Continued use of 30mg daily prednisolone has no effect on HPAA function
C. Glucocorticoids are produced in the medulla of the adrenal gland
D. The symptoms can be explained by infection only
E. This patient will demonstrate limited response to ACTH testing

42. A 65-year-old woman with rheumatoid arthritis is scheduled for an elective total hip replacement. She takes methotrexate and etanercept.
What would you advise her regarding her rheumatoid medication?
A. Continue both methotrexate and etanercept
B. Stop both methotrexate and etanercept the night before surgery
C. Stop etanercept and methotrexate the night before surgery
D. Stop etanercept 2 weeks before surgery, continue methotrexate
E. Stop methotrexate 2 weeks before surgery, continue etanercept

43. An intravenous drug user, who is known to be HIV-positive, is having incision and drainage of an abscess. The surgeon sustains a needlestick injury.
Which of the following is correct?
A. A solid needle causes a higher transmission risk
B. Baseline serum HIV test in the surgeon gives a good indication of likelihood of transmission
C. Post-exposure prophylaxis (PEP) should start when serum HIV test results are known
D. The risk of transmission from patient to surgeon when exposed to contaminated mucous membranes is 1:100
E. The risk of transmission from patient to surgeon with a needlestick injury is 1:300

44. A patient with factor V Leiden mutation is undergoing surgery.
Which of the following is the best answer?
A. They are at increased risk of developing a DVT
B. They are at increased risk of developing a post-operative infection
C. They are more likely to develop a haematoma
D. They have high incidence of latex allergy
E. They need factor V transfusion prior to surgical intervention

45. An insulin-dependent diabetic patient is awaiting a total hip replacement.
Which of the following is incorrect?
A. Diet-controlled diabetics do not need to be prioritised on the operating list
B. $HbA1_C$ can give a good indication of diabetic control

C. Patients expected to miss more than one meal should have a variable rate insulin infusion prescribed
D. Target blood glucose levels of 6–10mmol/l are acceptable
E. Variable-rate insulin infusion should be stopped before the administration of subcutaneous insulin post-operatively

46. **Which of the following is associated with a reduced risk of developing heterotopic ossification?**
A. Blast injury
B. Early operative intervention for acetabular fracture fixation
C. Prolonging mechanical ventilation following injury
D. The presence of spinal cord injury
E. Using the extended iliofemoral rather than the Kocher–Langenbeck approach for an acetabular fracture

47. **Which of the following statements is true concerning the prophylaxis of developing heterotopic ossification?**
A. A single dose of radiotherapy 72 hours before surgery is recommended
B. Bisphosphonates should be commenced following injury to help prevent HO formation
C. Medium to high doses of NSAIDs reduce the risk of developing heterotrophic bone formation after hip surgery
D. Indomethacin is used to promote cyclooxygenase activity, which helps prevent HO formation
E. Radiotherapy at a dose of 700cGy should be used as first-line treatment for all cases

48. **When planning treatment of heterotopic ossification, which of the following is correct?**
A. Early excision is recommended to help prevent further bone formation
B. Indomethacin can prevent further HO formation
C. Post-operative radiotherapy is not indicated due to the concern of wound-healing complications
D. Surgery should be timed for 6 months following injury in a patient with traumatic brain injury
E. Surgical excision of heterotrophic ossification is recommended in Brooker class I patients

49. **What is the inheritance pattern of haemophilia?**
A. Autosomal dominant
B. Autosomal recessive
C. Mitochondrial
D. X-linked dominant
E. X-linked recessive

50. **Haemophilia A affects which of the following clotting factors?**
A. Factor VIII, an extrinsic pathway clotting factor
B. Factor VIII, an intrinsic pathway clotting factor
C. Factor IX, an extrinsic pathway clotting factor
D. Factor IX, an intrinsic pathway clotting factor
E. Factor X, an intrinsic pathway clotting factor

51. A young male presents with recurrent swelling of his knees. There is no concern about infection.
Concerning haemophilia, which of the following statements is correct?
A. Arthroplasty is contraindicated in end-stage disease
B. Clotting factor levels have no influence on surgical intervention
C. Protein C and protein S deficiency manifests with haemarthrosis
D. Synovectomy can be performed when medical management has failed to control symptoms
E. von Willebrand disease is most likely to present with haemarthrosis

52. You receive a radiology report for a knee radiograph, suggesting epiphyseal overgrowth, osteopenia, early degenerative changes and squaring of the patella.
Which of the following is the most likely diagnosis?
A. Factor VIII abnormality
B. Osteoarthritis secondary to trauma
C. Osteogenesis imperfecta
D. Multiple hereditary exostoses
E. Osteoporosis secondary to steroids

53. An osteochondral lesion is noted on the lateral view of a plain radiograph of the knee of an 11-year-old boy, who has injured his knee playing football.
Where is the lesion most likely to have arisen from?
A. Posterior aspect of patella
B. Posterolateral side of medial femoral condyle
C. Posteromedial side of lateral femoral condyle
D. Tibial surface
E. Weight-bearing part of medial femoral condyle

54. **Concerning osteochondritis dissecans, which of the following is correct?**
A. Age has no bearing on the healing potential of OCD
B. Lateral femoral condyle lesions have a better prognosis than medial femoral condyle lesions
C. Pappas classification is based on the location of the osteochondral fragment
D. Pappas classification suggests excellent prognosis in patients >20 years of age
E. Pappas classification suggests excellent prognosis is seen in patients <12 years of age

55. **Which of the following is INCORRECT with regard to osteochondritis dessicans?**
A. Males are more commonly affected than females
B. Pappas classification is based on age, and suggests juveniles have an excellent healing potential
C. The medial femoral condyle is more commonly affected than the lateral femoral condyle
D. The presence of synovial fluid behind the lesion on MRI indicates good healing potential
E. Tunnel view radiographs are often required to view the source of the lesion

56. A 13-year-old girl with an incompletely detached OCD is on the operating table undergoing arthroscopic surgery to repair her injury, having failed non-operative management.
What is the best form of management?
A. Autologous chondrocyte implantation
B. Headless screw fixation
C. Matrix-induced chondrocyte implantation
D. Microfracture
E. Osteochondral graft

PATHOLOGY II STRUCTURED SBA ANSWERS

1. Answer B. **Aβ (A beta)**
This SBA deals with sensory receptors. Sensory receptors can be classified into five types, based on the nature of the stimuli to which each receptor responds.

Mechanoreceptors are a type of sensory receptor that responds to distortion or mechanical pressure.

The primary tactile mechanoreceptors that are present in human skin are Pacinian corpuscles, Merkel's disks, Ruffini endings and Meissner's corpuscles (Figure 26.1).

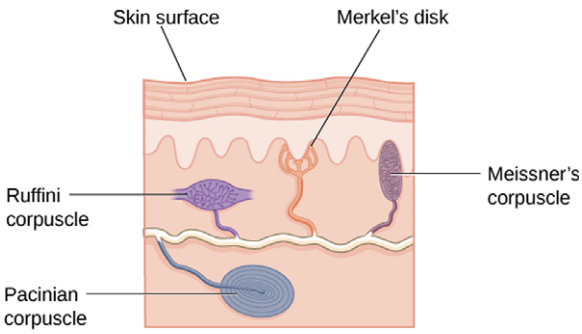


Figure 26.1 Afferent peripheral nerve fibres. Adapted from Naish J, Syndercombe Court D. *Medical Sciences*, 3d Ed. Edinburgh: Elsevier; 2018.

Pacinian corpuscles are rapidly adapting receptors that are located in the dermis of hairy and glabrous skin. They are present in the pancreas, genitals, joint capsules, bone periosteum and breasts.

Merkel's disks are located near the base of the epidermis of both hairy and glabrous skin. Glabrous skin is the hairless skin that is present on soles of feet, lips, palms and fingers. Ruffini endings are slow-adapting receptors that are located deeper in the epidermis in both hairy and glabrous skin. They are encapsulated receptors.

Feher J, ed. Cutaneous sensory systems. In *Quantitative Human Physiology*, 2nd Ed. London: Academic Press, 2012. Reproduced with permission.

2. Answer A. **C-reactive protein**
CRP is not part of the Kocher criteria, which can be remembered by the acronym 'NEWT'

Non weightbearing
ESR >40mm//h
White cell count >12,000 cells/μl
Temperature >38.5°C

The presence of all four criteria gives a high likelihood (99.6%) of septic arthritis. One = 3%, two = 40% and three = 93%.

Caird et al. (2006) suggested a modification to the Kocher criteria in 2006 after finding CRP >20mg/l was a strong independent risk factor for a septic hip arthritis.

Caird MS et al. Factors distinguishing septic arthritis from transient synovitis of the hip in children: a prospective study. *J Bone Joint Surg Am.* 2006;**88**:1251–1257.

Kocher MS, Zurakowski D, Kasser JR. Differentiating between septic arthritis and transient synovitis of the hip in children: an evidence-based clinical prediction algorithm. *J Bone Joint Surg Am.* 1999;**81**:1662–1670.

3. Answer D. **Knee**
The knee does not have an intra-articular metaphysis, which can be a cause of contiguous spread

Table 26.1 Free nerve endings – summary of the individual corpuscles

Type of receptor	Location	Sensation	Fibre type	Conduction velocity (m/s^{-1})	Adaptation
Pacinian corpuscles	Deep	Vibration	Aβ, large myelinated	30–70	Rapid
Meissner's corpuscles	Superficial	Flutter, touch, stroking	Aβ, large myelinated	30–70	Rapid
Merkel's discs	Superficial	Light pressure	Aδ, small myelinated	12–30	Slow
Ruffini endings	Deep	Stretch	Aβ, large myelinated	30–70	Slow
Nociceptors	Epidermis	First pain	Aδ, small myelinated	12–30	Slow
Nociceptors	Epidermis	Second pain	C, small unmyelinated	0.5–2	Slow

Adapted from Naish J, Syndercombe Court D. *Medical Sciences*. 3rd ed. Edinburgh: Elsevier; 2018. Feher J. *Quantitative Human Physiology*. Amsterdam: Academic Press; 2012.

of osteomyelitis into a septic arthritis. The other joints mentioned do.

4. Answer D. ***Staphylococcus aureus***
Staphylococcus aureus is the most common organism responsible for septic arthritis, although this can vary according to the age of the patient. Spread may be haematogenous, direct inoculation or secondary to contiguous spread.

Infants (<1 year)	Group B strep, *S. aureus*, *E. coli*
Children (1–16)	*S. aureus*, *Streptococcus pyogenes*, *Kingella kingae*
Adults (>16)	*S. epidermidis*, *S. aureus*, *Pseudomonas aeruginosa*, *E. coli*

Salmonella is a common cause of bone infection in patients with sickle cell disease, but the commonest organism is *Staphylococcus aureus.*

Romanò CL, Romanò D, Logoluso N, Drago L. Bone and joint infections in adults: a comprehensive classification proposal. *Eur Orthop Traumatol.* 2011;**1**:207–217.

da Silva Junior GB, Daher Ede F, da Rocha FA. Osteoarticular involvement in sickle cell disease. *Rev Bras Hematol Hemoter.* 2012;**34**:156–164.

5. Answer E. **Smith-Petersen approach**
Most sources advocate the Smith-Petersen approach to perform a washout of a paediatric hip. This involves a superficial incision between the sartorius and tensor fascia lata, and a deeper incision between rectus femoris and gluteus medius. The ascending branch of the lateral femoral circumflex artery is at risk. A capsulotomy is made to (a) wash out the hip and (b) release the intracapsular pressure, which can worsen chondral damage secondary to degrading enzymes such as MMPs released by virulent organisms. Arthroscopic washout for the hip is not recommended.

6. Answer E. **IV co-amoxiclav, immediate debridement**
BOA/BAPRAS open fracture guidelines suggest that open fractures from agricultural, sewage or aquatic environments should be taken to theatre for immediate debridement. Solitary high-energy injuries should be debrided within 12 hours, and all other low-energy open fractures within 24 hours. If wound closure is not possible at initial debridement, then this should be performed within 72 hours. IV prophylactic antibiotics should be administered as soon as possible, ideally within 1 hour of injury.

BOA website: https://www.boa.ac.uk/uploads/assets/3b91ad0a-9081-4253-92f7d90e8df0fb2c/29bf80f1-1cb6-46b7-afc761119341447f/open%20fractures.pdf.

7. Answer A. **A well-circumscribed cavity that is surrounded by a halo of sclerosis is typical for a Brodie abscess**
Brodie abscess is a chronic, localised bone abscess, typically occurring in the metaphysis of the femur or tibia. There are often few signs or systemic symptoms. Imaging demonstrates a well-defined cavity, lined by granulation tissue and containing seropurulent fluid. Typically, the abscess is surrounded by a halo of sclerosis. Usually no organisms are found. Treatment is usually biopsy (differentials include osteoid osteoma, Ewing's, LCH, ABC, GCT, NOF), debridement and intravenous antibiotics.

8. Answer B. **Hip arthrotomy with debridement and washout**
This girl's history is typical for a septic arthritis and meets three of the four criteria of the Kocher classification. While IV antibiotics are required, this should be in addition to washout of the hip, which is a surgical emergency. If the criteria are not met and there remains diagnostic uncertainty, then further imaging should be obtained. An MRI scan is useful to assess if there is any evidence of osteomyelitis.

Kocher MS, Zurakowski D, Kasser JR. Differentiating between septic arthritis and transient synovitis of the hip in children: an evidence-based clinical prediction algorithm. *J Bone Joint Surg Am.* 1999;**81**:1662–1670.

9. Answer D. ***Mycobacterium tuberculosis***
TB is caused by the rod-shaped organism *Mycobacterium tuberculosis*, an obligate aerobic acid-fast bacillus. Under the microscope, acid-fast bacilli are seen as bright red with Ziehl–Neelsen stain. Löwenstein–Jensen medium is required for culture. *Mycobacterium bovis* is most commonly found in cattle, and although it can cause human infection, *M. tuberculosis* is much more common.

10. Answer D. **Short-duration chemotherapeutic treatment is required to minimise the risk of developing resistance**
TB is caused by the rod-shaped organism *Mycobacterium tuberculosis*, an obligate aerobic acid-fast bacillus. Under the microscope, acid-fast bacilli are seen as bright red under Ziehl–Neelsen stain. Löwenstein–Jensen medium is required for culture. Treatment involves combination therapy with two chemotherapeutic drugs for at least 6 months (rifampicin and isoniazid), with two additional agents for the first 2 months (pyrazinamide and ethambutol). The long duration of treatment with multiple agents helps to reduce the risk of resistance.

11. Answer E. **Venous impregnation is the most likely route of spread**
The spine is the most common site of musculoskeletal TB, with spread via arterial channels and Batson's perivertebral venous plexus. Skip lesions are seen in 5–15% of spinal TB cases. Biopsy would reveal aerobic (not anaerobic), acid-fast bacilli, and culture is carried out on Löwenstein–Jensen culture medium (bright green colonies), a specific culture medium for mycobacteria.

12. Answer C. **Low threshold for operative exploration and washout**
'Fight bites' are common and should always be specifically asked about. Look for tooth foreign body on radiographs. Infection of the MCPJ is very common due to direct inoculation of the joint and should have an open washout under anaesthesia in theatre. Common infecting organisms include *S. aureus*, Streptococci, *Eikenella corrodens*, *Serratia* and *Enterobacter*. Antibiotics should be given and consideration for testing for blood-borne viruses.

13. Answer B. **If this woman has not been immunised, then human tetanus immunoglobulin should be administered**
Tetanus is caused by the toxin of *Clostridium tetani*, an anaerobic spore-forming bacillus.

Spores are found in soil and manure.

Tetanus-prone wounds include puncture-type injuries in a contaminated environment, wounds containing foreign bodies, open fractures, certain animal bites and wounds or burns with systemic sepsis.

High-risk tetanus-prone wounds include heavy contamination with soil or manure, wounds or burns with extensive devitalised tissue, or wounds or burns requiring surgery with a delay >6 hours.

In clean wounds, such as this, then only the tetanus vaccine should be given if patients are not immunised, not the human immunoglobulin. Human immunoglobulin is only required for tetanus-prone wounds in those who have not had previous vaccination, or high-risk tetanus-prone wounds in all patients.

Amirthalingam G et al. Guidance on the management of suspected tetanus cases and on the assessment and management of tetanus-prone wounds; 2019. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/820628/Tetanus_information_for_health_professionals_2019.pdf.

14. Answer C. **B2**
The Vancouver classification for periprosthetic fractures considers the site of the fracture, the quality of the surrounding bone, and the stability of the prosthesis. Type A fractures are around the trochanters, type B around the femoral stem, and type C distal to the femoral stem. B1 fractures have a well-fixed stem, B2 fractures have a loose stem but good bone stock, whereas B3 fractures have a loose stem and poor bone stock. The classification of these fractures helps guide management.

Brady OH, Garbuz DS, Masri BA, Duncan CP. The reliability and validity of the Vancouver classification of femoral fractures after hip replacement. *J Arthroplasty* 2000;**15**:59–62.

Duncan CP, Masri BA. Fractures of the femur after hip replacement. *Instr Course Lect.* 1995;**44**:293–304.

15. Answer B. **Protected weight bearing**
The Vancouver classification for periprosthetic fractures considers the site of the fracture, the quality of the surrounding bone and the stability of the prosthesis. Type A fractures are around the trochanters, type B around the femoral stem and type C distal to the femoral stem. B1 fractures have a well-fixed stem, B2 fractures have a loose stem but good bone stock, whereas B3 fractures have a loose stem and poor bone stock. The classification of these fractures helps guide management.

Vancouver A fractures are usually managed with protected weight bearing. If there is more than 2cm of displacement of fracture fragments, then cerclage wires or hook plate fixation is required to maintain abductor function.

B1 fractures require fixation with locking plates or cerclage wires.

B2 fractures may require a revision stem, bypassing the fracture site by greater than two cortical widths. Most stems used are uncemented, with or without distal locking. Fixation of the fracture is also required, using cerclage wires and or a locking plate.

B3 fractures require either revision of the femoral stem with allograft, or proximal femoral replacement.

C fractures require ORIF with a bridging locking plate.

16. Answer D. **Revision of the stem with fixation of the fracture**

The Vancouver classification for periprosthetic fractures considers the site of the fracture, the quality of the surrounding bone and the stability of the prosthesis. Type A fractures are around the trochanters, type B around the femoral stem and type C distal to the femoral stem. B1 fractures have a well-fixed stem, B2 fractures have a loose stem but good bone stock, whereas B3 fractures have a loose stem and poor bone stock. The classification of these fractures helps guide management.

Vancouver A fractures are usually managed with protected weight bearing. If there is more than 2cm of displacement of fracture fragments, then cerclage wires or hook plate fixation is required to maintain abductor function.

B1 fractures require fixation with locking plates or cerclage wires.

The authors of the Vancouver classification recommend B2 fractures are fixed using cerclage wires and/or a locking plate, and that the stem is revised, bypassing the fracture site by greater than 2 cortical widths. This would still be considered best management. However, it is important to note that there is increasing evidence to suggest anatomical fixation only without revision is an option. Proponents of this cite lower transfusion rates and fewer re-operations.

B3 fractures require either revision of the femoral stem with allograft, or proximal femoral replacement.

C fractures require ORIF with a bridging locking plate.

González-Martín D et al. Treatment algorithm in Vancouver B2 periprosthetic hip fractures: osteosynthesis vs revision arthroplasty. *EFORT Open Reviews* 2022;**7**:533–541.

Powell-Bowns MFR et al. Vancouver B periprosthetic fractures involving the Exeter cemented stem. *Bone Joint J.* 2021;**103-B**:309–320.

17. Answer C. **Vancouver B1 fractures require a revision stem bypassing the fracture site, along with fixation of the fracture**

The Vancouver classification for periprosthetic fractures considers the site of the fracture, the quality of the surrounding bone and the stability of the prosthesis. Type A fractures are around the trochanters, type B around the femoral stem and type C distal to the femoral stem. B1 fractures have a well-fixed stem, B2 fractures have a loose stem but good bone stock, whereas B3 fractures have a loose stem and poor bone stock. It is sometimes difficult to differentiate between B1 and B2 fractures with plain radiographs, which may cause problems intraoperatively depending on implants available.

Vancouver A fractures are usually managed with protected weight bearing. If there is more than 2cm of displacement of fracture fragments, then cerclage wires or hook plate fixation is required to maintain abductor function.

B1 fractures require fixation with locking plates or cerclage wires.

B2 fractures may require a revision stem, bypassing the fracture site by greater than 2 cortical widths. Most stems used are uncemented, with or without distal locking. Fixation of the fracture is also required, using cerclage wires and or a locking plate.

B3 fractures require either revision of the femoral stem with allograft, or proximal femoral replacement.

C fractures require ORIF with a bridging locking plate.

18. Answer B. **Irregular particles 0.1–10μm in size**

Wear debris (mode 1 wear) sources include cement, polyethylene or metal. Particles in the

range 0.1–10μm in size are phagocytosed by macrophages, stimulating a biological reaction. Particles smaller than this do not generate a significant response, whereas particles larger than this stimulate a giant cell response which does not induce osteolysis.

The release of mediators from macrophages, including IL-1, IL-6, TNF, PGE2 and MMPs, stimulates bone resorption through activation of osteoblasts which produce the RANK ligand receptor activator, attaching to the RANK receptor on osteoclasts to promote bone resorption. Irregular-shaped particles stimulate a greater response than spherical shaped. The volume of wear debris, the total number of particles and the immune response to the particles all influence the extent of osteolysis.

19. Answer D. **Mode 4**

Four modes of wear have been described:

Mode 1 is the generation of wear debris occurring between the two primary bearing surfaces as intended by the designers, e.g. femoral head and polyethylene cup liner.

Mode 2 is a primary bearing surface articulating with a secondary surface not intended for bearing, e.g. femoral head and metal acetabular backing after the polyethylene has worn through.

Mode 3 is due to an interposed third body between two normal bearing surfaces.

Mode 4 is two non-bearing surfaces rubbing together, e.g. fretting and corrosion of the Morse taper, back-sided wear of an acetabular liner or at the stem–cement interface.

20. Answer B. **Formation of a junction between two surfaces leading to shearing**

In adhesive wear, a junction (bond) forms between two surfaces. If this bond is stronger than the cohesive strength of the softer bearing material, then fragments shear off the softer material.

Two-body abrasive wear occurs between the asperities of two bearing materials (e.g. between polyethylene and metal) with the harder surface cutting grooves into the softer material, leading to detached particles.

The presence of polyethylene wear debris in between the normal articulation is an example of third body wear causing localised abrasive wear.

Delamination secondary to repetitive stressing is an example of fatigue wear and can be reduced by greater conformity between the bearing surfaces or increasing the thickness of the bearing surface.

Galvanic corrosion occurs where an anode and cathode are formed between two different conducting materials. Crevice and pitting corrosion can also occur.

21. Answer A. **Calcar pivot**

Gruen described four modes of failure of cemented femoral implants:

Type 1 – Pistoning:

(1a) Of the stem within the cement, with a radiolucent line seen between the stem and the cement.

(1b) Of the stem and the bone, with a radiolucent line seen around the entire cement mantle.

Type 2 – Medial stem pivot:

Caused by medial migration of the proximal stem, and lateral migration of the distal stem due to inadequate cement support in these areas.

Type 3 – Calcar pivot:

This is caused by toggle at the tip of the stem, with a well-fixed implant proximally. The surrounding cortical bone at the tip of the stem scleroses and thickens in response to the 'windscreen wiper' effect of the stem tip.

Type 4 – Cantilever bending:

This is due to loss of proximal support, but a well-fixed distal stem.

Gruen TA, McNeice GM, Amstutz HC. 'Modes of failure' of cemented stem-type femoral components: a radiographic analysis of loosening. *Clin Orthop Relat Res.* 1979;**141**:17–27.

22. Answer A. **Abrasive wear**

The most common wear for a THR is mode 1 abrasive wear. This occurs with the generation of wear debris between two primary bearing surfaces, as intended by the designers. In the case of a THR, this is between the femoral head and the acetabular liner (in this scenario, polyethylene). Corrosion/oxidative wear occurs where two different conducting materials are in contact with each other, forming an anode and a cathode.

Fatigue wear (delamination) is often seen in TKR.

23. Answer C. **DeLee and Charnley zone 3 is the most common area for osteolysis**
Gruen described seven zones on an AP radiograph of a cemented hip stem. Zone 1 is at the greater trochanter, 4 is at the tip and 7 is at the lesser trochanter.

DeLee and Charnley described three zones of the acetabulum; 1 is superior, 2 is in the middle and 3 is inferior, with zone 3 being the most common area for osteolysis.

Barrack et al. (1992) graded the quality of the cement mantle:

Grade A:	Complete whiteout of medullary canal with cement.
Grade B:	Slight radiolucency at bone–cement interface.
Grade C1:	Radiolucency >50%.
Grade C2:	Cement thickness <1mm or implant is against bone.
Grade D:	Radiolucency >100%, absent cement at distal tip, large voids.

Barrack RL, Mulroy RD Jr, Harris WH. Improved cementing techniques and femoral component loosening in young patients with hip arthroplasty: a 12-year radiographic review. *J Bone Joint Surg Br.* 1992;**74**:385–389.

DeLee JG, Charnley J. Radiological demarcation of cemented sockets in total hip replacement. *Clin Orthop Relat Res.* 1976;**121**:20–32.

24. Answer A. **Avascular necrosis**
The 'double-line sign' is seen at the periphery of a region of osteonecrosis in up to 80% of cases and is best seen on T2 images. It consists of a bright T2 line signifying granulation tissue, with surrounding dark zones indicating sclerotic adjacent bone.

25. Answer D. **Müller–Weiss syndrome**
Müller–Weiss syndrome is dorsolateral fragmentation of the adult navicular due to osteonecrosis. This is in comparison to Kohler's disease, which is childhood-onset osteonecrosis of the navicular. Kienböck's disease is osteonecrosis of the lunate, Freiberg's disease is osteonecrosis of the metatarsal (typically the second) and Sever's disease is an apophysitis of the calcaneus seen in growing children.

26. Answer D. **Spontaneous osteonecrosis of the knee**
Spontaneous osteonecrosis of the knee more commonly affects females in their mid-50s onwards, and typically occurs in the medial femoral condyle. It may be associated with a meniscal root tear. Radiographs and MRI can show the defect, with bone marrow oedema seen on T2-weighted images. Treatment usually involves rest, partial weight bearing and analgesia, including NSAIDs. If this fails, then surgical options include retrograde drilling to decompress the affected area, arthroplasty or a high-tibial osteotomy to offload the medial compartment.

27. Answer A. **Cemented total hip replacement**
Most patients with evidence of osteonecrosis do poorly with non-operative management. Described options of management include partial weight bearing, hyperbaric oxygen therapy, statins (to reduce circulating fats), bisphosphonates (to help restore bone) and anticoagulants (to stop microthrombosis). Electrical stimulation has also been described but has limited evidence and needs randomised controlled trials.

Surgical options include joint-preserving treatments such as mesenchymal stem cell injection, core decompression, decompression with porous tantalum rod implants or fibula bone graft to offer structural support, or a trapdoor procedure where the defect is opened and necrotic bone is removed and replaced with cancellous bone graft. Osteotomies can be used but are best for younger patients, with Ficat stage II or II disease and a Kerboul angle <200 degrees. They should be avoided in steroid- or alcohol-induced osteonecrosis. The aim is to move the affected portion of the femoral head medially. Two types have been described – angular intertrochanteric and rotational transtrochanteric (Sugioka). Joint-preserving treatments have had poor outcomes if the Kerboul angle of necrosis (measured on AP and lateral radiographs) is >200°.

Arthroplasty is an option including bipolar (risk of protrusion and erosion), hip resurfacing

(risk of metal debris and collapse), uncemented THA (best in younger patients) or cemented THA – poor results traditionally, but better now with newer cementing techniques and is a good option for elderly patients.

Kerboul M, Thomine J, Postel M, Merle d'Aubigné R. The conservative surgical treatment of idiopathic aseptic necrosis of the femoral head. *J Bone Joint Surg Br.* 1974;**56**:291–296.

Mont MA et al. Systematic analysis of classification systems for osteonecrosis of the femoral head. *J Bone Joint Surg Am.* 2006;**88**:16–26.

Sugioka Y. Transtrochanteric anterior rotational osteotomy of the femoral head in the treatment of osteonecrosis affecting the hip: a new osteotomy operation. *Clin Orthop. Relat. Res.* 1978;**130**:191–201.

28. Answer E. **Total hip arthroplasty is best for younger patients with stage IV disease**

An uncemented THA is suitable for younger patients with stage IV disease – cemented THA is now an option for older patients due to improved cementing techniques. Previous cemented THA for osteonecrosis had poor results – due to cementing into 'dead' bone. A rotational transtrochanteric osteotomy (Sugioka) aims to move the affected part of the femoral head medially, inferiorly and posteriorly to offload the affected area. Decompression of the femoral head may be used for early disease, but not stage IV when degenerative changes are seen. Joint-preserving treatments have poor outcomes if the Kerboul angle of necrosis (measured on AP and lateral radiographs) is >200°. Due to the risks of nonunion, osteotomy is not indicated in steroid-induced osteonecrosis.

29. Answer C. **II**

The Ficat classification is commonly used for grading osteonecrosis of the hip, although there are problems with interobserver reliability. The stages of the classification are described below:

0 – Pre-clinical (normal radiographs and MRI).

I – Pre-radiographic (normal radiographs, increased T2, decreased T1 signal on MRI).

II – Mixed osteopenia and/or sclerosis of femoral head without subchondral lucency (spherical).

III – Crescent sign indicating subchondral collapse.

IV – Secondary degenerative changes.

The Steinberg classification adds in additional detail to the Ficat classification, with stages 0–VI:

0–III as per the Ficat classification.

IV = Flattening of the femoral head with depression.

V = Joint space narrowing.

VI = Advanced degenerative change.

The Mitchell classification has four stages and is based on the MRI appearances of the lesion:

Class A = bright T1, indeterminate T2.

Class B = bright T1, bright T2.

Class C = indeterminate T1, bright T2.

Class D = dark T1, dark T2.

Arlet J, Ficat RP. Forage-biopsie de la tete femorale dans I'osteonecrose primitive: observations histopathologiques portant sur huit forances. *Rev Rheum.* 1964;**31**:257–264.

Ficat RP. Idiopathic bone necrosis of the femoral head: early diagnosis and treatment. *J Bone Joint Surg Br.* 1985;**67**:3–9.

Ficat RP. Aseptic necrosis of the femur head: preliminary remarks concerning staging. *Acta Orthop Belg.* 1981;**47**:239–241.

Mitchell DG et al. Femoral head avascular necrosis: correlation of MR imaging, radiographic staging, radionuclide imaging, and clinical findings. *Radiology* 1987;**162**:709–715.

Steinberg ME, Hayken GD, Steinberg DR. A quantitative system for staging avascular necrosis. *J Bone Joint Surg Br.* 1995;**77**:34–41.

Steinberg DR, Steinberg ME. The University of Pennsylvania classification of osteonecrosis. In Koo KH, Mont MA, Jones LC, eds. *Osteonecrosis*, 201–206. Heidelberg: Springer; 2014.

30. Answer D. **Idiopathic primary**

Idiopathic osteonecrosis accounts for 40% of cases. Primary osteonecrosis is more common in younger males and may be bilateral. Other causes include arterial disruption (fracture, dislocation or infection), arterial occlusion (thrombosis, embolism, Caisson's disease, sickle cell), vessel wall damage (vasculitis), steroid use,

alcohol, Gaucher disease, hyperlipidaemia, diabetes and radiotherapy.

Another way to classify causes is:

- Extraosseous arterial factors: disruption of blood supply, e.g. vasospasm, vasculitis, trauma.
- Intraosseous arterial factors: sickle cell, fat emboli, air emboli.
- Intraosseous venous factors: Caisson's disease, SCD.
- Intraosseous extravascular: fat cell hypertrophy, lipid deposits.
- Extraosseous extravascular: trauma, infection or arthritis (effusion).
- Pathology features are as follows:
- Necrosis of bone cells in marrow.
- Increased water content as seen on MRI with increased T2 signal.
- Reactive hyperaemia and vascular ingrowth.
- Creeping substitution by cutting cones.
- Osteoid laid down on dead cancellous trabeculae.
- Remodelling and maturation.

31. Answer E. ***S. epidermidis***
Staphylococcus epidermidis, along with *S. aureus*, is the most common organism causing prosthetic joint infection (PJI). Although all of the organisms in the question can cause PJI, *S. epidermidis* is the most prevalent. It can form biofilms, making eradication difficult.

32. Answer D. **Intraoperative Gram stain**
Preoperative blood tests can help with the diagnosis of periprosthetic infection, with CRP, ESR and IL-6 being sensitive for infection. Intraoperative Gram stain is not advocated to help with diagnosis of prosthetic joint replacement, although intraoperative histopathology can be used.

33. Answer A. ***Cutibacterium acnes***
Staphylococcus and *Streptococcus* are Gram-positive cocci, not bacilli. *Cutibacterium acnes*, formerly known as *Propionibacterium acnes*, is a slow-growing Gram-positive aerotolerant anaerobic rod. It is a skin commensal, often found in the axilla, and has been linked to infected shoulder arthroplasty.

34. Answer B. **Debridement, antibiotics and implant retention**
This patient has likely had an acute haematogenous infection, and as they have presented early, the implants look well-fixed and the organism is known, then they could be considered for a DAIR procedure (debridement, antibiotics and implant retention). This will require removal of all fibrous tissue, devitalised soft tissue, thorough lavage and exchange of the polyethylene liner. Six weeks of post-operative antibiotics, tailored to organism sensitivities, are required, and success rates can be as high as 80%. Arthroscopic washout or intravenous antibiotic suppression therapy may be indicated in patients who are medically unfit to undergo anaesthesia or a prolonged revision procedure.

Two-stage revision has traditionally been considered the gold standard of treatment, although there is now increasing evidence single-stage revision in appropriately selected patients has similar clinical outcomes, with good patient-reported outcomes and cost-effectiveness.

Blom AW et al. and INFORM Trial Group. Clinical and cost effectiveness of single stage compared with two stage revision for hip prosthetic joint infection (INFORM): pragmatic, parallel group, open label, randomised controlled trial. *Br Med J (Clin. Res. ed.)* 2022;**379**: e071281.

Pangaud C, Ollivier M, Argenson JN. Outcome of single-stage versus two-stage exchange for revision knee arthroplasty for chronic periprosthetic infection. *EFORT Open Reviews* 2019;**4**:495–502.

35. Answer C. **Inhibits peptidoglycan polymerisation**
Teicoplanin is of the glycopeptide class of antibiotics and has bactericidal activity against aerobic and anaerobic Gram-positive bacteria, including multi-resistant staphylococci. It inhibits peptidoglycan polymerisation, resulting in inhibition of bacterial cell wall synthesis and cell death.

Antibiotics can be split into different classes and have different mechanisms of action. They can be either bactericidal or bacteriostatic.

Penicillins: Bactericidal, inhibit cell wall synthesis by inhibiting peptidoglycan synthesis.

Cephalosporins: Bactericidal, inhibit cell wall synthesis.

Carbapenems: Bactericidal, inhibit cell wall synthesis.

Monobactams: Bactericidal, inhibit cell wall synthesis, work mainly against Gram-negative anaerobes.

Aminoglycosides: Bactericidal, inhibit protein synthesis, binding to 30S subunit of ribosomal RNA.

Macrolides: Inhibit translocation by binding to the 50S subunit of ribosomal RNA.

Quinolones: Inhibit DNA gyrase, preventing compression of DNA into supercoils.

Glycopeptides: Inhibit cell membrane / cell wall synthesis.

Tetracyclines: Bacteriostatic, inhibit bacterial protein synthesis by binding to 30S subunit of ribosomal RNA.

36. Answer D. **Screening for MRSA has no benefit on infection rate**
Chlorhexidine is a bisbiguanide with bactericidal and bacteriostatic properties with a broad spectrum of activity against Gram-positive and Gram-negative bacteria, fungi and lipophilic viruses. It disrupts membranes but is deactivated by many hand sanitisers and topical skin cleansers. Iodophors (iodine complexed with a solubilising agent such as povidone) are broad-spectrum bactericidal agents with activity against spores, fungi and viruses. They affect microbial proteins and DNA, but are inactivated by blood, faeces and pus. 70% alcohols denature proteins and have broad-spectrum activity against Gram-negative and Gram-positive bacteria. Chlorhexidine and iodophors are often used in conjunction with alcohol, although this is contraindicated on open wounds or delicate skin, where aqueous forms are utilised instead.

High-efficiency particulate air (HEPA) filters particles to 0.5μm in size, with >99% efficiency, with less than 10 colony-forming units per cubic metre at the centre of the operating theatre. Theatres can employ laminar-flow systems, which may be either vertical or horizontal.

Screening for MRSA infection does reduce infection rates, as positive patients can be given eradication therapy preoperatively; this includes topical mupirocin and chlorhexidine baths 5 days preoperatively. They can also be segregated on the wards – ring fencing elective wards can help reduce infection in arthroplasty patients and is recommended. Intravenous glycopeptides are the treatment of choice for MRSA infection.

37. Answer C. **Elevated serum WCC**
The working group on the Diagnosis of Periprosthetic Joint Infection at the Proceedings of the International Consensus Meeting on Periprosthetic Joint Infection in 2013 defined periprosthetic joint infection as two positive periprosthetic cultures with identical organisms, OR a sinus tract communicating with the joint, OR three of the following minor criteria:

Elevated CRP and ESR.

Elevated synovial fluid WCC OR ++ change on leukocyte esterase test strip.

Elevated synovial fluid PMN%.

Positive histological analysis of periprosthetic tissue.

Single positive culture.

A raised serum white cell count is not included in the definition.

In 2018, the European Bone and Joint Infection Society (EBJIS) published guidance to aid in the diagnosis of prosthetic joint infection (PJI). They created three categories – infection unlikely, infection likely and infection confirmed. The guidance utilises clinical and blood work-up, synovial fluid cytological analysis and presence of biomarkers, microbiology and histology results, and the use of nuclear imaging.

McNally M et al. The EBJIS definition of periprosthetic joint infection. *Bone Joint J.* 2021;**103-B**:18–25.

Parvizi J, Gehrke, T. Proceedings of the International Consensus Meeting on Periprosthetic Joint Infection; 2018. https://www.efort.org/wp-content/uploads/2013/10/Philadelphia_Consensus.pdf.

Parvizi J, Gehrke T, Chen AF. Proceedings of the International Consensus on Periprosthetic Joint Infection. *Bone Joint J.* 2013;**95-B**:1450–1452.

38. Answer D. **Powdered antibiotics should be used and added before mixing**
Powdered, not liquid, antibiotic should be used and added to the cement before mixing. Typically, high-dose vancomycin and gentamicin are used, but this should be adapted according to known organism sensitivities. Only heat-stable antibiotics can be used, due to the exothermic reaction while cement polymerises. Commercially available antibiotic cement has lower doses used for prophylaxis, not for treatment of infection. Antibiotic elution is highest for the first 24–72 hours following implantation. The addition of antibiotics can weaken cement, and so should only be used in the recommended doses.

39. Answer C. **Non-articulating cement spacers should be used in patients with bone loss or lack of soft tissue constraint**
Cement spacers can be articulating or non-articulating. While there are no absolute contraindications to their use, in patients with bone loss or a lack of soft tissue integrity, non-articulating spacers should be used. There is no reported difference between handmade or industry-made cement spacers on the rate of infection eradication. Synovial PMN% >90% is positive for acute infection, and a target of five intraoperative tissue samples should be obtained, according to consensus meeting definitions.

40. Answer E. **Two-week history of increasing pain in the hip, with a raised CRP and ESR; radiographs are satisfactory, culture results show *S. aureus***
Patients presenting within 3 weeks of surgery, or the onset of their symptoms, with stable implants and a known organism are suitable to undergo a DAIR procedure. If the history is longer than this, or the organism is not known, then a one- or two-stage revision should be performed. In cases where there is loosening (i.e. the acetabulum in DeLee and Charnley zone 3), revision is required, rather than just exchange of the femoral head. In the presence of a normal CRP and ESR, with negative culture, and aseptic loosening, a revision procedure would be required rather than DAIR.

41. Answer E. **This patient will demonstrate limited response to ACTH testing**
The adrenal gland consists of two parts: the cortex, which produces mineralocorticoids, glucocorticoids and androgens, and the medulla, which produces catecholamines. Chronic steroid use (such as in rheumatoid arthritis, COPD and polymyalgia rheumatica) can suppress the usual hypothalamic-pituitary-adrenal axis and render a patient unable to respond appropriately to trauma and stress. Patients require additional intravenous steroid in the perioperative period to prevent an adrenal crisis. Symptoms of adrenal insufficiency include hypotension, confusion, hypoglycaemia, sweating, abdominal pain and lethargy. In addition to fluids and glucose, intravenous steroid (typically hydrocortisone) is required. Patients with adrenal insufficiency will not respond to ACTH testing.

42. Answer D. **Stop etanercept 2 weeks before surgery, continue methotrexate**
Guidelines have now been published describing the perioperative management of anti-rheumatoid medication in patients undergoing hip and knee surgery. Disease-modifying drugs including methotrexate, sulfasalazine, hydroxychloroquine and leflunomide can be continued throughout the perioperative period. Biological agents should be stopped, and the timing depends on the dosing cycle, which relates to the half-life of the drug. They should be resumed a minimum of 14 days after surgery, when the wound has healed and there is no concern about infection.

Goodman SM et al. ACR AAHKS Perioperative Management Guideline; 2022. https://www.rheumatology.org/Portals/0/Files/ACR-AAHKS-Perioperative-Management-Guideline.pdf.

43. Answer E. **The risk of transmission from patient to surgeon with a needlestick injury is 1:300**
If a surgeon sustains a needlestick injury, this should be reported straight away to the occupational health department, and an incident form completed. The area affected should be washed immediately with water and encouraged to bleed. Occupational health should be contacted in-

hours, or the emergency department out-of-hours. Baseline blood tests from both donor and recipient should be obtained for HIV, HepB and HepC. In high-risk patients (including multiple sexual partners, multiple tattoos or piercings, blood transfusions abroad, recreational drug user, known blood-borne viruses), post-exposure prophylaxis should be started immediately, in conjunction with occupational health or infectious disease departments.

The risk of transmission from a needlestick injury of HIV is 0.3% (1:300), hepatitis C (3%), and hepatitis B (30%). The risk is less with exposure to a contaminated mucous membrane (~0.09%). Hollow, rather than solid, needles increase the risk of transmission.

44. Answer A. **They are at increased risk of developing a DVT**
Factor V Leiden mutation is an inherited disorder of factor V resulting in thrombophilia. Patients are at increased risk of developing DVT and PE and require prophylaxis/treatment for this.

45. Answer E. **Variable-rate insulin infusion should be stopped before the administration of subcutaneous insulin post-operatively**
Guidelines regarding perioperative diabetic management suggest that if a patient will miss less than one meal, then a variable-rate insulin infusion is not required if they have good diabetic control ($HbA1_C$ less than 69mmol/l). In elective cases, diabetic control can be optimised, as indicated by changes in $HbA1_C$. If patients have poor diabetic control, or are likely to miss more than one meal, then a variable-rate insulin infusion should be started, and continued until the patient is eating and drinking and has had their usual diabetic medication. They should be prioritised on elective operating lists. Diet-controlled diabetics do not need list-order prioritisation.

Barker P et al. Peri-operative management of the surgical patient with diabetes. *Anaesthesia* 2015;**70**:1427–1440.

Dhatariya K et al. Management of adults with diabetes undergoing surgery and elective procedures: improving standards; 2016. https://www.diabetes.org.uk/resources-s3/2017-09/Surgical%20guidelines%202015%20-%20full%20FINAL%20amended%20Mar%202016_0.pdf.

Sudhakaran S, Surani SR. Guidelines for perioperative management of the diabetic patient. *Surg Res Pract.* 2015;**2015**:284063.

46. Answer B. **Early operative intervention for acetabular fracture fixation**
The formation of heterotopic ossification is associated with spinal cord injury, traumatic brain injury, burns, high injury severity score, total hip arthroplasty, blast injuries, amputation through the zone of injury, prolonged need for mechanical ventilation and decubitus ulcers. Surgical approaches to the acetabulum in particular have been associated with HO, the extended iliofemoral having the greatest association. A delay in surgical intervention is associated with an increased risk of developing HO, so early surgical fixation is recommended.

47. Answer C. **Medium to high doses of NSAIDs reduce the risk of developing heterotrophic bone formation after hip surgery**
Prophylaxis against HO includes the use of the non-steroidal anti-inflammatory indomethacin, a non-selective COX-1 and COX-2 inhibitor which inhibits the effect of prostaglandin E2 on the differentiation of progenitor cells. Due to the cost and potential to induce malignancy with radiotherapy treatment, indomethacin is often the first line of treatment, although this has been associated with the risk of non-union of fractures. When radiotherapy is used, a single dose of ~700cGy within 72 hours following surgery has been shown to be of benefit. Bisphosphonates are no longer recommended to help prevent HO formation.

Fransen M et al. Safety and efficacy of routine postoperative ibuprofen for pain and disability related to ectopic bone formation after hip replacement surgery (HIPAID): randomised controlled trial. *Br Med J (Clinical Research Ed.)* 2006;**333**:519.

Neal B, Rodgers A, Dunn L, Fransen M. Non-steroidal anti-inflammatory drugs for preventing heterotopic bone formation after hip arthroplasty. *Cochrane Database Syst Rev.* 2000;**3**:CD001160.

48. Answer B. **Indomethacin can prevent further HO formation**

Prophylaxis against HO includes the use of the non-steroidal anti-inflammatory indomethacin, a non-selective COX-1 and COX-2 inhibitor which inhibits the effect of prostaglandin E2 on the differentiation of progenitor cells. Surgery to excise HO should be delayed until mature bone is noted, and the suggested delay is 6 months for traumatic HO, 12 months in spinal cord injury and 18 months for traumatic brain injury. The Brooker classification describes HO around the hip, and comprises four classes, with IV being the worst (ankylosis of the hip). Radiotherapy as a single-dose of 700–800cGy can be used up to 72 hours following surgery.

Heterotopic ossification (HO) is the formation of lamellar bone in extra-skeletal tissue, typically between the joint capsule and muscle. It can be classified into three subtypes: neurogenic, traumatic and fibrodysplasia ossificans progressiva (caused by a mutation in the *ACVR1* gene). Factors associated with formation of HO include spinal cord injury, traumatic brain injury, burns, high injury severity score, total hip arthroplasty, blast injuries, amputation through the zone of injury and decubitus ulcers. Surgical approaches to the acetabulum in particular have been associated with HO, the extended iliofemoral having the greatest association. The hip and elbow are the joints most commonly affected, with restricted movement of the joint noted. The Brooker classification has been developed to classify HO around the hip (Figure 26.2), and the Hastings and Graham classification for HO at the elbow (Table 26.2).

Plain radiographs can show HO, with bony cortex, sharp demarcation and trabecular bone pattern indicating mature bone. Bone scans can give an earlier diagnosis, although they are a more expensive test. Ultrasound and CT scans are also of use to aid diagnosis.

Prophylaxis against HO includes the use of the non-steroidal anti-inflammatory indomethacin, a non-selective COX-1 and COX-2 inhibitor which inhibits the effect of prostaglandin E2 on the differentiation of progenitor cells. Radiotherapy as a single-dose of 700–800cGy can be used up to 72 hours following surgery.

Table 26.2 Hastings and Graham classification (elbow). Reproduced with permission from Elsevier

Class	Description
I	Radiographic evidence, no functional problem
II A	Radiographic evidence with limitation in flexion-extension axis
II B	Radiographic evidence with limitation in pronation-supination axis
II C	Radiographic evidence with limitation in flexion-extension and pronation supination axes
III A	Ectopic bone formation and ankylosis in flexion-extension axis
III B	Ectopic bone formation and ankylosis in pronation-supination axis
III C	Ectopic bone formation and ankylosis in flexion-extension and pronation-supination axes

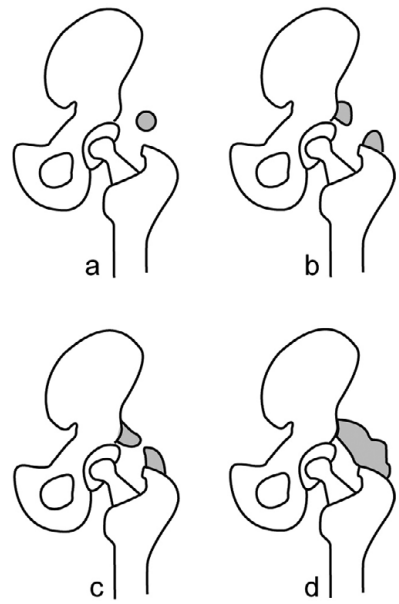


Figure 26.2 Brooker classification. (a) Grade 1 islands of bone in soft tissue, (b) bone spurs from either the femur or pelvis >1cm gap between spurs, (c) bone spurs from either the femur or pelvis <1cm gap across the spurs and (d) ankylosis of the hip

Bisphosphonates are not used. For established HO causing functional problems, surgical excision can be considered. This should be delayed until HO has 'matured' on plain radiographs, although it is suggested that the delay is 6 months for traumatic HO, 12 months in spinal cord injury and 18 months for traumatic brain injury.

Hastings II H, Graham TJ. The classification and treatment of heterotopic ossification about the elbow and forearm. *Hand Clinics* 1994;**10**:417–437.

Ranganathan K et al. Heterotopic ossification: basic-science principles and clinical correlates. *J Bone Joint Surg Am.* 2015;**97**:1101–1111.

49. Answer E. **X-linked recessive**
Haemophilia is an X-linked recessive inherited bleeding disorder, with two subtypes: haemophilia A (the most common) is due to an abnormality in factor VIII, whereas haemophilia B (Christmas disease) is due to an abnormality in factor IX. These two clotting factors are part of the intrinsic pathway.

50. Answer B. **Factor VIII, an intrinsic pathway clotting factor**
Haemophilia is an X-linked recessive inherited bleeding disorder, with two subtypes: haemophilia A (the most common) is due to an abnormality in factor VIII, whereas haemophilia B (Christmas disease) is due to an abnormality in factor IX. These two clotting factors are part of the intrinsic pathway.

51. Answer D. **Synovectomy can be performed when medical management has failed to control symptoms**
In haemophilia, treatment of acute haemarthroses includes splintage and analgesia, along with factor replacement to at least 25% of normal levels. Surgical options include synovectomy for recurrent haemarthroses despite maximal medical therapy, arthrodesis or arthroplasty for end-stage disease. Factor levels should be checked, and replacement given before surgery. Protein C and S deficiency can cause thrombosis, not bleeding.

52. Answer A. **Factor VIII abnormality**
Radiographic features of haemophilia include epiphyseal overgrowth, osteopenia, widening of the intercondylar notch, flattening of the femoral condyles and squaring of the patella. MRI or ultrasound is useful to determine the extent of soft tissue 'pseudotumours' secondary to intramuscular haemorrhage. Haemophilia is an X-linked recessive inherited bleeding disorder, with two subtypes: haemophilia A (the most common) is due to an abnormality in factor VIII, whereas haemophilia B (Christmas disease) is due to an abnormality in factor IX.

These two clotting factors are part of the intrinsic pathway. Haemophilia presents with recurrent haemarthroses or bleeding deep within muscles (pseudotumours) either following trauma or spontaneously. The knee is the most common joint affected.

Recurrent bleeding causes haemosiderin deposition in the synovium and cartilage destruction secondary to the release of proteolytic enzymes. Radiographic features of haemophilia include epiphyseal overgrowth, osteopenia, widening of the intercondylar notch and squaring of the patella. MRI or ultrasound is useful to determine the extent of pseudotumours.

Treatment of acute haemarthroses includes splintage and analgesia, along with factor replacement to at least 25% of normal levels. Desmopressin may be used in mild cases. Surgical options include synovectomy for recurrent haemarthroses, despite maximal medical therapy, arthrodesis or arthroplasty for end-stage disease. Factor levels should be checked, and replacement given before surgery and in the post-operative period.

53. Answer B. **Posterolateral side of medial femoral condyle**
Osteochonditis dissecans is a lesion of the articular cartilage and underlying subchondral bone. The knee is the most common joint affected, with most lesions occurring in the posterolateral non-weight-bearing aspect of the medial femoral condyle.

54. Answer E. **Pappas classification suggests excellent prognosis is seen in patients <12 years of age**
Pappas classification is based on age and suggests those <12 years (juvenile) have excellent healing potential of an OCD; adolescents (12–20 years) have an unpredictable outcome, and adults (>20 years) have a poor prognosis. The presence of an open physis can indicate a good prognosis. Lateral femoral condyle lesions have a poorer prognosis than medial femoral condyle lesions.

Pappas A. Osteochondrosis dissecans. *Clin Orthop Relat Res*. 1981;**158**:59–69.

55. Answer D. **The presence of synovial fluid behind the lesion on MRI indicates good healing potential**
The presence of synovial fluid behind the lesion on MRI indicates a poor prognosis, as it suggests the fragment is separated from the underlying subchondral bone. Increasing age and lesions of the lateral femoral condyle or patella are also associated with a poorer prognosis.

56. Answer B. **Headless screw fixation**
For early separated or incompletely detached lesions, securing the fragment with headless screws can give up to 85% healing rates in juvenile patients. Osteochondral grafts, autologous chondrocyte implantation, matrix-induced chondrocyte implantation and microfracture are more suited to completely detached lesions. For *in situ* lesions, retrograde or antegrade drilling may be indicated. In young patients with open physes, activity modification and restricted weight bearing will allow most lesions to heal.

Chapter 27

Pathology III Structured SBA

Jonathan Lenihan and Alexander Durst

PATHOLOGY III STRUCTURED SBA QUESTIONS

1. A patient with a scapular neck fracture undergoes repair, utilising an internervous plane, to expose the glenoid.
   Which intermuscular approach is utilised?
   A. Deltoid and pectoralis major
   B. Deltoid and infraspinatus
   C. Deltoid and supraspinatus
   D. Infraspinatus and teres minor
   E. Supraspinatus and infraspinatus

2. A patient restarts their usual anticoagulation 4 weeks after a total hip replacement. They suffer a life-threatening bleed, receiving a reversal agent which has a higher affinity for their anticoagulant than thrombin does.
   Which anticoagulant have they been taking?
   A. Apixaban
   B. Dabigatran
   C. Fondaparinaux
   D. Rivaroxaban
   E. Warfarin

3. A front-seat passenger sustains a traumatic native hip dislocation in a road traffic collision resulting in a nerve injury.
   What is the root value of the injured nerve?
   A. L1, L2, L3, L4, L5
   B. L2, L3, L4, L5, S1
   C. L3, L4, L5, S1, S2
   D. L4, L5, S1, S2, S3
   E. L5, S1, S2, S3, S4

4. A 36-year-old man presents to the Emergency Department with a hot, swollen native knee. Microscopy and Gram reaction show purple spheres in clusters, resistant to penicillin.
   Which protein is responsible?
   A. AnkB F-Box
   B. BamA
   C. Cas9
   D. ClfA
   E. PBP2A

5. A month after a football injury, a 14-year-old boy has a knee arthroscopy demonstrating a healing, stable vertical tear.
   Which cell type facilitates this regeneration?
   A. Chondrocytes
   B. Fibrochondrocytes
   C. Type A synovial macrophages
   D. Type B synovial fibroblasts
   E. Type C synovial cells

6. A 6-year-old child with short stature and bowed legs has raised calcium and urinary phosphoethanolamine.
   What is the most likely cause?
   A. Hypophosphatasia
   B. Renal osteodystrophy
   C. Type II vitamin D dependent
   D. Vitamin D deficiency rickets
   E. Vitamin D resistant rickets

7. A 12-year-old girl with hepatosplenomegaly, caused by an autosomal recessive storage disorder, receives treatment for severe disabling bone pain.
   Which physeal zone is affected?
   A. Degenerative zone
   B. Maturation zone
   C. Proliferative zone
   D. Reserve zone
   E. Zone of provisional calcification

8. A diabetic patient is unable to feel cotton wool on their lower limb, during a neurological examination.

Which afferent nerve fibre is affected?
A. Aα
B. Aβ
C. Aγ
D. Aδ
E. C

9. A 23-year-old student transects their index radial digital nerve with a kitchen knife, which is directly repaired after 2 days. Their outcome is assessed in clinic.
Which modality is the first to return?
A. Deep pressure
B. Light touch
C. Proprioception
D. Superficial pain
E. Vibration sense

10. A 19-year-old woman has a median nerve repair at the wrist, following a suicide attempt.
What is the greatest determinant for regeneration?
A. Alignment of nerve ends
B. Compliance to training
C. Injury level
D. Injury type
E. Patient age

11. A skier sustains a soft-tissue valgus stress injury to their knee, that is treated non-operatively with rest and physiotherapy.
What type of collagen is prevalent during peak angiogenesis?
A. I
B. II
C. III
D. V
E. IX

12. An anterior cervical approach is performed in a myelopathic patient.
Which nerve supplies the first muscle that is divided?
A. Ansa cervicalis
B. Cranial nerve VII
C. Cranial nerve X
D. Cranial nerve XI
E. Recurrent laryngeal nerve

13. A 15-year-old boy notices a fast-growing painless mass in his left arm. A biopsy is undertaken that reveals poorly differentiated round cells with multinucleated giant cells.
What is the most likely diagnosis?
A. Alveolar rhabdomyosarcoma
B. Chondrosarcoma
C. Ewing sarcoma
D. Myxoid liposarcoma
E. Synovial sarcoma

14. A 15-year-old girl has a painful thoracolumbar scoliosis, worse at night and relieved by ibuprofen.
What would you expect to see on histology?
A. Anaplastic spindle cells in storiform pattern
B. Anastomosing trabeculae with osteoblastic rimming
C. Hypercellular stroma with 'blue-balls'
D. Hyperchromic epithelial cells
E. Round blue cells in sheets

15. On initial contact during normal gait, high loads can be carried by a native knee as the bearing surfaces are driven apart.
Which lubrication method is responsible?
A. Boosted lubrication
B. Elastohydrodynamic lubrication
C. Hydrodynamic lubrication
D. Squeeze film lubrication
E. Weeping lubrication

16. After being stabbed in his upper torso, a 46-year-old man has his wound washed and closed in theatre. He attends clinic several weeks later, demonstrating painless weakness when performing 'Hornblower's test' but has normal 'regimental patch' sensation.
Which anatomical space has likely been violated?
A. Posterior triangle
B. Quadrangular space
C. Suprascapular canal
D. Triangular interval
E. Triangular space

17. Following a forearm fracture non-union, a 56-year-old man undergoes revision open reduction, internal fixation with iliac crest bone grafting.
By which mechanism does the graft integrate?
A. Creeping substitution
B. Endochondral ossification

C. Intramembranous ossification
D. Primary bone healing
E. Secondary bone healing

18. During a total hip replacement, the proximal extent of the incision is limited to reduce the risk of pain, limping and weak hip abduction secondary to nerve injury.
What is the root value of the nerve?
A. L1, L2, L3
B. L2, L3, L4
C. L3, L4, L5
D. L4, L5, S1
E. L5, S1, S2

19. A 2-year-old girl with precocious puberty, a goitre and irregular café au lait spots has a proximal femoral deformity.
Which gene mutation is responsible?
A. COL2A1
B. COL5A1
C. COMP
D. GNAS
E. NF-1

20. A catheterised man with suspected cauda equina syndrome has their catheter tugged, during a per rectal examination.
Which nerve is responsible for the afferent arm of this pathway?
A. Deep perineal
B. Dorsal nerve of the penis
C. Inferior anal
D. Posterior scrotal
E. Superficial perineal

21. During walking, the hindfoot is locked before initial contact.
Which muscle contraction is responsible?
A. Concentric contraction of gastrocnemius
B. Concentric contraction of tibialis anterior
C. Eccentric contraction of extensor hallucis longus
D. Eccentric contraction of peroneus longus
E. Isometric contraction of soleus

22. In pre-assessment a 73-year-old man, with peripheral vascular disease awaiting a total knee replacement, is advised to stop his antithrombotic agent 7 days before surgery.
What is the mechanism of this drug?
A. Enhanced antithrombin III activity
B. Inactivation of Factor IIa
C. Inhibition of ADP receptors
D. Inhibition of protein C
E. Inhibition of protein S

23. A tibial fracture is being treated with a uniplanar external fixator. Several methods are utilised to increase the construct rigidity, intraoperatively.
Which method has the greatest efficacy?
A. Adding a stacked connecting bar
B. Increasing connecting bar diameter
C. Increasing pin diameter
D. Reducing the pin separation distance in each fracture segment
E. Reducing the distance between bone and connecting bars

24. An 18-year-old man presents with multiple palpable soft tissue swellings, some related to minor trauma, generalised tenderness, decreased lumbar range of motion and progressive hearing loss over 3 years. He was born with 'funny looking' big toes.
Which genetic defect is responsible?
A. ACVR1
B. COL1A
C. COMP
D. EXT1
E. FGFR3

25. During a normal neurological examination, a patient can feel the tuning fork against their medial malleolus.
Which mechanoreceptor is responsible?
A. Golgi organ
B. Meissner's corpuscle
C. Merkel cell
D. Pacinian corpuscle
E. Ruffini's end organs

26. An MRI scan reveals an unstable chondral flap, in a 32-year-old cross-fitter, following an injury to her right knee. During arthroscopic evaluation, a deep articular cartilage laceration is noted, penetrating to the subchondral bone.
In healthy tissue, what is the predominant collagen type at this transitional area?

A. I
B. II
C. V
D. VI
E. X

27. A 48-year-old man with low-impact L1 and subsequent distal radius fractures has a Dual Energy X-ray Absorptiometry (DEXA) scan with T-score = −1.8 and Z-score = −2.5.
What is his diagnosis?
A. Normal
B. Osteopenia based on T-score
C. Osteopenia based on Z-score
D. Osteoporosis based on T-score
E. Osteoporosis based on Z-score

28. A 63-year-old woman with low impact L1-3 wedge compression fractures has a DEXA scan with T-scores of lumbar = −2.7, hip = −2.0, distal radius = −2.5 and Z-scores of lumbar = −2.5, hip = −1.3, distal radius = −2.3.
What is her diagnosis?
A. Osteopenia based on average T-score (lumbar, hip, radius)
B. Osteopenia based on average Z-score
C. Osteopenia based on hip Z-score
D. Osteoporosis based on distal radius T-score
E. Osteoporosis based on lumbar T-score

29. A 34-year-old man presents with chronic back pain and degenerative lumbar discs, confirmed on MRI scan. After receiving an interbody fusion, his disc is sent for histology.
What features are visible on microscopy?
A. Decreased fibroblast-like cell density
B. Decreased collagen
C. Increased chondroitin sulphate
D. Increased cell density
E. Increased large aggregated proteoglycans

30. A 4-year-old boy with a disproportionate short stature caused by a type II collagen problem affecting the reserve zone of his physis, is brought into clinic by his phenotypically similar father.
What is the most likely cause?
A. Achondroplasia
B. Hunter syndrome
C. Kniest syndrome
D. Morquio syndrome
E. Pseudoachondroplasia

31. Raloxifene hydrochloride is an anti-resorptive bone medication used to treat osteoporosis.
What is its mode of action?
A. Bio-active portion of parathyroid hormone
B. Inhibition of osteoclast ruffled border
C. Monoclonal antibody which binds to and inhibits RANK-L prevention activation of osteoclasts
D. Metabolised into non-functional ATP which induces osteoclast cell apoptosis
E. Selective oestrogen receptor modulator

32. **Which of the following are not features of haemophilia?**
A. Autosomal dominant inheritance
B. Decreased factor VII
C. Increased PT
D. Squaring of the distal pole of the patella
E. Widened intracondylar notch on AP knee AP radiograph

PATHOLOGY III STRUCTURED SBA ANSWERS

1. Answer D. **Infraspinatus and teres minor**
Scapula neck and posterior glenoid rim fractures are generally approached posteriorly. The posterior (Judet) approach to the scapula body is a true internervous plane between the axillary and suprascapular nerves. To expose the glenoid in deep dissection, teres minor is retracted inferiorly and infraspinatus is retracted superiorly. A deltoid splitting approach can also be used for access, however this is less extensile than the Judet approach. The deltopectoral approach, between deltoid (axillary nerve) and pectoralis major (medial/lateral pectoral nerves), is another internervous plane that can be utilised for accessing the anterior, medial and lateral aspects of the glenohumeral joint, and fixing anterior glenoid and coracoid fractures.

Bartoníček J, Frič V, Tuček M. Fractures of the anatomical neck of the scapula: two cases and review of the literature. *Arch Orthop Trauma Surg.* 2013;**133**:1115–1119.

2. Answer B. **Dabigatran**
Dabigatran is a direct oral anticoagulant (DOAC); a reversible direct thrombin (Factor IIa) inhibitor that undergoes renal metabolism, used in the management of atrial fibrillation and venous thromboembolism. Idarucizumab (Praxbind) is licensed as a specific reversal agent.

Rivaroxaban and apixaban are direct Xa inhibitors. Andexanet alfa is a recombinant form of human Factor Xa, which binds specifically to rivaroxaban and apixaban. Fondaparinaux in an indirect Factor Xa inhibitor. It has no specific reversal agent yet. Warfarin inhibits Vitamin K 2,3-epoxide reductase (VKORC1). Vitamin K is required for gamma-carboxylation of glutamic acid for Factors II (Prothrombin), VII, IX and X. The action of warfarin can be reversed through administration of vitamin K, fresh frozen plasma (FFP), prothrombin complex concentrate (PCC) or recombinant Factor VIIa.

Dhakal P, Rayamajhi S, Verma V, Gundabolu K, Bhatt VR. Reversal of anticoagulation and management of bleeding in patients on anticoagulants. *Clin Appl Thromb Hemost.* 2017;**23**:410–415.

3. Answer D. **L4, L5, S1, S2, S3**
The sciatic nerve is the most common nerve injured in trauma hip dislocations. The risk of nerve injury increases with delayed reduction. The nerve forms anterior to piriformis, from the L4-S3 roots of the sacral plexus. It then passes beneath piriformis through the greater sciatic notch exiting the pelvis.

Clegg TE, Roberts CS, Greene JW, Prather BA. Hip dislocations – epidemiology, treatment, and outcomes. *Injury* 2010;**41**:329–334.

Nicholson JA, Scott CEH, Annan J, Ahmed I, Keating JF. Native hip dislocation at acetabular fracture predicts poor long-term outcome. *Injury* 2018;**49**:1841–1847.

Vivas AC, Uribe JS. Innervation of the lower limb and nerve blockade techniques. In Brennan PA, Standring S, Wiseman S, eds. *Gray's Surgical Anatomy*, 584–588. London: Elsevier; 2019.

4. Answer E. **PBP2A**
Methicillin-resistant *Staphylococcus aureus* (MRSA) is the causative organism. On Gram staining, Gram-positive bacteria retain crystal violet, appearing purple/blue, whereas Gram-negative bacteria gain the pink/red appearance of the counterstain, safranin. Staphylococci appear as spheres in clusters, or in 'grape-like bunches' (coccus = berry; staphyle = grape, in Greek). *Staphylococcus aureus* was first described by Sir Alexander Ogston in 1880 after microscopy of pus from a knee; saying that 'the masses looked like bunches of grapes'. MRSA binds poorly to penicillin as PBP2A (penicillin binding protein 2A) conveys resistance to β-lactams. AnkB F-Box is excreted by *Legionella.* BamA is found in Gram-negative bacteria. Cas9 is involved in the immunity of *Streptococcus pyogenes*.

Licitra G. Etymologia: *Staphylococcus*. *Emerg Infect Dis.* 2013;**19**:1553.

Peacock SJ, Paterson GK. Mechanisms of methicillin resistance in *Staphylococcus aureus*. *Ann Rev Biochem.* 2015;**84**:577–601.

5. Answer B. **Fibrochondrocytes**
Meniscus and labrum constitute fibroelastic cartilage; fibrochondrocytes are responsible for regeneration, producing a fibrovascular scar. Normal synovium consists of two types of

synovial cells, two cell layers in thickness. Type A synoviocytes have macrophage lineage and are phagocytic. Type B (fibroblast-like) have mesenchymal origin and produce synovial fluid. Type C, or intermediate cells, are believed to be precursors to A and B cells.

Andress B et al. Meniscus cell regional phenotypes: dedifferentiation and reversal by biomaterial embedding. *J Orthop Res*. 2021;**39**:2177–2186.

Asif Amin M, Fox DA, Ruth JH. Synovial cellular and molecular markers in rheumatoid arthritis. *Semin Immunopathol.* 2017;**39**:385–393.

6. Answer A. **Hypophosphatasia**
Hypophosphatasia is an autosomal recessive disorder, caused by a mutation of tissue-nonspecific isoenzyme of alkaline phosphatase (TNSALP), resulting in low levels of ALP and decreased phosphate production. In the physis, the zone of provisional calcification does not develop and the physis concurrently fails to mineralise. Clinically it is heterogeneous and can present with pain, similarly to rickets with abnormal teeth, short stature, bowed legs, arthropathy, lower limb fractures; or in its most extreme form stillbirth without mineralised bone.

Fenn JS, Lorde N, Ward JM, Borovickova I. Hypophosphatasia. *J Clin Pathol*. 2021;**74**:635–640.

7. Answer D. **Reserve zone**
Gaucher disease, the most common lysosomal storage disorder, is caused by a deficiency in B-glucocerebrosidase. In the general population, it has an incidence of 1 in 40–60,000, but a much higher incidence in Ashkenazi Jews (1 in 800). As with most lysosomal storage disorders, it has autosomal recessive inheritance. Along with pseudoachondroplasia, it affects the reserve zone of the physis. Symptomology is diverse, depending on type, with some patients asymptomatic and others with child-onset disease. Clinically presentation often starts with hepatosplenomegaly, anaemia and thrombocytopenia. Orthopaedic manifestations include osteonecrosis, osteopenia/lytic lesions, chronic bone pain and acute episodes of excruciating pain known as 'bone crises'. Treatment is by enzyme replacement therapy, more recently by substrate reduction therapy; and symptomatic treatment of orthopaedic manifestations.

Fan J et al. Gaucher disease protects against tuberculosis. *Proc Natl Acad Sci USA* 2023;**120**: e2217673120.

Jmoudiak M, Futerman AH. Gaucher disease: pathological mechanisms and modern management. *Br J Haematol.* 2005;**129**:178–188.

8. Answer B. **Aβ**
Cotton wool is assessing fine touch, which is conveyed by Aβ nerve fibres, which also convey vibration sense. Aα convey limb proprioception, Aγ, Aδ and C fibres convey different types of pain.

Groener JB et al. Understanding diabetic neuropathy – from subclinical nerve lesions to severe nerve fiber deficits: a cross-sectional study in patients with Type 2 diabetes and healthy control subjects. *Diabetes* 2020;**69**:436–447.

Moehring F, Halder P, Seal RP, Stucky CL. Uncovering the cells and circuits of touch in normal and pathological settings. *Neuron* 2018;**100**:349–360.

9. Answer A. **Deep pressure**
After nerve injury and repair, tactile sensibility and pain caused by deep pressure are the first signs of sensory recovery. This is followed by gradual recovery of superficial pain and light touch. Early (i.e. immediately after injury) sensory relearning is important in recovery, however tactile discrimination functions rarely recover following a 'good' repair, as they are related to cortical remapping.

Evertsson L et al. Incidence, demographics and rehabilitation after digital nerve injury: a population-based study of 1004 adult patients in Sweden. *PLoS ONE* 2023;**18**:e0283907.

Rosen B, Lundborg G. A model instrument for the documentation of outcome after nerve repair. *J Hand Surg Am*. 2000;**25**:535–543.

10. Answer E. **Patient age**
Nerve regeneration following trauma is determined by multiple factors including nerve/cell (survival, axonal regeneration and misdirection) and patient (age, compliance to training); as well as level and type of injury. Whereas tactile discrimination rarely recovers following repair, children under 10 usually regain full functional sensibility, with function. This is believed to be

linked to cortical re-learning. Animal studies have shown delayed Wallerian degeneration, as well as decreased trophic and tropic factor secretion from Schwann cells. This leads to delayed interaction between the Schwann cells and the regenerating axons, with a non-linear (to age) decreased rate of axonal regeneration. Age also negatively affects neuronal loss in the dorsal root ganglia, after injury. Other factors, such as timing of repair, level of injury have importance, but much less in comparison with age.

Lundborg G, Rosén B. Hand function after nerve repair. *Acta Physiol (Oxf.)* 2007;**189**:207–217.

11. Answer C. **III**
Valgus stress injuries during skiing often represent MCL sprains. Ligament healing goes through four phases, which overlap but have distinct processes: Inflammation (0–7 days), Proliferation (2–21 days), Remodelling (from day 14) and Maturation (up to 18 months).

Initially, platelets in the formed clot cause local inflammation by releasing cytokines (TGFβ, IGF-I and PDGF) and recruiting neutrophils, which activate macrophages. TGFβ and IGF-I recruit fibroblasts and stimulate extracellular matrix, which starts the proliferative phase. Fibroblasts proliferate, promoting angiogenesis, cellular increase and collagen synthesis (predominantly type III). Type III collagen, which is normally found in skin and blood vessels, stabilises the zone of injury through rapid crosslink production. The remodelling phase increases fibrous matrix, whilst reorganising collagen by replacing type III with type I, which has greater tensile strength through more crosslinks and better fibre alignment (along lines of stress).

Leong NL et al. Tendon and ligament healing and current approaches to tendon and ligament regeneration. *J Orthop Res*. 2020;**38**:7–12.

Liu SH, Yang RS, al-Shaikh R, Lane JM. Collagen in tendon, ligament, and bone healing: a current review. *Clin Orthop Relat Res*. 1995;**318**:265–278.

12. Answer B. **Cranial nerve VII**
Platysma is the first muscle encountered in the anterior cervical approach, supplied by the cervical branch of the facial nerve (VII). The superior root of the ansa cervicalis (C1) supplies omohyoid. The spinal accessory nerve (XI) supplies sternocleidomastoid. The recurrent laryngeal is a branch of CN X, supplying all intrinsic muscles of the larynx except cricothyroid (supplied by the superior laryngeal branch of CN X).

Cheung KM, Mak KC, Luk KD. Anterior approach to cervical spine. *Spine (Phila Pa 1976)* 2012;**37**:E297–302.

Norris CD, Anzai Y. Anatomy of neck muscles, spaces, and lymph nodes. *Neuroimaging Clin N Am*. 2022;**32**:831–849.

13. Answer A. **Alveolar rhabdomyosarcoma**
Rhabdomyosarcoma (RMS) is the most common type of soft-tissue cancer in children. There are four subtypes of RMS: embryonal, alveolar, botryoid and pleomorphic. Embryonal RMS is the most common type affecting 2–6-year-olds, whereas alveolar RMS affects children in their teenage years. Alveolar RMS has a common t (2;13) translocation, and forms the Pax3-FKHR fusion protein. Chondrosarcomas typically occur in patients older than 40 years, presenting as a painful mass with biopsy showing hypercellular stroma. Ewing sarcoma presents with pain and fever, mimicking infection. Biopsy shows sheets of small blue round cells on biopsy. Synovial sarcoma usually presents between 15 and 40 years old, growing near, but not within a joint. Biopsy shows a biphasic appearance with atypical spindle cells and epithelial cells. Myxoid liposarcomas are the most common histological type of liposarcoma. They usually occur in adults between 50 and 80 years old.

Skubitz KM, D'Adamo DR. Sarcoma. *Mayo Clin Proc*. 2007;**82**:1409–1432.

14. Answer B. **Anastomosing trabeculae with osteoblastic rimming**
This is a representative clinical history for an osteoid osteoma: diffuse pain, worse at night, relieved by NSAIDS. In the spine, an osteoid osteoma can cause a painful scoliosis, with the lesion at the convex curve apex. On plain film radiographs, a characteristic small (<1cm) osteolytic nidus surrounded by sclerosis may be seen, however this is often more clearly demonstrated on CT/MRI. 'Anastomosing trabeculae' signify woven bone with a border, equalling the characteristic 'nidus' of osteoid osteoma. Hyperchromic

epithelial cells are found in osteofibrous dysplasia. Spindle cells indicate a sarcoma (pleomorphic, undifferentiated sarcoma, fibrosarcoma or leiomyosarcoma), whereas storiform (*storea* means woven mat in Latin) indicates fibrous tissue: fibrosarcoma. 'Blue-balls' are characteristic in high-grade chondrosarcoma. Round blue cells indicate Ewing sarcoma.

Flanagan AM, Lindsay D. A diagnostic approach to bone tumours. *Pathology* 2017;**49**:675–687.

Lee EH, Shafi M, Hui JH. Osteoid osteoma: a current review. *J Pediatr Orthop.* 2006;**26**:695–700.

15. Answer D. **Squeeze film lubrication**
When the heel strikes the ground during initial contact, the load on the knee suddenly increases while the entraining velocity is reduced towards zero. The thick film that previously has been generated starts to squeeze out and reduce. In the normal gait cycle, this load is only applied for a short period of time, so the squeeze film mechanism is able to maintain a viable film of lubricant throughout this stage.

Ali AM, Yousif AE. The role of lubrication mechanisms in the knee synovial joints. *NUCEJ* 2008;**11**:522–535.

16. Answer C. **Suprascapular canal**
Hornblower's test can be used to assess the strength of teres minor or infraspinatus. Teres minor is supplied by the axillary nerve, which passes through the quadrangular space along with the posterior humeral circumflex artery. The axillary neve also supplies the skin overlying the deltoid muscle, known as the 'regimental patch/badge'. Infraspinatus and supraspinatus are both innervated by the suprascapular nerve, which is formed from the ventral rami of C5 and 6. The suprascapular nerve passes posterior to the brachial plexus in the posterior triangle of the neck, then courses laterally through the suprascapular notch (innervating supraspinatus) and into the suprascapular canal. Within the canal it gives off deep sensory fibres to the glenoacromial and acromioclavicular joints, before exiting the spinoglenoid notch to innervate infraspinatus. The radial nerve and profunda brachii pass through the triangular interval, whereas the triangular space contains the scapular circumflex vessels.

Al-Redouan A, Holding K, Kachlik D. 'Suprascapular canal': anatomical and topographical description and its clinical implication in entrapment syndrome. *Ann Anat.* 2021;**233**:151593.

Shapiro BE, Preston DC. Entrapment and compressive neuropathies. *Med Clin North Am.* 2009;**93**:285–315.

17. Answer A. **Creeping substitution**
Cancellous autograft is osteogenic, osteoconductive and osteoinductive, achieving early structural strength with rapid incorporation. After an inflammatory phase, creeping substitution occurs, with the graft stimulating osteoblastic activity followed by osteoclastic resorption and a remodelling phase. Cortical autograft incorporates via osteoclast cutting cones, followed by osteoblasts laying down lamellar bone, with no remodelling. Allograft (cancellous or cortical) has a longer inflammatory phase (T-cell mediated) and is slower than in autograft, with a chance of rejection. Vascular grafts incorporate in similar fashion to healing fractures.

Baldwin P et al. Autograft, allograft, and bone graft substitutes: clinical evidence and indications for use in the setting of orthopaedic trauma surgery. *J Orthop Trauma*. 2019;**33**:203–213.

Burchardt H. The biology of bone graft repair. *Clin Orthop Relat Res*. 1983;**174**:28–42.

18. Answer D. **L4, L5, S1**
The superior gluteal nerve innervates gluteus medius and gluteus minimus (as well as piriformis and tensor fasciae latae), which stabilise the pelvis during gait. The nerve lies 3–5cm proximal to the anterior tip of the greater trochanter. Incision placements in anterolateral, lateral and transgluteal approaches aim to avoid iatrogenic superior gluteal nerve injury, however gluteal muscle splitting and traction may also contribute to post-operative abductor weakness.

Odak S, Ivory J. Management of abductor mechanism deficiency following total hip replacement. *Bone Joint J*. 2013;**95-B**:343–347.

19. Answer: D. **GNAS**
The clinical scenario describes McCune–Albright syndrome, a rare sporadic, non-heritable multisystem disease, characterised by the triad of

polyostotic (i.e. multiple bone) fibrous dysplasia, irregular (coast of Maine) café-au-lait spots and hyperfunctioning endocrinopathies. Clinical diagnosis is made with co-occurrence of two of these signs.

Mosaicism occurs, due to random Guanine Nucleotide-Binding Protein, Alpha-Stimulating Activity Polypeptide (GNAS) mutations, with severity of McCune–Albright syndrome linked to the number of mutations. GNAS encodes the alpha unit in G-proteins; mutation causes hyperactivation of the G-protein coupled receptor system and resultant hyperfunctioning endocrinopathies, impaired skeletal stem cell differentiation and resultant impaired bone remodelling. Treatment is symptomatic, requiring a wide MDT, including endocrinologists. In girls, menses is often started by age 2 (secondary to ovarian cysts); boys may also, but less commonly, have precocious puberty. If the pituitary is involved, acromegaly is observed (coarse facial features, large hands and feet). Hyperthroidism occurs in ~50%. Cushing's can occur rarely, before age 2. COL2A1 mutations are associated with achondro- and hypochondrogenesis, Kniest dysplasia and spondyloepiphyseal dysplasia congenita. COL2A1 mutations cause 'classical' Ehlers–Danlos syndrome. COMP mutations cause multiple epiphyseal dysplasia and pseudoachondroplasia. NF-1 mutations cause neurofibromatosis type 1.

Nicolaides NC et al. McCune–Albright syndrome: a case report and review of literature. *Int J Mol Sci.* 2023;**24**:8464.

20. Answer B. **Dorsal nerve of the penis**
The paired pudendal nerve (S2,3,4) divides into the inferior rectal, perineal, posterior scrotal/labial and dorsal nerve of the penis/clitoris. The afferent arm of the arc is carried by the dorsal penile nerve, with the efferent by the deep perineal.

Granata G et al. Electrophysiological study of the bulbocavernosus reflex: normative data. *Funct Neurol.* 2013;**28**:293–295.

21. Answer B. **Concentric contraction of tibialis anterior**
In ready position: concentric tibialis anterior contraction locks the hindfoot.

First rocker: eccentric tibialis anterior contraction allows the flexible foot to absorb shock and decelerate. The calcaneus everts.

Second rocker: In midstance, the shank advances over the maximally dorsiflexed and rigid foot, as the plantar flexors (gastrocnemius, soleus, plantaris) eccentrically contract. The subtalar joint inverts.

Third rocker: As midstance progresses to toe off, the gastrosoleus complex concentrically contracts and the 1st MTPJ dorsiflexes (by way of the windlass mechanism).

Honeine JL, Schieppati M, Gagey O, Do MC. The functional role of the triceps surae muscle during human locomotion. *PLoS ONE* 2013;**8**:e52943.

Simon SR, Mann RA, Hagy JL, Larsen LJ. Role of the posterior calf muscles in normal gait. *J Bone Joint Surg Am.* 1978;**60**:465–472.

22. Answer C. **Inhibition of ADP receptors**
The patient is taking clopidogrel, which inhibits the PSY_{12} chemoreceptor for ADP on platelets. Antiplatelet agents should be stopped 5–7 days preoperatively and restarted after 24 hours, in major joint arthroplasty. Aspirin irreversibly inactivates the cyclooxygenase-1 enzyme, which synthesises thromboxane A_2, inhibiting platelet aggregation during the 8–9-day lifetime of the affected platelet. As such, aspirin should be stopped 7–10 days preoperatively, and restarted after 24 hours; except in high cardiovascular risk where it should be continued. Dabigatran reversibly inhibits Factor IIa (thrombin) whereas heparin enhances the activity of antithrombin III. Warfarin inhibits the vitamin K 2,3-epoxide reductase (VKORC1) enzyme which in turn inhibits the synthesis of vitamin K-dependent anticoagulant proteins C and S as well as coagulant factors II, VII, IX and X.

Santana DC et al. Perioperative management of chronic antithrombotic agents in elective hip and knee arthroplasty. *Medicina (Kaunas)* 2021;**57**:188.

23. Answer C. **Increasing pin diameter**
Unilateral frames produce greater rigidity than hybrid and Ilizarov frames. Pin diameter is the greatest determinant of unilateral frame stability; pin stiffness correlates to the fourth power of the

pin radius. Reducing the distance between bone and connecting bars decreases pins' working length, creating changes to the third power of the distance.

Abd Aziz AU et al. A finite element study: finding the best configuration between unilateral, hybrid, and Ilizarov in terms of biomechanical point of view. *Injury* 2020;**51**: 2474–2478.

Fernando PLN, Abeygunawardane A, Wijesinghe P, Dharmaratne P, Silva P. An engineering review of external fixators. *Med Eng Phys.* 2021;**98**:91–103.

24. Answer A. **ACVR1**
The clinical scenario describes fibrodysplasia ossificans progressiva (FOP), also known as 'stone man syndrome', myositis ossificans progressiva or Munchmeyer's disease. It is rare, with roughly 600 described cases. It is caused by a defect in ACVR1 (ACtivin Receptor type 1) which is a BMP type-1 receptor. The disease is linked to BMP 4, which contributes to normal embryonal skeletal formation. Individuals are born with malformed halluces. During childhood, ligaments and tendons become ossified; neck and shoulder stiffness often are the first presentation. Restrictive lung disease and inability to open the jaw are observed. Falls and minor trauma can cause myositis, leading to rapid ossification of the injured area.

COL1A1 mutations cause osteogenesis imperfecta and Caffey disease. COMP mutations cause multiple epiphyseal dysplasia and pseudoachondroplasia. EX1 mutations cause hereditary multiple osteochondromas. FGFR3 mutations cause achondroplasia.

Groppe JC, Shore EM, Kaplan FS. Functional modeling of the ACVR1 (R206H) mutation in FOP. *Clin Orthop Relat Res.* 2007;**462**:87–92.

Haupt J, Xu M, Shore EM. Variable signaling activity by FOP ACVR1 mutations. *Bone.* 2018;**109**:232–240.

25. Answer D. **Pacinian corpuscle**
In a sensory exam a 128Hz tuning fork is used, testing fast vibration sense. Pacinian corpuscles comprise ~15% of mechanoreceptors in skin and detect fast vibration and deep pressure. Golgi organs sense changes in muscle tension, within skeletal muscle. Meissner corpuscles and Merkel cells primarily convey different elements of light touch sensation. Meissner corpuscles sense slow vibrations (10–50Hz) and changes in texture, whereas Merkel cells primarily detect sustained touch/pressure and aid in two-point discrimination; they can also detect very-slow vibration (5–15Hz). Ruffini end-organs are sensitive to skin stretch and continuous pressure.

Moehring F, Halder P, Seal RP, Stucky CL. Uncovering the cells and circuits of touch in normal and pathological settings. *Neuron* 2018;**100**:349–360.

26. Answer E. **X**
The 'tidemark' or calcified cartilage zone is the transition between articular cartilage and subchondral bone. Type X cartilage is expressed by hypertrophic chondrocytes, facilitating calcification. Injuries at this level do not heal but rather, type I collagen and fibrocartilage are produced. This type of articular cartilage injury is considered grade IV on both Outerbridge and ICRS (International Cartilage Repair Society) grading systems. Type II collagen is the predominant type in the superficial zone of articular cartilage.

Slattery C, Kweon CY. Classifications in brief: Outerbridge classification of chondral lesions. *Clin Orthop Relat Res.* 2018;**476**:2101–2104.

Smith GD et al. Arthroscopic assessment of cartilage repair: a validation study of 2 scoring systems. *Arthroscopy* 2005;**21**:1462–1467.

27. Answer E. **Osteoporosis based on Z-score**
In males <50, premenarchal women and children, the Z-score (age, sex and ethnicity matched) is used to measure osteoporosis. A positive score is 2.5SD (standard deviations) away from the mean, whereas a positive score for osteoporosis is between 1 and 2.5SD from the mean. An abnormal T-score is used in postmenarchal women and men >50.

Anam AK, Insogna K. Update on osteoporosis screening and management. *Med Clin North Am.* 2021;**105**:1117–1134.

Rachner TD, Khosla S, Hofbauer LC. Osteoporosis: now and the future. *Lancet* 2011;**377**:1276–1287.

28. Answer D. **Osteoporosis based on distal radius T-score**

In post-menarchal women and men >50 the lowest T-score from lumbar, hip and distal radius is used to classify bone mineral density. Areas with fractures are excluded. Z-scores are used in younger patients (age, sex matched).

Anam AK, Insogna K. Update on osteoporosis screening and management. *Med Clin North Am*. 2021;**105**:1117–1134.

Rachner TD, Khosla S, Hofbauer LC. Osteoporosis: now and the future. *Lancet* 2011;**377**:1276–1287.

29. Answer E. **Increased large aggregated proteoglycans**
In the degenerative disc, although there is a decrease in proteoglycans, an increase in degradative enzyme activity leads to increased large aggregated proteoglycans. There is an increased keratin to chondroitin sulphate ratio and decrease in water content and nutritional transport from the vertebral endplate.

Ohnishi T, Novais EJ, Risbud MV. Alterations in ECM signature underscore multiple sub-phenotypes of intervertebral disc degeneration. *Matrix Biol Plus* 2020;**6–7**:100036.

30. Answer C. **Kniest syndrome**
Kniest syndrome/dysplasia is an autosomal dominant defect in COL2A1, causing a short-trunk disproportionate short stature. As type II collagen is highest in the reserve zone, this is the physeal zone that it affects. Achondroplasia is an autosomal dominant mutation of FGFR3, inhibiting chondrocyte proliferation in the proliferative zone of the physis, affecting longitudinal growth and causing short-limbed short stature. Pseudoachondroplasia is a short-limbed short stature caused by a mutation in the Cartilage Oligomeric Matrix Protein (COMP) gene, affecting the reserve zone; with autosomal dominant inheritance. Hunter and Morquio syndrome are autosomal recessive mucopolysaccharidoses resulting in proportionate short stature and multiple orthopaedic manifestations. Mucopolysaccharidoses affect the hypertrophic zone.

Gregersen PA, Savarirayan R. Type II collagen disorders overview. In Adam MP et al., eds. *GeneReviews*, 1993–2023. Seattle, WA: University of Washington, Seattle; 2019.

Parvizi J, Kim GK, eds. Growth plate. In *High Yield Orthopaedics*, 213–214. Philadelphia, PA: W.B. Saunders; 2010.

31. Answer E. **Selective oestrogen receptor modulator**
Raloxifen is a selective oestrogen receptor modulator; in bone it acts as an agonist of the oestrogen receptor and thus inhibits osteoclast formation and activity. Teriparatide is the bioactive portion of parathryroid hormone (PTH). PTH stimulates bone resorption and formation. The drug should only be used for 12 months during which time bone formation predominates. Denosumab is a monoclonal antibody which binds to and inhibits RANK-L preventing the activation of osteoclasts. All monoclonal antibodies (MAB) can be recognised by the ending 'mab'. Nitrogen-containing bisphosphonates (e.g. alendronic acid, risendronate, ibandronic acid, zolendronic acid) inhibit osteoclast ruffled border formation whereas non-nitrogen-containing bisphosphonates (e.g. etidronate) are metabolised into non-functional ATP which induces osteoclast cell apoptosis. Oral bisphosphonates are considered as first-line choices for most patients with postmenopausal osteoporosis due to their broad spectrum of anti-fracture efficacy. Intravenous bisphosphonates (ibandronic acid or zoledronic acid), denosumab or raloxifene hydrochloride are alternative options in women who are intolerant of oral bisphosphonates or in whom they are contraindicated. Hormone replacement therapy is an additional option usually restricted to younger postmenopausal women. Teriparatide is reserved for postmenopausal women with severe osteoporosis at very high risk for vertebral fractures.

32. Answer A. **Autosomal dominant inheritance**
Haemophilia A and B are X-linked recessive defects of factor VIII (A) and IX (B, also known as Christmas disease). Haemophilias A and B impair the intrinsic clotting pathway (VIII, IX, XI and XII) and so prothrombin time (PT) is normal whereas activated partial thromboplastin time (APTT) is significantly prolonged in severe haemophilia, but may be normal in mild haemophilia. Haemophilic arthropathy is characterised by chronic proliferative synovitis and cartilage destruction. Bleeding episodes most commonly occur in large joints: knees, elbows, ankles, hips and shoulders. Recurrent atraumatic joint haemorrhages result in synovial inflammation, hyperplasia and angiogenesis which further predispose

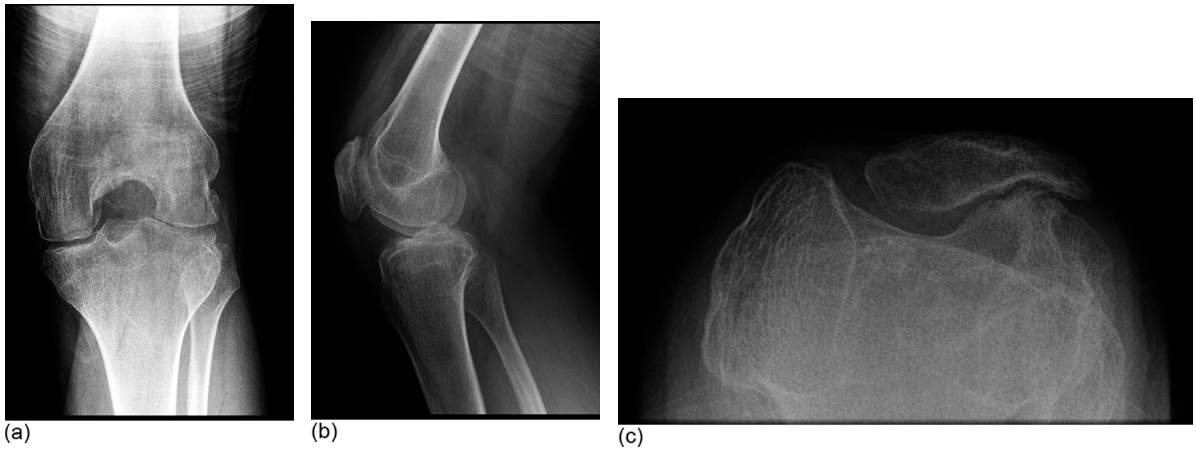


Figure 27.1 Radiographs knee. (a) Anteroposterior (AP) widened intercondylar notch, flattened condylar surfaces; (b) lateral squared inferior margin of the patella; and (c) patella

to haemorrhage. Cartilage damage occurs due to a combination of direct effects of blood exposure and synovial production of cytokines and proteases. Classical radiographic features of knee haemophilic arthropathy include a widened intercondylar notch, squared inferior margin of the patella and flattened condylar surfaces (Figures 27.1 and 27.2).

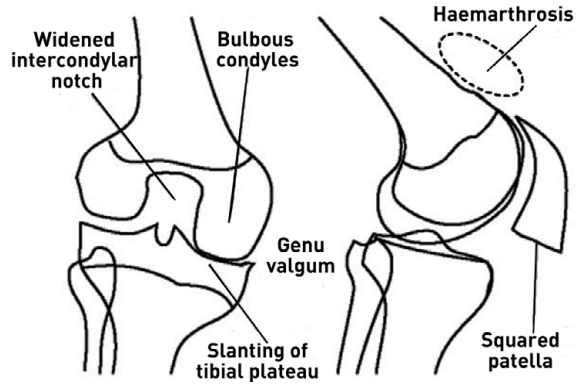


Figure 27.2 Schematic diagram radiographic feature haemophilic knee

Chapter 28

Orthopaedic Oncology Structured SBA

Heledd Havard, Walid A. Elnahal, Ossama Al-Obaedi, Muthana Abdelhalim and Craig H. Gerrand

ORTHOPAEDIC ONCOLOGY STRUCTURED SBA QUESTIONS

1. A 10-year-old female presents with an enlarging painless mass in the left buttock extending over the greater trochanter, resulting in some restriction of hip movement. The overlying skin is tense and at risk of ulceration. Investigations demonstrate hyperphosphataemia and a periarticular well-circumscribed cystic mass with fluid–fluid levels suggestive of a sedimentation sign.
   What is the most likely diagnosis?
   A. Calcifying epithelioma of Malherbe
   B. Gout
   C. Infection
   D. Synovial osteochondromatosis
   E. Tumoural calcinosis

2. A 14-year-old male presents to the ED after sustaining an ankle injury playing football. X-rays performed demonstrate a Weber A fracture of the lateral malleolus. Note is made of a well-defined lesion with a geographic margin based in the anterior cortex of the tibial diaphysis with thinning of the cortex and associated sclerosis. There is no evidence of periosteal reaction and the patient denies any symptoms in the area.
   What is the most appropriate management?
   A. Above knee cast with period of non-weight bearing
   B. Management of fracture and observation of tibial lesion until skeletal maturity
   C. Management of fracture with no mention of cortical lesion
   D. Surgical fixation of fracture with curettage and grafting of tibial lesion
   E. Urgent biopsy

3. Radiographs of a young boy demonstrate an exophytic lesion arising from the cortical surface of the proximal phalanx of his left ring finger. There does not appear to be continuity with the medullary cavity. The lesion is excised, as it is causing impingement to flexion at the PIPJ. Histology demonstrates a 'bizarre' proliferation of bone, cartilage and fibrous tissue.
   Which of the following is the most likely diagnosis?
   A. Bizarre parosteal osteochondromatous proliferation
   B. Ollier disease
   C. Osteochondroma
   D. Parosteal osteosarcoma
   E. Periostitis ossificans

4. Bone tumours are often associated with classical appearances on radiological investigation and are commonly located in specific anatomical locations.
   Which of the following statements is incorrect?
   A. Adamantinoma usually occurs in the diaphysis of the tibia
   B. Bone cysts such as UBC or ABC usually affect the metaphyseal region
   C. Chondroblastoma and clear cell chondrosarcoma typically occur in the epiphyseal region
   D. Ewing sarcoma in long bones most often occurs in the diaphyseal/metaphyseal portions
   E. Giant cell tumours of bone are almost always located in the diaphyseal region

5. **Which of the following statements about osteochondromas is true?**
   A. A cartilage cap 0.5cm thick is concerning for malignant transformation
   B. Malignant transformation is common, and higher in those with osteochondromatosis (hereditary multiple exostoses)

C. Multiple osteochondromas are characteristic of Ollier disease and Maffucci syndrome
D. Osteochondromas usually arise in the diaphyseal region of bone
E. There is usually continuity of the medullary cavity between the osteochondroma and the underlying bone

6. **The following statements regarding cartilaginous tumours are all true except which?**
A. An enchondroma is a benign cartilage tumour that occurs only in bones which develop from endochondral ossification
B. Enchondromas are most commonly seen in the hands and feet but can occur elsewhere
C. Enchondromas typically do not increase in size after skeletal maturity; however, growth or pain raises suspicion of malignant transformation
D. In the setting of multiple lesions, malignant transformation is less frequent than in osteochondromatosis (hereditary multiple exostoses)
E. Larger lesions may require curettage and grafting due to pain or impending fracture risk

7. A 7-year-old girl presents to ED after a minor fall in the playground at school. Radiographs demonstrate a large lytic lesion in the proximal humerus with an associated pathological fracture which is minimally displaced. The lesion has a geographic margin, no periosteal reaction and a 'fallen leaf' fragment in it.
What is the most appropriate next step?
A. Conservative management in collar and cuff with serial X-rays
B. Manipulation under anaesthetic with elastic nailing
C. Oncology referral to exclude cancer
D. Paediatric referral for metabolic bone workup and formal assessment of non-accidental injury
E. Urgent CT and/or MRI scan

8. A 12-year-old boy presents to ED with a short history of a swelling in the left shoulder. He sustained an injury playing rugby a few weeks beforehand; however, because of increasing swelling and pain he attended for an X-ray. This demonstrated an eccentric metaphyseal expansile lytic lesion in the proximal humerus with cortical erosion. CT and MRI confirmed fluid–fluid levels and no evidence of soft tissue mass or periosteal reaction.
What is the likely diagnosis?
A. Aneurysmal bone cyst
B. Chondroblastoma
C. Ewing sarcoma
D. Giant cell tumour of bone
E. Simple bone cyst with swelling secondary to trauma

9. A 17-year-old male presents with a 6-month history of pain in the right proximal thigh. He denies any significant trauma. He complains of night pain and denies any other systemic symptoms. He finds anti-inflammatory medication very helpful in relieving pain.
The following statements are all true except which?
A. His night pain is likely to be secondary to production of prostaglandin
B. Histology would demonstrate osteoid trabeculae separated by vascular fibrous connective tissue and sharply demarcated from the surrounding bone
C. Imaging is likely to identify a cortically based osteolytic lesion within the metaphysis or diaphysis with a sclerotic rim
D. Treatment almost always requires surgical excision
E. This usually occurs in adolescents and young adults with a male predilection

10. A 13-year-old male presents with a history of acute onset right thigh pain following a short prodromal fever. He has a mildly elevated ESR and his remaining laboratory results are normal. X-rays demonstrate a lesion in the mid-diaphysis of the femur, and MRI confirms no evidence of any soft tissue component. Biopsy demonstrates a histiocyte-rich lesion.
Which of the following statements is true?
A. Biopsy should always be sent for histology only
B. Disseminated forms include Letterer–Siwe disease and Hand–Schüller–Christian disease
C. Eosinophilic granuloma always requires surgical treatment
D. Histiocytes are characteristic of Ewing sarcoma of bone
E. Radiological appearances are pathognomonic

11. A 30-year-old female physiotherapist presents with right wrist pain and swelling with no history of trauma. X-ray demonstrates an eccentric, lytic lesion in the distal radius (Figure 28.1), and MRI demonstrates a breach in the cortex with a small soft tissue component. Biopsy reveals a tumour comprising multinucleated giant cells and stromal cells.

Figure 28.1
AP radiograph wrist

The following statements are all true except which?

A. Denosumab is a recognised adjuvant treatment in selected cases
B. It can be graded radiologically using the Campanacci system
C. Patients who develop lung metastases have a poor outcome
D. Recurrence rates can be high following curettage
E. This tumour rarely affects skeletally immature patients

12. A 20-year-old male presents with a 3-month history of progressive right knee pain, swelling and restricted movement. X-ray demonstrates a small radiolucent epiphyseal lesion within the tibial plateau with no cortical involvement and MRI confirms extensive surrounding oedema with no soft tissue component. Biopsy demonstrated hyaline cartilage with 'chicken-wire calcification'.

What is the most likely diagnosis?

A. Chondroblastoma
B. Clear cell chondrosarcoma
C. Giant cell tumour of bone
D. Osteoblastoma
E. Osteoid osteoma

13. A 50-year-old male presents following a fall from scaffolding with injuries to his left arm and left knee. Radiographs demonstrate a pathological fracture of the midshaft of the humerus through a well-defined radiolucent area. X-rays of the femur and tibia also demonstrate expansile radiolucent lesions with a thin sclerotic rim and a ground-glass matrix. He has a previous history of two benign soft tissue excisions from his left buttock and medial thigh.

What is the most likely diagnosis?

A. Brown tumour of hyperparathyroidism
B. Mazabraud syndrome
C. McCune–Albright syndrome
D. Metastatic bone disease
E. Paget's disease

14. A 60-year-old female presents with a 10-year history of an enlarging painless mass in the right thigh. An MRI scan demonstrates a 10cm × 5cm well-encapsulated homogeneous lesion superficial to the adductor compartment with post-contrast fat-saturated T1 imaging confirming complete suppression of fat signal intensity within the mass.

All of the following statements are true except which?

A. Following excision, most lesions require adjuvant radiotherapy to prevent recurrence
B. Lesions deep to the fascia with thick septations and heterogeneity raise the possibility of a sarcoma
C. MDM2 amplification may help differentiate benign from atypical lesions
D. Multiple subcutaneous lesions can be associated with Dercum's disease
E. Marginal resection is acceptable

15. A 30-year-old female presents with a recurrent painful mass in the left infraclavicular fossa. She also complains of intermittent paraesthesia in the left arm with some mild weakness. The mass lies deep to a surgical scar from a previous excision of a benign fibrous lesion. She has a history of familial adenomatous polyposis. Biopsy showed bland fibroblasts and myofibroblasts.

All of the following statements are true except which?

A. Histology typically demonstrates clonal fibroblastic proliferation with abundant collagen
B. Radiotherapy can be used in recurrent cases or where surgical excision is not possible
C. There are systemic treatment options, including anti-oestrogens
D. This condition can be associated with Gardner's syndrome
E. Treatment is usually with primary excision and local recurrence is uncommon

16. A 28-year-old male presents with pain and swelling in the left knee. He describes recurrent episodes of swelling following minor trauma and has previously had aspiration of the joint in the ED in which blood-stained fluid was removed. A recent MRI demonstrates diffuse synovitic changes with a mass in the intercondylar notch, low signal on T1 because of haemosiderin deposition and early destructive changes in the articular cartilage.
What is the most likely diagnosis?
A. Gout
B. Haemophilia
C. Pseudogout
D. Rheumatoid arthritis
E. Tenosynovial giant cell tumour

17. A 40-year-old male presents with a painful mass in the thigh. It is particularly painful if knocked. He complains of intermittent tingling and a shooting pain into the foot. MRI demonstrates a mass of low T1 signal and high T2 with diffuse enhancement with gadolinium and a 'sweet potato' sign (Figure 28.2 shows coronal T2 sequence).

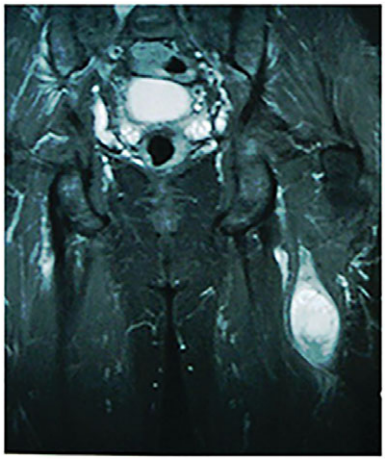


Figure 28.2 MRI coronal T2 sequence

All of the following statements are true except which?
A. Histology is likely to demonstrate Antoni A and B cells
B. Immunohistochemistry demonstrates strongly uniform S100 antibody staining
C. Lesions only affect sensory nerves and not motor nerves
D. They can be associated with mutations affecting the NF2 gene
E. Verocay bodies are pathognomonic

18. A 40-year-old male presents with a 5-year history of pain and swelling in the left knee, which is worse with activity. He complains of intermittent stiffness and locking and is no longer able to cycle. A radiograph of the knee demonstrates multiple small, loose bodies with a well-preserved joint space.
What is the most likely diagnosis?
A. Chondrosarcoma
B. Rheumatoid arthritis
C. Synovial chondromatosis
D. Tenosynovial giant cell tumour
E. Tophaceous gout

19. A 50-year-old male presents with a painful lesion on the medial plantar aspect of his right foot. He has been aware of the lesion for some years; however, it is now exquisitely painful. Imaging has demonstrated a superficial, small <1cm lesion closely related to a vein.
What is the most likely diagnosis?
A. Angioleiomyoma
B. Fibroma
C. Ganglion
D. Inclusion cyst
E. Lipoma

20. **Bisphosphonates can be used as part of the treatment of all the following conditions except which?**
A. Eosinophilic granuloma
B. Fibrous dysplasia
C. Metastatic bone disease
D. Multiple myeloma
E. Paget's disease

21. **Non-ossifying fibroma is a benign fibrogenic lesion that can be associated with all of the following conditions except which?**

A. Aneurysmal bone cyst
B. Familial multifocal non-ossifying fibroma
C. Jaffe–Campanacci syndrome
D. Neurofibromatosis
E. Tenosynovial giant cell tumour

22. A 63-year-old male presents with progressive stiffness in the right elbow and an associated mechanical block to ROM. He was involved in a road traffic accident 6 months ago, where he sustained a skull fracture and intracerebral haemorrhage. He has a resolving right-sided hemiplegia. Plain radiographs show well-defined calcification in the soft tissues.

All of the following statements are true except which?

A. Associated findings may include soft tissue contractures, nerve impingement and chronic regional pain syndrome
B. Can also occur following lower limb arthroplasty
C. Surgical resection is the mainstay of management
D. The hip is the most commonly involved joint
E. This is a recognised sequela of neurological trauma

23. A 20-year-old male presents with a firm mass in the anterior compartment of the thigh. He sustained an injury to the area approximately 6 months ago during a rugby tackle. The bruising has since resolved. X-ray, CT and MRI have demonstrated a lesion within the rectus femoris for which a biopsy has been performed. The tissue demonstrated an irregular mass of immature fibroblasts surrounded by trabeculae of lamellar and woven bone.

What is the most likely diagnosis?

A. Chronic abscess
B. Chronic calcifying haematoma
C. Desmoid fibromatosis
D. Myositis ossificans
E. Undifferentiated pleomorphic sarcoma

24. **Which of the following statements regarding tenosynovial giant cell tumour is true?**

A. It rarely arises in the hands
B. Lesions are capable of eroding articular cartilage
C. Radiotherapy is usually indicated
D. Recurrence is rare after surgical excision
E. This forms part of a spectrum of conditions including giant cell tumour of bone

25. A 40-year-old male presents with worsening pain around his left knee. He was told as a child that he had a bony growth arising from the distal femur which was benign and required no treatment. He has recently been training for a triathlon and has noticed that the swelling has increased. X-ray demonstrates a pedunculated lesion arising from the posterolateral aspect of the distal femur in continuity with the medullary cavity.

What would the next most appropriate step in his management be?

A. CT scan with contrast to assess relationship with the popliteal vessels
B. Local and systemic staging including CT chest
C. MRI scan
D. Urgent oncology opinion
E. Urgent wide excision with reconstruction

26. A 30-year-old male presents with a 3-year history of left knee pain. Radiographs demonstrate an eccentric lytic lesion within the metaphysis, which on MRI demonstrates low signal on T1- and high signal on T2-weighted images. Biopsy shows variable amounts of chondroid, fibromatoid and myxoid tissue with stellate cells.

What is the most likely diagnosis?

A. Aneurysmal bone cyst
B. Chondroblastoma
C. Chondromyxoid fibroma
D. Enchondroma
E. Non-ossifying fibroma

27. **All of the following conditions have the potential to undergo malignant transformation and/or metastasise except which?**

A. Fibrous dysplasia
B. Giant cell tumour of bone
C. Non-ossifying fibroma
D. Paget's disease
E. Synovial chondromatosis

28. A 50-year-old female presents with a 6-month history of right knee pain. Radiographs

demonstrate a well-defined lytic lesion in the proximal tibia with a sclerotic rim and no periosteal reaction. She is frustrated that she has been in pain for 6 months.

What is the next most appropriate step in her management?

A. Biopsy
B. Diagnostic arthroscopy
C. Intra-articular steroid injection
D. MRI scan
E. Prescription for opioid analgesia with referral to physiotherapy

29. A 6-year-old otherwise healthy boy presents with a year's history of pain in the mid shin. The pain wakes him up at night but responds to anti-inflammatory medication. Examination is unremarkable. Plain radiograph shows an area of thickened cortex in the mid diaphysis of the tibia.

Which investigation is most likely to confirm the diagnosis?

A. Blood test including inflammatory markers
B. Fine-cut CT
C. MRI
D. Tc99 bone scan
E. Ultrasound scan

30. A 72-year-old man presents with increasing pain in the pelvis. A plain radiograph shows expanded bone in the superior pubic ramus, with coarse 'purposeful' trabeculae. Further investigation with MRI shows an associated soft tissue mass arising from the area of abnormal bone.

Which of the following statements is true?

A. Biopsy is not required
B. Bisphosphonate treatment has minimal role in the treatment of Paget's disease
C. On isotope bone scan, the abnormal area in the pelvis is unlikely to show increased uptake
D. Osteosarcoma secondary to Paget's disease has a poor outcome
E. The serum alkaline phosphatase is likely to be normal

31. A 26-year-old female presents with a fracture through a lesion in the 3rd metacarpal. X-rays and MRI scans show a lytic expansile medullary lesion with cortical thinning and stippled calcification.

Which of the following statements is true?

A. Complete resection is required
B. Cellular atypia is often seen in cartilaginous tumours of the hands and feet
C. Needle biopsy is useful to grade the tumour
D. Solitary lesions are characteristic of Ollier disease
E. The fracture is unlikely to heal with appropriate immobilisation

32. A 9-year-old boy presents with a painful progressive lump in his distal thigh (Figure 28.3). MRI and biopsy revealed a high-grade osteosarcoma. CT of the chest and whole-body MRI showed no evidence of metastases.

Figure 28.3 Anteroposterior (AP) radiograph knee

Which of the following is not a part of standard treatment for an osteosarcoma in this patient?

A. Adjuvant chemotherapy
B. Complete surgical resection of the primary tumour
C. Limb sparing surgery
D. Neoadjuvant chemotherapy only
E. Radiotherapy to the primary site

33. A 65-year-old with a painful mass in the proximal thigh is diagnosed with a grade 2 chondrosarcoma arising from the femur. Further investigations showed no distant metastasis.

Which of the following is the appropriate treatment?

A. Intralesional resection by curettage
B. Neoadjuvant chemotherapy
C. Radiotherapy followed by marginal resection

D. Radiotherapy followed by wide local excision
E. Wide local surgical resection alone

34. A 14-year-old boy presents with leg pain, swelling and fever, elevated ESR and WBC. X-rays show lytic bone destruction in the diaphysis of the fibula with areas of periosteal reaction (Figure 23.4). Needle biopsy revealed a tumour comprising small round blue cells.

Figure 28.4 Anteroposterior (AP) radiograph knee

Which of the following statements is not true?
A. Chemotherapy is the first line of treatment in the majority of cases
B. The lesion is associated with an 11;22 translocation in the majority of cases
C. At the time of diagnosis, about 50% of patients present with metastatic disease
D. Radiotherapy is often used in the local management
E. Rhabdomyosarcoma and non-Hodgkin's lymphoma may appear similar under microscopy

35. **Which of the following is not characteristic of a classic high-grade osteosarcoma?**
A. Extramedullary soft tissue mass
B. Narrow zone of transition
C. Periosteal reaction
D. Production of osteoid matrix
E. Distal femur is a common site

36. A 52-year-old presents with low back pain; MRI showed a midline mass anterior to the sacrum suspicious of a chordoma (Figure 23.5). You are making a referral to the regional sarcoma centre.

Figure 28.5 MRI scan sacrum

The patient is anxious and asks you about the treatment ahead.
Which of the following is most likely?
A. Chemotherapy only
B. Neoadjuvant chemotherapy before surgery
C. Radiotherapy only
D. Surgical resection with a neurological deficit including incontinence
E. Surgical resection without neurological deficit

37. A 25-year-old male presents with a painful lump in the mid tibia. X-rays reveal a well corticated but lytic lesion with 'soap bubble' appearance. Biopsy reveals epithelial and osteofibrous components characteristic of an adamantinoma.
Which of the following statements is true?
A. Chemotherapy is not part of standard treatment
B. This is a benign, slowly growing tumour that does not metastasise
C. This is a locally aggressive lesion that has a high rate of local recurrence but no risk of distant spread
D. This is a slowly growing malignant lesion that has a risk of local recurrence and a risk of distant metastasis
E. Treatment is with radiotherapy alone

38. **Which of the following is the least useful investigation for multiple myeloma?**
A. Bone marrow biopsy
B. FDG–PET scan
C. Serum protein electrophoresis
D. Tc99 bone scan
E. Whole body MRI scan

39. Following piecemeal excision of a presumed benign subcutaneous soft tissue tumour, a histological diagnosis of a grade 2 soft tissue sarcoma was made. A staging CT of the chest and an MRI of the primary tumour site were performed. There were no metastases.
What would the next appropriate step in treatment be?
A. Adjuvant chemotherapy
B. Observation only
C. Radiotherapy only
D. Re-excision of the scar and tumour bed including the deep fascia
E. Repeat imaging after an interval of 3–6 months

40. Which of the following statements about biopsy is not true?
A. Biopsies should be planned in consultation with the operating surgeon
B. Core needle biopsies are not useful in the diagnosis of soft tissue sarcoma
C. Specimens should be sent for microbiological testing
D. The approach to a tumour should avoid crossing uninvolved anatomical compartments
E. Where possible, the biopsy track should be resected with the tumour

41. A patient with a known diagnosis of metastatic breast cancer presents with a metastasis in the intertrochanteric region of the proximal femur. She has pain on weight bearing. On plain radiographs, the lesion has a mixed lytic and blastic appearance and takes up more than a third of the width of the bone.
Which of the following statements is true?
A. According to the Mirel scoring system, the risk of fracture is low
B. According to the Mirel scoring system, blastic lesions in bone have a lower risk of fracture
C. Endoprosthetic replacement has no role in the treatment of a femoral metastasis
D. Load-sharing devices are ideal for the fixation of pathological fractures
E. Mechanical pain on weight bearing is not an important predictor of the risk of fracture

42. A 78-year-old frail male complains of a slowly growing mass in front of the elbow (Figure 23.6).

Figure 28.6
MRI scan elbow

On MRI scan, this is a 7cm bland intramuscular lipomatous tumour, deep to the fascia, and which suppresses completely on fat-suppression images.
Which of the following is the most appropriate management?
A. Biopsy to confirm the diagnosis
B. Radiotherapy followed by surgery
C. Radiotherapy only
D. Reassurance and observation only
E. Urgent surgical excision

43. Osteochondromatosis is the most common inherited skeletal dysplasia.
Which of the following statements is not true?
A. In severely affected individuals, there may be ulnar and fibular shortening with associated deformity of the wrists and ankles
B. Inheritance is autosomal recessive
C. Most patients have palpable lesions around the knee by the age of 8
D. Osteochondromas which grow after skeletal maturity should be investigated for malignant change
E. The risk of malignant transformation is less than 5%

44. **Which of the following types of soft tissue sarcoma is the most likely to develop lymph node metastases?**
A. Dermatofibrosarcoma protuberans
B. Embryonal rhabdomyosarcoma
C. Low-grade fibromyxoid sarcoma
D. Myxofibrosarcoma
E. Myxoid liposarcoma

45. **All of the following statements about chondrosarcoma are true except which?**
    - A. Complete resection is the treatment of choice for grade 2 tumours
    - B. De-differentiated chondrosarcoma often presents with a pathological fracture
    - C. Disease-specific survival depends on histological grade
    - D. Histological evidence of permeation of the cartilage tumour into bone trabeculae is characteristic
    - E. Tumours typically produce an osteoid matrix

46. A 10-year-old boy presented with a painful right hip. X-rays reveal a lesion in the proximal femur with loss of the normal trabecular architecture and a ground glass matrix within it.
    Which of the following statements is not true?
    - A. Fibrous dysplasia is a mosaicism, meaning it can be polyostotic in one limb or one side of the body
    - B. Large lesions, particularly in the proximal femur, may cause fractures
    - C. Patients may have an elevated blood level of FGF23
    - D. Polyostotic fibrous dysplasia can be associated with hormonal abnormalities in McCune–Albright syndrome
    - E. Polyostotic fibrous dysplasia has an autosomal dominant inheritance

47. A 25-year-old female presented with a painless mass in the popliteal fossa and an inability to flex the knee. X-rays showed a well-mineralised mass attached to the posterior cortex of the femur (Figure 23.7).

Figure 28.7 Lateral radiograph knee

Which of the following statements is true?
- A. An X;18 translocation is characteristic
- B. De-differentiation into a higher-grade tumour never occurs
- C. It is associated with an excellent prognosis, with over 90% survival at 5 years
- D. Radiotherapy before surgery is required
- E. Treatment requires neoadjuvant chemotherapy

48. A 35-year-old male presents with a painful lesion in his femur. MRI demonstrated an infiltrative lesion in the meta-diaphyseal area of the femur with soft tissue extension. A CT-guided biopsy revealed a large B-cell lymphoma. A PET–CT showed no lymph node involvement, and no other lesions.
    Typically, oncological treatment would involve which of the following?
    - A. Chemotherapy alone
    - B. Chemotherapy with radiotherapy to the primary site
    - C. Radiotherapy alone
    - D. Radiotherapy followed by surgical debulking of the tumour
    - E. Surgical resection and limb reconstruction

49. A 40-year-old male presents with a 2-year history of pain in the hip. Imaging reveals a well-defined lytic lesion in the epiphysis of the right hip (Figure 23.8).

Figure 28.8 Anteroposterior (AP) pelvis

Which of the following statements is true?
- A. The lesion is a slow-growing tumour, often with a long history

B. Main surgical treatment is curettage
C. Neoadjuvant chemotherapy is standard
D. Surgical resection alone is seldom curative
E. The most common anatomical site is the spine

50. A 21-year-old female presents with a 2-year history of a painful lump around the ankle. MRI confirms a 4cm mass arising from around the extensor tendons. Biopsy shows epithelial and spindle cell components, which on cytogenetics demonstrates an X;18 translocation.

Which of the following statements is true?

A. Chemotherapy has no role in treatment
B. Plain radiographs are of no value in characterising the tumour
C. These tumours usually occur within synovial joints
D. This is a low-grade tumour which rarely metastasises
E. Treatment usually includes surgical excision

51. A 68-year-old man presented with a painless lump over the ankle. MRI showed a soft tissue tumour sitting on the deep fascia with indistinct boundaries and a high signal tail on T2 sequences. CT of the chest showed no metastases. Biopsy confirms a grade 2 myxofibrosarcoma.

Which of the following statements is true?

A. Marginal excision is the standard treatment
B. Myxofibrosarcoma has a higher local recurrence rate than other types of soft sarcoma
C. Myxofibrosarcoma has a higher metastatic rate than other types of soft tissue sarcoma
D. Radiotherapy has no role in the treatment of myxofibrosarcoma
E. The high signal tail is unlikely to contain tumour

52. Which of the following conditions has the highest risk of malignant transformation?

A. Maffucci syndrome
B. McCune–Albright syndrome
C. Ollier disease
D. Paget's disease
E. Polyostotic fibrous dysplasia

53. A 64-year-old female with a history of breast cancer presents with a femoral midshaft fracture through a lytic lesion with bone destruction and a periosteal reaction. CT of chest, abdomen and pelvis and a whole-body bone scan show no other tumours. Needle biopsy was inconclusive and showed fracture haematoma.

What is the next most appropriate management?

A. Perform an open biopsy
B. PET–CT scan
C. Plating and cementing of the lesion
D. Proceed to surgery an intramedullary nail and send the reamings for histopathology
E. Wide local excision and diaphyseal replacement

54. A 10-year-old boy presents with a painful swelling in the index finger of the right hand. This has grown slowly over 6–12 months. Plain X-rays show multiple osteolytic lesions in the small bones of the hand, with expansion of the proximal phalanx of the index finger.

Which of the following statements is true?

A. Maffucci syndrome includes multiple osteochondromas and haemangiomas
B. Ollier disease is characterised by multiple osteochondromas
C. Ollier disease shows autosomal dominant inheritance
D. Persistent pain and growth of an enchondroma raises the possibility of malignant transformation
E. The risk of malignant transformation in Ollier disease is close to 100%

55. A 35-year-old female presents with a 6-month history of a soft tissue swelling in the thenar eminence of the dominant hand.

Which of the following statement about tumours in the hand is not true?

A. Enchondromas of the hand bones can lead to cortical thinning and fracture
B. Glomus tumours can be exquisitely painful and sensitive to the cold
C. Lung cancers are more likely to lead to metastases in the hand than other primary tumours
D. Skin tumours affecting the hand include squamous cell carcinomas and malignant melanoma
E. First-line treatment of tenosynovial giant cell tumour is radiotherapy

56. A 75-year-old patient presents to your outpatient clinic with a 2-month history of right-sided chest

pain that is localised to the ribs with generalised fatigue. You obtain a chest radiograph which demonstrates a lytic lesion in the right 5th rib. Initial investigations are performed and the MDT decision was to proceed with a biopsy.

The biopsy histology result will most likely show?

A. Blood-filled spaces with thin strands of bone
B. Epithelioid cells on a background of fibrous stroma
C. Multiple osteoclast-like giant cells and spindle shaped stromal cells
D. Plasma cells with an eccentric nucleus and a 'clock face' chromatic orientation
E. Sheets of small round blue cells

57. You are examining a patient in clinic. You identify a faint blue tinged papule under the nail and elicit pain when you probe it with a pin head. The pain is relieved upon removing the pin.

The most likely diagnosis is:

A. Glomus tumour
B. Herpetic whitlow
C. Melanoma
D. Paronychia
E. Raynaud's phenomenon

58. You have been referred a 12-year-old girl who attends your clinic with her mother. She has had left hip pain and a limp for the last 6 months. On further questioning, she mentions her periods started at the age of 8. A plain radiograph of the pelvis demonstrates a large lytic lesion in the left femoral neck.

What is the best next step in management of this patient?

A. Arrange a whole-body MRI (WBMRI) to assess for other lesions and refer to paediatrics for an endocrine review
B. Curettage of lesion with surgical stabilisation
C. Observe and review in 3 months with repeat radiographs
D. Protected weight bearing with crutches for 6 weeks then mobilise normally
E. Reassurance and discharge from clinic

59. This patient had excision of this lesion (Figure 28.9) from the volar aspect of the forearm which has been troubling them for many years. The lesion was very sensitive with a positive Tinel sign. MRI showed a split fat sign.

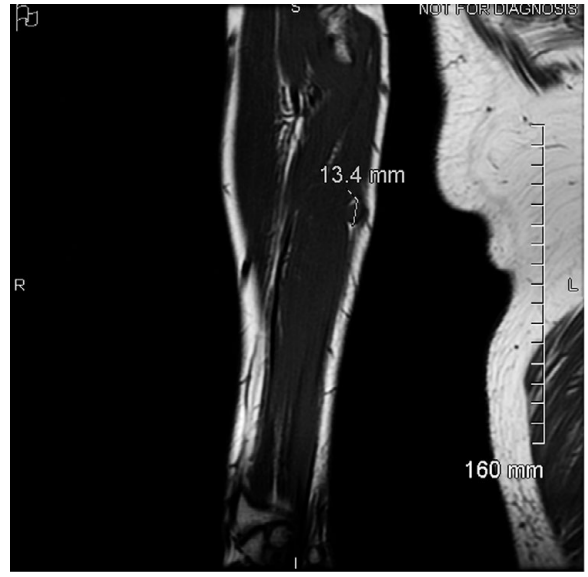


Figure 28.9 MRI of the forearm

The most likely diagnosis is:

A. Ganglion cyst
B. Leiomyoma
C. Lipoma
D. Liposarcoma
E. Schwannoma

60. **A patient is on your list for excision of a lipoma from the deltoid region. What type of surgical margin are you hoping to achieve?**

A. Complete but close excision of the tumour without removing normal structures
B. Resection margin that enters the tumour itself
C. Resection margin that involves removal of the entire osteofascial compartment
D. Resection margin that involves removing the tumour along with a cuff of normal tissue
E. This is not applicable to a lipoma

61. A 60-year-old attends your clinic with a 6-month history of worsening left hip pain associated with night pain. He is normally under the care of a rheumatologist and tells you he has been taking pamidronate. You manage to access previous radiographs of the pelvis which demonstrate coarsened trabeculae with hip osteoarthritis.

The next appropriate step would be:
A. Arrange an echocardiogram
B. Continue with bisphosphonate treatment and conservative management
C. List the patient for a total hip replacement
D. Offer a hip corticosteroid injection for diagnostic and therapeutic purposes
E. Perform local and distant staging scans

62. A 14-year-old boy has a low-grade osteosarcoma of the distal femur which extends into the quadriceps compartment on MRI. Staging investigations do not show metastatic disease.
What stage is this tumour according to the MSTS (Enneking) system?
A. IA
B. IB
C. IIA
D. IIB
E. III

63. A 60-year-old painter/decorator reports a 12-month history of clunking of the right shoulder blade. There is no history of trauma. The clunking is particularly noticed when he brings his arm out to the side or when he crosses the arm across his chest. On examination there is a palpable mass under the inferior angle of the scapula. MRI scan demonstrates a fibrofatty mass deep to serratus anterior.
The most likely diagnosis is:
A. Chondrosarcoma
B. Elastofibroma
C. Lipoma
D. Synovial chondromatosis
E. Synovial sarcoma

64. **Risk factors for development of soft tissue and bone sarcomas include all the following except:**
A. Gardner's syndrome
B. Gaucher disease
C. Hereditary retinoblastoma
D. Li-Fraumeni syndrome
E. Paget's disease

65. **All of the following statements regarding sarcomas are true except:**
A. Most bone sarcomas are extracompartmental at presentation
B. Sarcomas are generally enclosed by a reactive zone, or pseudo capsule
C. Sarcomas grow centrifugally with the periphery of the lesion being the least mature
D. Sarcomas take the path of least resistance and initially grow within the anatomical compartment of origin
E. The pseudocapsule around soft tissue sarcomas seldom contains tumour cells

66. **Which of the following is not a risk factor for symptomatic venous thromboembolism (SVTE) in patients with soft tissue sarcoma?**
A. Body mass index
B. Metastatic disease
C. Post-operative chemotherapy
D. Preoperative and post-operative partial thromboplastin time (PTT)
E. Tumour size greater than 10cm

67. **Which of the following soft tissue sarcomas has the lowest frequency of lymph node metastasis?**
A. Angiosarcoma
B. Clear cell sarcoma
C. Epithelioid sarcoma
D. Rhabdomyosarcoma
E. Synovial sarcoma

68. **Which of the following is true regarding malignant peripheral nerve sheath tumour (MPNST):**
A. History of therapeutic irradiation is the most important risk factor for MPNST
B. Most MPNSTs are low grade at presentation
C. MRI is the gold standard for MPNST diagnosis
D. Radiotherapy is often recommended for high-grade lesions or tumours larger than 5cm
E. Several studies have shown that adjuvant chemotherapy improves survival

ORTHOPAEDIC ONCOLOGY STRUCTURED SBA ANSWERS

1. Answer E. **Tumoural calcinosis**
   This is a rare benign tumour characterised by excessive calcium salt deposition, typically in periarticular soft tissues. It usually manifests in childhood or adolescence as a painless mass in a periarticular location. Lesions can become large and cause restriction in range of movement as well as ulceration of the overlying skin. Primary tumoural calcinosis can either be hyperphosphataemic or normophosphataemic and is managed with surgical excision, although local recurrence is common. Secondary tumoural calcinosis is associated with chronic renal failure and the resulting secondary or tertiary hyperparathyroidism where the mainstay of treatment is with dietary modification and phosphate binders/acetazolamide.

2. Answer B. **Management of fracture and observation of tibial lesion until skeletal maturity**
   This case describes an incidental finding of an otherwise asymptomatic tibial lesion. The most likely diagnosis given the location within the cortex of the anterior diaphysis is osteofibrous dysplasia. A non-ossifying fibroma and fibrous cortical defects are differential diagnoses but are more often metaphyseal. Adamantinoma typically looks more aggressive with areas of lucency.

   Osteofibrous dysplasia is a rare form of fibrous dysplasia that classically affects the tibia. These lesions are often incidental findings, and patients are often asymptomatic. Occasionally, the lesions can cause tibial bowing, and a pseudarthrosis can develop in 10–30% of patients. Histology is similar to fibrous dysplasia except for the fact that there is osteoblastic rimming. While lesions can sometimes regress, it is important to continue surveillance until skeletal maturity not only to monitor for tibial bowing but also to exclude progression of the lesion and adamantinoma. If the latter is suspected, then a biopsy is necessary.

3. Answer A. **Bizarre parosteal osteochondromatous proliferation**
   This case describes the appearances of a bizarre parosteal osteochondromatous proliferation (BPOP), also known as a Nora's lesion. It is a rare benign lesion arising from the cortical surface of the affected bone but is not in continuity with the medullary cavity, differentiating it from a classical osteochondroma. It usually consists of a mixture of bone, cartilage and fibrous tissue and is seen most commonly in the hands. An important differential to exclude is a parosteal osteosarcoma (although these are rare in the hands and feet); however, BPOP can be mistaken for a malignant lesion in part due to a high rate of local recurrence but also due to rapid growth and atypical histological appearance.

4. Answer E. **Giant cell tumours of bone are almost always located in the diaphyseal region**
   Giant cell tumours of bone are always epiphyseal in location and may expand to involve the metaphysis. They usually involve the subcortical bone next to a joint. They are typically eccentric and osteolytic with a 'soap-bubble' appearance. Although considered benign but locally aggressive tumours, they can undergo malignant transformation and occasionally metastasise (in up to 2%). The remaining statements are true.

5. Answer E. **There is usually continuity of the medullary cavity between the osteochondroma and the underlying bone**
   While it is true that osteochondromas can be solitary or multiple, Ollier disease and Maffucci syndrome refer to multiple enchondromas, not osteochondromas. Patients with multiple osteochondromas have osteochondromatosis (previously known as hereditary multiple exostoses). Osteochondromas can be sessile or pedunculated (on a stalk), and they tend to grow away from the physis. The medulla of an osteochondroma classically is in continuity with the medullary cavity of the bone from which it has arisen, as are the cortices of the lesions. Malignant transformation in solitary lesions is rare (estimated at 1%), but more common in osteochondromatosis (estimated at 4%). New onset of pain or increased growth following skeletal maturity or a cartilage cap larger than 1.5cm raise concern for malignant transformation.

6. Answer D. **In the setting of multiple lesions, malignant transformation is less frequent than**

in osteochondromatosis (hereditary multiple exostoses)
Enchondromas are benign cartilaginous lesions most commonly seen in the hands and feet but can occur in any bone which develops from endochondral ossification. Multiple enchondromas are seen in Ollier disease where the estimated rate of malignant transformation is around 25%. Patients with Maffucci syndrome also have multiple enchondromas but also present with multiple haemangiomas or lymphangiomas, and the rate for malignant transformation is believed to be as high as 50–100%. In contrast, the estimated risk of malignant transformation in patients with osteochondromatosis (hereditary multiple exostoses) is 4%.

7. Answer A. **Conservative management in collar and cuff with serial X-rays**
The clinical scenario describes a simple (aka unicameral) bone cyst with minimal displacement in a common anatomical location. These are often asymptomatic until they fracture, and radiographs will often demonstrate a 'fallen leaf sign' representing a cortical fragment that falls into the cyst and is considered pathognomonic. Fractures routinely heal, but the underlying cyst often remains.

Management aims to reduce the risk of further fracture. This can involve puncture of the cyst and either injection with steroid or autologous bone marrow. Larger lesions may require curettage and grafting with or without internal fixation.

8. Answer A. **Aneurysmal bone cyst**
This scenario describes an aneurysmal bone cyst (ABC), which is a benign active/aggressive lesion characterised by pain and swelling. They typically occur in the metaphysis of long bones appearing as eccentrically based expansile osteolytic lesions with associated cortical erosion. MRI often confirms classical fluid–fluid levels. The most important differential diagnosis to exclude is a telangiectatic osteosarcoma which is indistinguishable on imaging alone and requires biopsy. ABC can be primary or represent secondary changes (e.g. arising from a chondroblastoma or GCT). Rarely lesions resolve spontaneously following fracture or biopsy; however, most require treatment with curettage where feasible. Other options include embolisation, or sclerotherapy, and rarely systemic treatment.

9. Answer D. **Treatment almost always requires surgical excision**
Osteoid osteoma is a small benign active tumour consisting of a central nidus surrounded by a halo of reactive sclerotic bone most commonly seen in adolescents and young adults. Osteoid osteomas are typically located within the cortex of the metaphysis or diaphysis but can also be intra-articular, which can cause an effusion. Classically patients present with insidious onset pain which is worse at night and is associated with the production of prostaglandin. Patients report symptomatic relief with salicylates, and traditionally the treatment consisted of surgical curettage or excision. Most patients with osteoid osteoma are now managed with CT-guided radiofrequency ablation, although those with very superficial or unusually shaped tumours may still require surgery.

10. Answer B. **Disseminated forms include Letterer–Siwe disease and Hand–Schüller–Christian disease**
Eosinophilic granuloma is a benign lesion typically seen in skeletally immature patients. The lesions are composed of Langerhans histiocytes. Presenting symptoms include acute onset pain with swelling, sometimes with a mildly elevated ESR. Radiological appearances can be highly variable from benign-looking lesions to diaphyseal lesions with 'onion-skin' periosteal reaction requiring biopsy to exclude Ewing sarcoma, which is characterised by small, round blue cells histologically. Specimens should always be sent for histology and microbiology as osteomyelitis is an important differential diagnosis. Lesions can be treated expectantly, as many will regress. Patients require investigation to exclude the multiple lesions which occur in Langerhans cell histiocytosis (of which Letterer–Siwe and Hand–Schüller–Christian disease are variants) and which require specialist treatment including chemotherapy. Treatment options for lesions which do not resolve include curettage, steroid injection and radiotherapy.

11. Answer C. **Patients who develop lung metastases have a poor outcome**
GCT is a benign but locally aggressive tumour which classically originates in the epiphyseal region adjacent to joints and gives an osteolytic 'soap-bubble' appearance often resulting in cortical expansion and erosion. There may be a soft tissue mass. Treatment usually involves curettage and grafting or excision with reconstruction. The tumour comprises multinucleated giant cells (osteoclasts) and underlying stromal cells. It is important to check the blood calcium to exclude a brown tumour of hyperparathyroidism, which is histologically identical. Where resection is anticipated, neoadjuvant treatment with denosumab results in reossification of the tumour, which facilitates resection. Malignant transformation is seen in approximately 5% of cases but is believed to be as high as 15% in recurrent lesions, with metastases reported in up to 2%.

Although the behaviour of pulmonary metastases is unpredictable, metastatic disease in giant cell tumours does not carry the same poor prognosis as malignant tumours elsewhere.

12. Answer A. **Chondroblastoma**
Chondroblastoma is a benign tumour classically seen in patients aged 10–30 years in the epiphyses of long bones, most commonly around the knee, hip or proximal humerus. Patients present with pain, effusion and restricted range of motion, with X-rays demonstrating a small radiolucent lesion within the epiphysis, often with a sclerotic rim. It may be possible to identify calcification within a chondroid matrix, and MRI scan classically demonstrates extensive surrounding oedema. Some lesions may be associated with secondary ABC change, and the most important differential diagnosis to exclude is a clear cell chondrosarcoma. Histology demonstrates hyaline cartilage that is often described as having 'chicken-wire calcification'. Treatment is usually curettage +/– grafting, or in skeletally immature patients, radiofrequency ablation may be preferred in order to minimise damage to the physis.

13. Answer B. **Mazabraud syndrome**
Fibrous dysplasia consists of mono- or polyostotic fibro-osseous lesions most commonly seen in the proximal femur but can occur throughout the skeleton. Diagnosis is often incidental or as a consequence of fracture. Treatment is often conservative or may include bisphosphonate therapy. In larger lesions with risk of pathological fracture, curettage and grafting or fixation may be required. Radiographs demonstrate well-defined radiolucent lesions which are often expansile and give a 'ground-glass' appearance. Histology consists of benign fibroblasts with woven bone and 'Chinese-letter' configuration without osteoblastic rimming.

Polyostotic lesions are usually confined to one limb or side of the body and can be associated with McCune–Albright syndrome, a triad of FD, café-au-lait lesions and precocious puberty; or Mazabraud syndrome, a combination of FD with intra-muscular myxomas (the soft tissue lesions referred to in the question). Osteosarcomatous transformation from fibrous dysplasia is very rare, estimated at approximately 0.5%.

14. Answer A. **Following excision, most lesions require adjuvant radiotherapy to prevent recurrence**
Lipomatous tumours are the commonest form of soft tissue tumour and represent a spectrum of lesions ranging from small, simple lipomas to de-differentiated liposarcomas. Superficial lipomatous tumours are almost always benign, have few septations and are very slow growing.

Tumours arising deep to the fascia with thick septations and heterogeneity on MRI raise the suspicion of liposarcoma, and often larger or suspicious lesions will be analysed with FISH for cytogenetic MDM2 amplification. The scenario here describes a well-encapsulated superficial benign lesion which does not require radiotherapy. Treatment is usually by observation or close resection/shelling out, rather than the wide resection required of malignant tumours.

15. Answer E. **Treatment is usually with primary excision and local recurrence is uncommon**
Fibromatosis is a benign proliferation of myofibroblasts with abundant deposition of collagen which can classically consist of superficial lesions in the hands and feet (palmar/plantar fibromatosis) or represent the more invasive or deeper lesions known as desmoid tumours. These often involve the proximal limb girdle and can extend

to involve the skin or cause compression of nearby structures. Gardner's syndrome is an autosomal dominant form of familial adenomatous polyposis. Treatment is usually conservative, with surgery reserved for those that grow, are painful despite non-surgical treatment and are surgically resectable. Recurrence rates are high despite adequate margins. In cases of recurrence or in areas where surgery is difficult, lesions can be considered for radiotherapy.

16. Answer E. **Tenosynovial giant cell tumour**
Tenosynovial giant cell tumours are a spectrum of benign but aggressive lesions arising either in the tendon sheath or from synovial joints (previously known as pigmented villo-odular synovitis (PVNS)). Lesions can be either nodular or diffuse, and while tendon sheath tumours tend to affect the digits, the intra-articular lesions are commonest in the knee, hip and ankle where they are capable of damaging articular cartilage, leading to an arthropathy. Surgical excision is the gold standard; however, in diffuse cases, recurrence is common and patients occasionally in severe and unresectable cases require adjuvant treatment such as radiotherapy or tyrosine kinase inhibitors (e.g. imatinib).

17. Answer C. **Lesions only affect sensory nerves and not motor nerves**
Schwannoma is a benign nerve sheath tumour composed of Schwann cells. Lesions tend to be well encapsulated and are located on the surface of a peripheral nerve which can be either motor or sensory. Radiological appearances usually demonstrate a low signal on T1-weighted images and high signal on T2 with diffuse enhancement following gadolinium and may form a 'sweet potato' or 'string' sign. They are difficult to differentiate from neurofibromas but histologically are composed of Antoni A and B cells with Verocay bodies, which are pathognomonic. Immunohistochemistry demonstrates strongly uniform S100 antibody staining. Malignant transformation is extremely rare. Tumours can be multiple in schwannomatosis.

18. Answer C. **Synovial chondromatosis**
Synovial chondromatosis is a proliferative disease of the synovium associated with cartilage metaplasia and characterised by multiple intra-articular loose bodies. Presentation is typically in patients between 30 and 50 years of age with a long history of slowly progressive pain and swelling. This may be worse with activity, with associated mechanical symptoms or restricted movement. While the knee is the most commonly affected joint, it can also occur within a bursa or overlying an osteochondroma or in other joints, such as the hip. Most patients are symptomatic and benefit from removal of loose bodies or synovectomy; however, local recurrence is common. Although extremely rare, malignant transformation can occur, leading to secondary synovial chondrosarcoma.

19. Answer A. **Angioleiomyoma**
Vascular leiomyoma is a benign smooth muscle tumour arising from the tunica media of a vessel which can occur anywhere but more commonly affects the lower extremities. Pain is the predominant symptom, and lesions are typically $<$2cm in size. Differentials include ganglion, neuroma, schwannoma, inclusion cyst, fibroma and leiomyosarcoma. Treatment is usually with excision for symptomatic relief and to confirm the diagnosis. Recurrence rates are typically low.

20. Answer A. **Eosinophilic granuloma**
Bisphosphonates inhibit osteoclastic activity. Indications for their use include osteoporosis, Paget's disease, fibrous dysplasia, metastatic bone disease, multiple myeloma and osteogenesis imperfecta. They are contraindicated in severe renal impairment, and their use is associated with osteonecrosis of the jaw and atypical subtrochanteric fracture of the femur.

21. Answer E. **Tenosynovial giant cell tumour**
Non-ossifying fibroma is a benign fibrogenic lesion which affects between 30–40% of children. Lesions typically occur in the metaphysis of long bones of the lower extremity and are often incidental. The majority regress spontaneously and they have no known malignant or metastatic potential. They can be associated with a number of conditions including Jaffe–Campanacci syndrome, neurofibromatosis, familial multifocal non-ossifying fibroma and aneurysmal bone cysts.

22. Answer C. **Surgical resection is the mainstay of management**
Heterotopic ossification is defined as the formation of bone in atypical extraskeletal tissues. It most commonly occurs following trauma, particularly neurological injury including spinal cord injury and traumatic brain injury/stroke. The hip and elbow are the most commonly affected joints. One of the most critical decisions in the management of such lesions is the timing of surgical excision. Early surgical intervention during the active phase results in extensive recurrence; thus every effort should be made to ensure that the lesion has matured sufficiently to minimise risk of recurrence. Typically, it is recommended that surgery is delayed for a minimum of 12–18 months following neurological injury.

23. Answer D. **Myositis ossificans**
Myositis ossificans is a reactive process usually secondary to direct trauma/intramuscular haematoma consisting of a proliferation of fibroblasts, cartilage and bone within muscle. The lesion is usually self-limiting; however, it is important to differentiate from sarcoma. Typical radiological features include peripheral bone formation with a central lucent area visible on plain radiograph and an eggshell appearance on CT, representing peripheral calcification with no central calcification. Histologically, the periphery demonstrates mature trabeculae of lamellar and woven bone, while centrally there is an irregular mass of immature fibroblasts/cartilage with no cellular atypia. Surgery should be avoided when possible, and if it is necessary, it should be delayed until the lesion is fully matured.

24. Answer B. **Lesions are capable of eroding articular cartilage**
Tenosynovial giant cell tumour and giant cell tumour of bone are two entirely separate entities, despite sharing the term 'giant cell' in their name. Tenosynovial giant cell tumour arises within synovium or tendon sheath and giant cell tumour of bone arises within the epiphysis of bone. TGCT often occurs in the hands and is capable of eroding articular cartilage and bone.

25. Answer C. **MRI scan**
The scenario describes a patient with a long-standing osteochondroma. While malignant transformation is a possibility, the recent increase in activity level with an increase in swelling is likely to represent development of an overlying bursa rather than true increase in the size or cartilage cap of the osteochondroma. An MRI would allow assessment of both the cartilage cap and any surrounding bursa. If there are concerning features, the next step would be a biopsy.

26. Answer C. **Chondromyxoid fibroma**
Chondromyxoid fibroma is a benign tumour composed of a mixture of chondroid, myxoid and fibromatoid tissue. It usually arises in the metaphyseal region of long bones, although it can also occur in the pelvis or small bones of the hands or feet. X-rays demonstrate an eccentric lytic lesion with a narrow zone of transition. Treatment is usually surgical with curettage and grafting/cementoma, but recurrence rates are reported to be as high as 25%.

27. Answer C. **Non-ossifying fibroma**
Rates of potential malignant transformation vary between tumour types; however, estimations of risk include:

Fibrous dysplasia 0.5%.

Giant cell tumour of bone 5%.

Synovial chondromatosis 1–10%.

Paget's disease 1%.

Non-ossifying fibroma is not known to become malignant or metastasise.

28. Answer D. **MRI scan**
While the clinical scenario likely describes a benign lesion, based on this information alone, a tumour cannot be excluded. While both MRI and biopsy would be appropriate, it is important to obtain an MRI scan prior to biopsy for biopsy planning and because the biopsy may complicate the interpretation of the images.

29. Answer B. **Fine-cut CT**
Osteoid osteoma typically presents with nocturnal pain that responds to NSAIDs. A fine-cut CT is usually diagnostic and shows a radiolucent nidus with surrounding sclerosis. Bone scan is also positive but non-specific. Treatment is usually by radiofrequency ablation.

30. Answer D. **Osteosarcoma secondary to Paget's disease has a poor outcome**
The radiological appearances of Paget's disease classically include remodelled coarsened trabeculae. Bisphosphonate treatment is effective in reducing the pain and vascularity of affected bones. Biopsy is indicated.

Despite recent advances in chemotherapy, sarcomas arising in the setting of Paget's disease continue to have a poor prognosis. Five-year survival rate averages 10%, compared with 70–80% seen in osteosarcomas in the paediatric population. In addition, Paget's sarcoma may rarely be the presenting symptom of Paget's disease. Recent studies suggest the poor prognosis in Paget's sarcoma is not due to site or stage at presentation and that sarcomas arising in this clinical setting may have a different biological potential.

Deyrup AT et al. Sarcomas arising in Paget disease of bone: a clinicopathologic analysis of 70 cases. *Arch Pathol Lab Med*. 2007;**131**:942–946.

31. Answer B. **Cellular atypia is often seen in cartilaginous tumours of the hands and feet**
Needle biopsy is not usually helpful in determining the grade of a cartilage tumour, and fractures through an enchondroma usually heal, although the underlying cartilage tumour tends to persist. Most low-grade chondrosarcomas in the hands and feet can be treated with intralesional curettage and complete resection is not required. Ollier disease is characterised by multiple enchondromas.

32. Answer E. **Radiotherapy to the primary site**
The mainstay of treatment of osteosarcoma is neoadjuvant (preoperative) multiagent chemotherapy, complete surgical excision (+/– reconstruction) and adjuvant (post-operative) chemotherapy. Radiotherapy is used for palliation and is not standard treatment. Most patients are treated with limb-sparing surgery.

33. Answer E. **Wide local surgical resection alone**
Chondrosarcoma is a primary malignant bone tumour. Treatment is by surgical resection; radiotherapy and chemotherapy are not standard treatments, although chemotherapy has a role in de-differentiated and mesenchymal variants.

34. Answer C. **At the time of diagnosis, about 50% of patients present with metastatic disease**
Ewing sarcoma of bone is a primary malignant bone tumour, which is the most common malignant tumour in the diaphysis of long bones. Biopsy reveals a small round blue cell tumour, with an 11;22 translocation on cytogenetic testing. Patients are treated with combination chemotherapy and then local therapy, which may include radiotherapy for tumours that have been incompletely resected, have not responded to chemotherapy or are in inoperable sites such as the sacrum.

At the time of diagnosis, about 25% of patients present with metastatic disease.

Metastasis usually occurs to the lungs (70–80%) and to the bone (40–45%). Despite current aggressive cytotoxic treatment regimens, the 5-year overall survival of patients with metastatic ES ranges from 20–35%.

35. Answer B. **Narrow zone of transition**
High-grade osteosarcoma classically occurs in the metaphyseal growing regions of long bones in the second and third decades of life. There is usually a periosteal reaction and an extraosseous soft tissue mass. As this is a rapidly evolving aggressive lesion, the zone of transition is usually wide rather than narrow (or geographic).

36. Answer D. **Surgical resection with a neurological deficit including incontinence**
Chordoma is a slowly growing tumour that is classically chemotherapy resistant. Surgery is the mainstay of treatment, with significant neurological sequelae which increase with more proximal resections. The picture shows a tumour involving the body of S2. Resection of both S3 nerve roots is likely to lead to urinary incontinence. Radiotherapy can be used pre- or post-operatively where there is a risk of close or incomplete excision. Neoadjuvant chemotherapy is not used routinely.

37. Answer D. **This is a slowly growing malignant lesion that has a risk of local recurrence and a risk of distant metastasis**
Adamantinoma is a rare, malignant, slowly growing bone tumour which characteristically occurs in the tibia. Treatment is by wide

resection, and recurrence is common if wide surgical margins are not achieved. There is a 15–20% risk of late distant metastasis. Chemotherapy and radiotherapy alone for the primary tumour are not routinely indicated. Chemotherapy can be used for distal metastasis.

38. Answer D. **Tc99 bone scan**
Investigation of a patient with suspected multiple myeloma may include serum electrophoresis, bone marrow biopsy, FDG–PET and whole-body MRI. Skeletal survey may also be helpful. A Tc99 whole body bone scan is less useful, as there is little osteoblastic response in skeletal deposits.

39. Answer D. **Re-excision of the scar and tumour bed including the deep fascia**
After unplanned excision of a subcutaneous soft tissue sarcoma, the appropriate management would be to stage the patient with a CT of the chest and image the operative site in an attempt to identify the extent of contamination. The most appropriate management would be to re-excise the tumour bed; excising the deep fascia provides a good deep margin for tumour excision.

40. Answer B. **Core needle biopsies are not useful in the diagnosis of soft tissue sarcoma**
Biopsy of musculoskeletal tumours should be carefully planned in order to avoid contamination of uninvolved tissues. Core needle biopsies are the investigation of choice and best results are obtained when radiological guidance is used. The approach should be planned so that the biopsy track can be excised with the tumour, and the approach should not contaminate uninvolved anatomical compartments. Infection is an important differential for many tumours and therefore samples should be sent for culture and sensitivity.

41. Answer B. **According to the Mirel scoring system, blastic lesions in bone have a lower risk of fracture**
The decision about whether to surgically intervene to prevent a pathological fracture balances the risk of fracture against the risks of surgery. The Mirel scoring system is a clinically useful guide to whether a metastasis is at risk of causing a fracture, although it has been criticised for being non-specific. Mechanical pain on weight bearing is an important predictor of the risk of fracture. This lesion scores 2 for 'site', 3 for 'functional' pain, 2 for 'mixed' and 2 for 'size', giving a total of 9. Lesions which score more than 8 should be considered for surgery according to the scoring system. In the system, 'blastic' lesions are associated with a lower score. Load-sharing devices such as dynamic hip screws are not well suited to the fixation of metastases, as healing of the metastasis is unpredictable. Endoprosthetic replacement as a rule provides a more predictable outcome, which does not rely on fracture healing.

42. Answer D. **Reassurance and observation only**
Bland lipomatous tumours on MRI are either simple lipomas or atypical lipomas. These tumours have characteristic appearances on MRI scanning and do not require a biopsy to confirm the diagnosis. De-differentiation is rare but more common in retroperitoneal tumours (20%) than in extremity tumours (2%). Although many patients opt to have these removed (they require a close, planned marginal excision), surveillance is very reasonable, particularly in a frail patient.

43. Answer B. **Inheritance is autosomal recessive**
Osteochondromatosis, previously known as hereditary multiple exostoses, is a condition in which there is a mutation in EXT genes, which gives rise to the development of multiple exostoses. Typically, these appear to grow away from the physis. Inheritance is autosomal dominant, and the risk of malignant degeneration is low (around 4%). If an osteochondroma grows after skeletal maturity, then it should be investigated because of the risk of malignant degeneration. Relative shortening of the narrower bones (ulna and fibula) in the limb occurs with associated ulnar deviation, or valgus deformity of the ankles. Most patients develop palpable osteochondromas around the knee by the age of 8.

44. Answer B. **Embryonal rhabdomyosarcoma**
Lymph node metastases are rare in soft tissue sarcoma. However, they occur most commonly in embryonal rhabdomyosarcoma, epithelioid sarcoma and clear cell sarcoma.

45. Answer E. **Tumours typically produce an osteoid matrix**
Chondrosarcomas are malignant bone tumours, the majority of which occur in preexisting lesions such as osteochondromas or enchondromas. Survival depends on histological grade, ranging from more than 90% at 5 years for grade 1 tumours to less than 10% for de-differentiated tumours. Complete surgical resection is the treatment of choice for tumours of grade 2 and above. Grade 1 tumours can be considered for curettage, although there is a risk of local recurrence. Histologically, chondrosarcoma characteristically shows permeation of malignant cartilage into bone trabeculae. De-differentiated tumours often present with a pathological fracture. The characteristic matrix of a chondrosarcoma is chondroid, showing 'popcorn' calcification, as distinct from the osteoid production of osteosarcoma.

46. Answer E. **Polyostotic fibrous dysplasia has an autosomal dominant inheritance**
Fibrous dysplasia occurs because of a mutation in an intracellular signalling protein. It can be mono- or polyostotic and associated with a raised level of FGF23, with associated phosphaturic rickets a possibility. It can be associated with hormonal abnormalities – typically precocious puberty – in McCune–Albright syndrome, which is also characterised by café-au-lait spots.

Affected bones are weaker and may fracture or deform over time, requiring surgical intervention. Although caused by a mutation, fibrous dysplasia is not inherited.

47. Answer C. **It is associated with an excellent prognosis with over 90% survival at 5 years**
Parosteal osteosarcoma classically occurs in the popliteal fossa, arising from the posterior cortex of the femur. Treatment is complete surgical excision, with chemotherapy considered for tumours with de-differentiated components. An X;18 translocation is typical of synovial sarcoma; there is no characteristic translocation associated with parosteal osteosarcoma. Prognosis is excellent, although there is a risk of de-differentiation.

48. Answer B. **Chemotherapy with radiotherapy to the primary site**
Primary bone lymphoma is one in which the tumour arises in the bone rather than the more common sites of lymph nodes. Treatment is under the supervision of a haemato-oncologist and typically involves chemotherapy and local radiotherapy. Surgical management is limited to biopsy, stabilisation of pathological fracture or decompression of the spinal canal if there is neurological compromise. There is no role for debulking surgery or resection. Tumours usually respond very well to initial non-surgical treatment.

49. Answer A. **The lesion is a slow-growing tumour often with a long history**
Clear cell chondrosarcoma typically occurs in the physis of long bones, most often in the head of the femur or humerus. Radiographically it looks well defined with a geographic margin and can resemble chondroblastoma or giant cell tumour of bone. The history can be long. Treatment is by wide local excision with a good prognosis: chemotherapy is not standard.

50. Answer E. **Treatment usually includes surgical excision**
Synovial sarcoma is a type of soft tissue sarcoma characterised by an X;18 translocation. Despite the name, most occur in juxta-articular locations rather than in synovial joints. Presentation is often delayed, and the history can be very long, despite the presence of pain. These tumours are thought to be more chemosensitive than other types, and therefore chemotherapy is often used for high-risk tumours. Small peripheral tumours can be treated with surgery alone, however.

51. Answer B. **Myxofibrosarcoma has a higher local recurrence rate than other types of soft sarcoma**
Myxofibrosarcoma is one of the more common types of soft tissue sarcomas. The risk of distant metastases is generally lower than for other soft tissue sarcomas. Metastatic sites include lung, bone and lymph nodes, with histological grade being the main risk factor for metastasis. Myxofibrosarcomas often arise on top of the investing fascia and can track along fascial planes, manifested on MRI by a high signal 'tail' which often contains tumour. The risk of local recurrence is consequently high compared with other sarcomas. Local treatment usually comprises surgery and radiotherapy.

52. Answer A. **Maffucci syndrome**
The risk of malignancy can be difficult to estimate because it can be difficult to sample a large population. However, reasonable estimates for malignant change are as follows. In McCune–Albright syndrome, conversion to malignancy is very rare, although it may be higher than in fibrous dysplasia alone (estimated at 0.5%). Similarly, the risk of development of osteosarcoma in Paget's disease is low (estimated at <1%).

In multiple enchondromatosis, the risk of malignant change is accepted as higher in Maffucci syndrome (50–100%) than in Ollier disease (5–50%): the major concern is around the degeneration of enchondromas to central chondrosarcomas, but there can be associated malignancies including brain tumours, and these may be more life-threatening.

53. Answer A. **Perform an open biopsy**
Patients who present with a solitary tumour in bone should have the diagnosis established before fixation of the fracture. Therefore, the most appropriate next management is to proceed to open biopsy if the needle biopsy has been inconclusive. It is not appropriate to fix the fracture and send the reamings, as this would contaminate the whole femur with tumour, which may require a salvage amputation in the presence of a primary bone tumour.

54. Answer D. **Persistent pain and growth of an enchondroma raises the possibility of malignant transformation**
Ollier disease is characterised by multiple enchondromas, with a risk of malignant transformation which is thought to be between 5 and 50%. It is not inherited. Maffucci syndrome is characterised by multiple enchondromas and haemangiomas, not osteochondromas.

55. Answer E. **First-line treatment of tenosynovial giant cell tumour is radiotherapy**
Skin tumours are relatively common in the hand, of which squamous cell tumours and malignant melanoma are the most common. Enchondromas of the small bones of the hand may cause cortical thinning and fracture – treatment is to treat the fracture and then to consider curettage. Conditions with multiple enchondromas of the hand bones are Ollier disease and Maffucci syndrome. These tumours often show more cytological atypia than benign enchondromas in other bones. Tenosynovial giant cell tumour (previously known as pigmented villonodular synovitis) of the hand typically arises from the tendon sheath – treatment is usually by surgical excision rather than radiotherapy.

56. Answer D. **Plasma cells with an eccentric nucleus and a 'clock face' chromatic orientation**
Multiple myeloma (MM) accounts for about 10% of haematological malignancies and often presents with bony involvement (Rajkumar 2020). It typically affects patients aged 50–80 years. Radiographically, the lesions typically appear as lytic and punched-out (Miller & Thomson 2016).

The diagnosis of MM requires a combination of clinical, laboratory, radiological and histological results. The revised international Myeloma Working Group criteria requires at least one or more myeloma defining events (MDE) with 10% or more plasma cells on bone marrow aspiration or a biopsy proven plasmacytoma. Patients are tested for presence of M proteins (serum electrophoresis or urine). The typical histology result would demonstrate plasma cells with an eccentric nucleus and a 'clock face' chromatic orientation.

Answer A is describing an aneurysmal bone cyst. Answer B is describing an adamantinoma which typically involves the tibia. Answer C describes a giant cell tumour of bone. Answer E is describing a small round blue cell tumour, of which Ewing sarcoma is an example.

Miller M, Thomson S. *Miller's Review of Orthopaedics*, Seventh Ed. New York: Elsevier; 2016.

Rajkumar SV. Multiple myeloma: 2020 update on diagnosis, risk-stratification and management. *Am J Hematol.* 2020;**95**:548–567.

57. Answer A. **Glomus tumour**
The brief case vignette is describing the Love test which is one of many tests to diagnose a glomus tumour.

The Love test involves using a pinhead, or even ballpoint pen to press against the tumour. The patient will experience exquisite pain which reduces upon removing the sharp stimulus (Hazani et al. 2008).

Hazani R, Houle J, Morton K, Wilhelmi B. Glomus tumors of the hand. *Eplasty* 2008;**8**:447–450.

58. Answer A. **Arrange a whole-body MRI (WBMRI) to assess for other lesions and refer to paediatrics for an endocrine review**
This describes a classic presentation of a patient with McCune–Albright syndrome (MAS). This condition was originally described in 1936 as a triad of bony fibrous dysplasia, precocious puberty and café-au-lait skin lesions (Spencer et al. 2020).

The best next step in the management of this patient would be to obtain further imaging such as a whole-body MRI (WBMRI) to assess for any other associated lesions. Additionally, the precocious puberty warrants assessment by the paediatric team for an endocrine review. Curettage of the lesion with surgical stabilisation is likely in this patient given the chronic symptoms but is not the best next step in this context.

Spencer T, Pan KS, Collins MT, Boyce AM. The clinical spectrum of McCune-Albright syndrome and its management. *Horm Res Paediatr.* 2020;**92**:347–356.

59. Answer E. **Schwannoma**
Schwannomas are benign nerve sheath tumours composed of Schwann cells. Symptoms can vary depending on the location and involved nerve. Patients may report sensory or motor symptoms. In this question, it is important to use the anatomical clues to make a diagnosis using vague clinical information. The MRI in Figure 28.9 demonstrates a well-circumscribed mass with a split fat sign (this can be seen as a fine outer layer of fat surrounding the schwannoma).

60. Answer A. **Complete but close excision of the tumour without removing normal structures**
This question is testing knowledge of surgical margins. A lipoma is a benign tumour of mature fat. A marginal resection is adequate. This involves complete but close excision of the tumour without removing normal surrounding structures.

Option B describes an intralesional resection. Option C describes a radical resection. Option D describes a wide margin.

61. Answer E. **Perform local and distant staging scans**
This case vignette is describing a patient with Paget's disease. Secondary bone sarcomas (typically osteoblastic osteosarcoma; Hansen et al. 2007) can arise from Pagetic bone and should be excluded. Deteriorating pain at night suggests this diagnosis. A local MRI scan is an appropriate next step to identify changes including a soft tissue mass which may require a biopsy.

Paget's sarcoma is associated with a poor prognosis with long-term survival being less than 20%. This likely reflects delays in diagnosis and a typically older population who are unable to receive cytotoxic chemotherapy.

Hansen MF, Seton M, Merchant A. Osteosarcoma in Paget's disease of bone. *J Bone Miner Res.* 2007;**22**(Suppl. 2):58–63.

62. Answer B. **IB**
Knowledge of the Enneking staging system is key (Jawad & Scully 2010). A lesion is classified into either low or high grade, whether it is confined to or extends beyond an anatomical compartment (in this case the femur bone) and whether there are detectable metastases.

Jawad MU, Scully SP. Classifications in brief. Enneking classification: benign and malignant tumors of the musculoskeletal system. *Clin Orthop Relat Res.* 2010;**468**:2000–2002.

63. Answer B. **Elastofibroma**
Elastofibromas are rare benign tumours which typically involve the subscapular region. They can often present with a history of clunking around the shoulder in older patients (>50 years of age) which is typically pronounced on abduction and adduction of the shoulder (Smith et al. 2016). A soft tissue sarcoma must be excluded, but the MRI appearances and anatomical location are characteristic. About 30% are bilateral. Biopsy typically shows elastin fibres. Management is generally conservative although excision may be appropriate for some symptomatic lesions.

Smith HG et al. Elastofibroma dorsi: the clunking tumour that need not cause alarm. *Ann R Coll Surg Engl.* 2016;**98**:208–211.

64. Answer B. **Gaucher disease**
Risk factors for soft-tissue and bone sarcomas include previous radiation therapy, exposure to

chemicals (e.g. vinyl chloride, arsenic), immunodeficiency, prior injury (scars, burns), chronic tissue irritation (foreign-body implants, lymphoedema), neurofibromatosis, Paget's disease, bone infarcts and genetic cancer syndromes (hereditary retinoblastoma, Li–Fraumeni syndrome, Gardner's syndrome). However, most patients have no specific aetiology. The incidence of solid tumours and haematological malignancies (other than multiple myeloma) does not appear to be significantly increased in patients with Gaucher disease followed through early to middle age (Rosenbloom et al. 2005; Shmookler et al. 2006).

Rosenbloom et al. Gaucher disease and cancer incidence: a study from the Gaucher Registry. *Blood* 2005;**105**:4569–4572. http://dx.doi.org/10.1182/blood-2004-12-4672.

Shmookler B, Bickels J, Jelinek J, Sugarbaker P, Malawer M. Bone and soft-tissue sarcomas: epidemiology, radiology, pathology and fundamentals of surgical treatment. In Musculoskeletal Cancer Surgery, pp. 3–35. New York: Springer; 2006.

65. Answer E. **The pseudocapsule around soft tissue sarcomas seldom contains tumour cells**
Sarcomas generally grow centrifugally with the periphery of the lesion being the least mature. The edge of the tumour is often the most rewarding place to biopsy – the centre can be necrotic. Sarcomas are generally enclosed by a reactive zone, or pseudocapsule containing compressed normal tissues, inflammatory cells and tumour cells. The thickness of the reactive zone varies with the histological type and grade of the tumour, as well as the local tissue. The local invasion of high-grade sarcomas can lead to the formation of local 'skip metastases' which may cause local recurrence if not treated adequately.

Sarcomas usually respect anatomical borders and initially grow within the osteofascial anatomical compartment of origin before invading bone or fascia and becoming extra-compartmental (Shmookler et al. 2006). Complete removal of a soft tissue sarcoma therefore requires resection of the reactive zone.

Shmookler B, Bickels J, Jelinek J, Sugarbaker P, Malawer M. Bone and soft-tissue sarcomas: epidemiology, radiology, pathology and fundamentals of surgical treatment. In Musculoskeletal Cancer Surgery, 3–35. New York: Springer; 2006.

66. Answer A. **Body mass index**
Six variables were found to be significant predictors of SVTE in patients with soft tissue sarcoma undergoing surgery: tumour size greater than 10cm, metastasis at diagnosis, post-operative chemotherapy, preoperative and post-operative partial thromboplastin time (PTT) and additional surgical procedures. Surgeons and healthcare professionals may minimise the risk of SVTE by actively following patients with risk factors and reducing surgical complications (Kamalapathy et al. 2023).

Kamalapathy PN et al. Predictors of symptomatic venous thromboembolism in patients with soft tissue sarcoma in the lower extremity. *Cancers (Basel)* 2023;**15**.

67. Answer E. **Synovial sarcoma**
Appreciation of the associated risk of lymph node metastasis attributed to different subtypes of soft tissue sarcomas can influence decision making. A study by Jacobs et al. (2018) studied a large national database to help understand overall risks. The risk of lymph node metastasis in order of highest to lowest frequency based on the provided choices are: rhabdomyosarcoma, clear cell, epithelioid, angiosarcoma and synovial sarcoma.

Jacobs AJ, Morris CD, Levin AS. Synovial sarcoma is not associated with a higher risk of lymph node metastasis compared with other soft tissue sarcomas. *Clin Orthop Relat Res*. 2018;**476**:589–598.

68. Answer D. **Radiation therapy is often recommended for high-grade lesions or tumours larger than 5cm**
Malignant peripheral nerve sheath tumour (MPNST) is a soft tissue sarcoma with limited therapeutic interventions and a poor prognosis. Prognostic factors for survival include the subtype and molecular variations. 50% of patients with MPNST have associated neurofibromatosis type 1, 10% have had previous radiation exposure, and the rest of cases tend to be sporadic (Yao et al. 2023).

The National Comprehensive Cancer Network (NCCN) guidelines recommend using

PET/CT for MPNST diagnosis, looking particularly at whether there is increased uptake in pre-existing lesions. The only effective treatment is complete surgical resection with negative margins. Several studies have shown that adjuvant chemotherapy has a limited effect on survival or recurrence rate. As with other soft tissue sarcomas, radiotherapy is often recommended for high-grade lesions or tumours larger than 5cm.

Yao C et al. Malignant peripheral nerve sheath tumors: latest concepts in disease pathogenesis and clinical management. *Cancers (Basel)* 2023;**15**:1–19.

Chapter 29

Prosthetics and Orthotics Structured SBA

Emerson Budhoo

PROSTHETICS AND ORTHOTICS STRUCTURED SBA QUESTIONS

1. **Which one of the following prostheses is best suited in the paediatric population with the added advantage of ambulating on uneven terrain?**
   A. Constant friction knee
   B. Fluid-controlled hydraulic knee
   C. Polycentric knee
   D. Stance phase control knee
   E. Variable-friction knee

2. **Which one of the following is typical of an antalgic gait pattern?**
   A. Patient leans their trunk laterally over the contralateral side in ipsilateral hip arthritis
   B. Patient's contralateral step length is increased in ipsilateral ankle arthritis
   C. Patients adopt a hamstring avoidance in ipsilateral knee arthritis
   D. The affected knee is maintained in slight flexion with ipsilateral toe walking
   E. The swing phase of gait on the ipsilateral side is decreased in hip arthritis

3. **Which of the following is correct regarding the increase in metabolic demand in lower limb amputations?**
   A. The metabolic demand is 100% above normal in transfemoral (TF) amputations related to peripheral vascular disease
   B. The metabolic demand is 50% above baseline in TF amputations
   C. The metabolic demand is 50% below baseline in TF amputations
   D. The metabolic demand is the same in TF and a short below-knee amputation (BKA)
   E. The metabolic demand is the same in vascular BKA versus traumatic BKA

4. **A prosthetic foot that is placed too far inset will result in which of the following?**
   A. Choke syndrome
   B. Increased knee extension and varus knee during stance
   C. Increased knee flexion and valgus knee during stance
   D. Socket pain lateral proximally and medial distally
   E. Socket pain medial proximally and lateral distally

5. **Which of the following describes the fastest gait pattern?**
   A. 3-point gait
   B. 4-point gait
   C. Normal walking
   D. Swing-through gait
   E. Swing-to gait

6. **Which one of the following upper limb prostheses is best indicated for heavy labour?**
   A. Body-powered prosthesis (terminal device activates with shoulder adduction and flexion)
   B. Body-powered prosthesis (terminal device activates with shoulder abduction and flexion)
   C. Myoelectric device (3-site, 2-function device)
   D. Myoelectric prosthesis (1-site, 2-function device)
   E. Myoelectric prosthesis (2-site, 2-function device)

7. **Which of the following statements is true regarding the polycentric knee?**
   A. A prosthetic polycentric knee with hydraulic swing control is best chosen for an older patient who requires stability in the stance phase
   B. The piston mechanism in the hydraulic knee allows variable cadence
   C. The polycentric knee has a fixed centre of rotation

D. When the centre of rotation (COR) is anterior to the line of weight bearing, extension is improved
E. When the COR is posterior to the line of weight bearing, it allows control in the swing phase

8. **A 54-year-old active female with stage II posterior tibial tendon dysfunction will require which of the following orthotics to re-centre her weight bearing axis through the ankle?**
A. CROW walker
B. Insole with forefoot abduction post
C. Insole with lateral arch support
D. Insole with medial hindfoot post
E. Knee–ankle–foot orthosis to correct her hindfoot valgus

9. **Which of the following is true regarding upper limb prosthesis for above elbow amputations?**
A. Elbow movement is controlled by shoulder abduction and external rotation
B. Elbow movement is controlled by shoulder adduction and external rotation
C. Elbow movement is controlled by shoulder extension and depression
D. Elbow movement is controlled by shoulder flexion and abduction
E. Elbow movement is controlled by shoulder flexion and internal rotation

10. **Which of the following correctly describes the sequence of events in 3-point gait utilising a walker?**
A. Stronger leg in front => walker follows through => weaker leg
B. Walker in front => both legs swing at same time => walker in front
C. Walker in front => stronger leg follows through => weaker leg
D. Walker in front => weaker leg follows through => stronger leg
E. Weaker leg in front => walker follows through => stronger leg

11. A 70-year-old male recently underwent a below-knee amputation and was fitted in a prosthesis several months afterwards. He presented to clinic complaining of swelling of his thigh just above the prosthesis. The skin was indurated, and a diagnosis of choke syndrome was made.
This most likely could have been due to which of the following?
A. Loose proximal and loose distal socket
B. Loose proximal and normal-fitting distal socket
C. Loose proximal and tight distal socket
D. Tight proximal and loose distal socket
E. Tight proximal and tight distal socket

12. **Which deformity would result in a patient undergoing a Chopart amputation without tendon balancing?**
A. Equinus deformity
B. Hindfoot valgus
C. Hindfoot varus
D. Planus deformity
E. Supination deformity

13. A 65-year-old diabetic with severe peripheral arterial disease presents with a spontaneous rupture of his tibialis anterior tendon, causing difficulty in dorsiflexion of his ankle. He has a 3cm gap on ultrasound examination.
Which one of the following would be the best option to manage this?
A. Darco shoe with hindfoot rocker
B. Palmaris longus autograft to bridge the gap
C. Posterior leaf spring ankle–foot orthosis (AFO)
D. Posterior tibialis tendon transfer onto the talar neck
E. Solid ankle cushioned heel (SACH) foot

14. A 32-year-old male presents with a cavovarus deformity. Examination reveals a positive Coleman block test.
Which of the following orthotics will be most suitable?
A. Recessed first ray with lateral hindfoot post
B. Elevated first ray with lateral hindfoot post
C. Elevated first ray with medial hindfoot post
D. Recessed first ray with medial hindfoot post
E. Recessed second to fourth rays with lateral hindfoot post

15. **Which of the following best explains the mechanics in utilising a cane for ipsilateral hip arthritis?**

A. A cane held in the contralateral hand reduces joint reaction forces through the affected hip up to 50% by reducing abductor muscle pull
B. A cane held in the contralateral hand reduces joint reaction forces through the affected hip up to 25% by reducing abductor muscle pull
C. The cane improves the abductor muscle pull on the opposite side of the hip arthritis
D. The cane reduces the abductor muscle pull on the opposite side of the hip arthritis
E. The cane reduces the joint reaction force when it is held on the same side as the hip arthritis

16. A 34-year-old male undergoes a below-knee amputation for a mangled limb. He wishes to continue running on a regular basis.
Which of the following terminal devices would be best suited?
A. Articulated dynamic response foot with lengthened keel
B. Articulated dynamic response foot with sagittal split keel
C. Articulated dynamic response foot with shortened keel
D. Elastic keel foot
E. Solid ankle cushioned heel (SACH) foot

17. **Which one of the following amputations involves preservation of the calcaneus, which is then fused to the distal tibia?**
A. Boyd
B. Chopart
C. Gritti–Stokes
D. Syme's
E. Transmetatarsal

18. A 68-year-old male underwent a total knee arthroplasty utilising a posterior stabilised (PS) design prosthesis. Four months afterwards, he felt his knees 'dislocate' and went to the A&E. Radiographs revealed a cam jump.
Which of the following surgical errors could have led to this?
A. Loose extension gap
B. Loose flexion gap
C. Patella baja
D. Tight extension gap
E. Tight flexion gap

19. **Which one of the following issues may arise in a patient with a below-knee amputation in which the heel of the foot prosthesis is too rigid?**
A. Excessive knee extension
B. Excessive knee flexion
C. Excessive valgus knee stress
D. Reduced knee flexion
E. Reduced knee rotation

20. **Which of the following best describes the appropriate position of the feet in the Denis Browne bar brace?**
A. 60–70° external rotation (ER) on the affected side, 30° ER on the unaffected side, 10–15° dorsiflexion bilaterally
B. 60–70° ER on the affected side, 0° (neutral) rotation on the unaffected side, 10–15° dorsiflexion bilaterally
C. 30° ER of the affected side, 0° (neutral) rotation on the unaffected side, 10–15° dorsiflexion bilaterally
D. 60–70° ER on both affected and unaffected sides, 10–15° dorsiflexion bilaterally
E. 30° ER bilaterally, 10–15° dorsiflexion bilaterally

21. **Which of the following correctly describes the Kleinert protocol following flexor tendon repairs?**
A. Active finger extension, active finger flexion
B. Active finger extension, dynamic splint-assisted passive finger flexion
C. Active finger flexion, dynamic splint-assisted passive finger extension
D. Passive finger extension, active finger flexion
E. Passive finger flexion, dynamic splint-assisted passive finger extension

22. **Which of the following correctly describes the principle involved in application of a Pavlik harness in an infant with developmental dysplasia of both hips?**
A. Anterior straps flex the hip to 90–100°, posterior straps externally rotate the hip to 20°
B. Anterior straps prevent flexion of the hip, posterior straps abduct the hip to 45°
C. Anterior straps flex the hip to 40–50°, posterior straps abduct the hip to 20°

D. Anterior straps flex the hip to 90–100°, posterior straps prevent adduction of the hip
E. Anterior straps flex the hip to 90–100°, posterior straps prevent internal rotation of the hip

23. **Which one of the braces can be utilised in a child with scoliosis in which the apex of the curve is above T7 vertebra?**
A. Boston-style brace
B. Charleston bending brace
C. Milwaukee brace
D. TLSO
E. Wilmington brace

24. **What type of prosthetic knee design is best suited in a young active female below-knee amputee who desires a prosthesis with variable cadence?**
A. Constant friction knee
B. Fluid-controlled hydraulic knee
C. Manual locking knee
D. Stance phase control knee
E. Variable-friction knee

25. **Which of the following statements is correct regarding halo traction for cervical spine injuries?**
A. It can be used to treat type II odontoid fractures in younger patients
B. Dural puncture is the most common complication
C. It is more effective in treating subaxial spine injuries
D. More pins are required for adults than paediatrics
E. Supraorbital nerve palsy is the most common nerve injury due to halo placement

26. A 64-year-old male suffers a laceration to his wrist, severing his ulna nerve. Repair is performed, but 1 year afterwards he develops a claw hand deformity. His joints are fully mobile and he refuses any further surgical intervention.
Which of the following splints is indicated?
A. Dorsal splint to flex the metacarpophalangeal joint (MCP) joint of the ring and middle fingers to 35–45°
B. Dorsal splint to flex the MCP joint of the ring and middle fingers to 90° and extend the proximal interphalangeal (IP) joint to neutral
C. Dorsal splint to neutralise the MCP joint of the ring and middle fingers and flex the IP joints to 45°
D. Volar wrist splint with the wrist in 20° flexion, MCP in 90° flexion
E. Volar wrist splint with the wrist in 45° flexion, MCP in 10° flexion

27. Following an altercation, a 54-year-old male noticed his middle finger was swollen. The resident on call made a clinical diagnosis of a central slip rupture of his extensor tendon apparatus. There were no bony injuries on X-ray.
Which one of the following splints may be useful in the acute setting?
A. Buddy strapping
B. Capener splint
C. Extension block splinting
D. Mallet splint
E. Sugar tong splint

28. A 45-year-old male sustained multiple trauma involving closed midshaft femur fracture, hemopneumothorax and intracerebral haemorrhage secondary to basal skull fracture. He was placed in ICU for optimisation as he was haemodynamically and physiologically unstable.
Which one of the following traction devices would be best suited to temporarily splint his femur fracture?
A. Bryant's traction
B. Buck's traction
C. Dunlop traction
D. Hamilton Russell traction
E. Thomas splint

29. A 60-year-old poorly controlled diabetic presents with an Eichenholtz stage III midfoot collapse.
Which of the following orthotics would be most appropriate?
A. Charcot restraint orthotic walker (CROW) boot
B. Double rocker sole modification footwear
C. Heel-to-toe rocker sole modification footwear
D. High arch medial support insoles with hindfoot valgus post
E. Total contact casting

30. **Which of the following is true regarding an individual with a vaulting gait?**

A. It can occur in a unilateral transfemoral amputee in which the prosthesis is too short
B. It occurs during the initial and middle parts of the prosthetic swing phase
C. It occurs during the prosthetic side midstance phase
D. It usually occurs when the prosthesis is too anteriorly aligned
E. The primary compensatory mechanism is engagement of the hip abductors on the non-amputee side

31. **Which of the following is a cause of a medial whip in an above knee amputee with a prosthesis?**
A. Decreased abduction of hip at toe off
B. Increased adduction of hip at toe off
C. Internal rotation of hip at toe off
D. Knee axis of the prosthesis is in excessive external rotation
E. Knee axis of the prosthesis is in excessive internal rotation

32. **Which one of the following conditions would a UCBL (University of California at Berkeley Laboratory) insert be best suited for?**
A. Patient with chronic Achilles tendinopathy
B. Pes cavus with rigid hindfoot varus
C. Stage IIb posterior tibial tendon dysfunction (PTTD)
D. Stage III PTTD
E. Stage IV PTTD

33. **Which one of the following correctly describes the proper positioning of the trim lines in an ankle–foot orthosis in a 6-year-old patient with forefoot abduction secondary to cerebral palsy?**
A. At the ankle, the trim line should fully cover the lateral malleolus to improve donning
B. At the forefoot, the trim line must be at the level of the 5th metatarsal head
C. At the forefoot, the trim line must be distal to the 5th metatarsal head
D. At the forefoot, the trim line must be proximal to the 5th metatarsal head
E. At the top, the trim line must be 2cm proximal to the fibula head

34. **Which of the following statements is true?**
A. A long transradial amputation allows up to 60° pronation and supination and maintains strong elbow flexion
B. A long transradial amputation preserves 40–75% of forearm length
C. A medium transradial amputation is beneficial due to preservation of pronation and supination
D. A medium transradial amputation preserves 55–85% of forearm length
E. A short transradial amputation preserves 20–40% of forearm length

35. A 48-year-old female started to complain of severe paraesthesia in her left ring and little fingers for a duration of 6 months. Clinical examination revealed cubital tunnel syndrome.
Which of the following bracing positions will assist in relief of symptoms?
A. Night splinting with elbow in 20° flexion and forearm in supination
B. Night splinting with elbow in 45° flexion and forearm neutral
C. Night splinting with elbow in 45° flexion and forearm pronated
D. Night splinting with elbow in 45° flexion and forearm supinated
E. Night splinting with elbow in 60° flexion and forearm pronated

36. **Patients with a trans-tibial prosthesis experiencing 'Drop off' should undergo which of the modifications?**
A. Externally rotate the prosthetic foot
B. Increase the length of the pylon
C. Move foot more anterior
D. Move the foot more posterior
E. Move toe break of prosthesis more posterior

37. **Which is the most commonly injured nerve in application of Halo orthosis**
A. Abducens nerve
B. Great auricular nerve
C. Occulomotor nerve
D. Supraorbital nerve
E. Supratrochlear nerve

38. **What type of splint can be used for unresolved Erb's palsy?**
    - A. Aeroplane splint
    - B. Dynamic wrist hand orthosis with Metacarpophalangeal joint assist
    - C. Turnbuckle splint
    - D. Volkmann splint
    - E. Wrist drop splint

39. **What type of prosthetic foot is used for K2 users?**
    - A. Carbon fiber 'J' shaped feet
    - B. Jaipur foot
    - C. Multi-axis foot
    - D. SACH foot
    - E. Single axis foot

40. **Which of the following statements is true?**
    - A. Bare foot walking is not possible with the Jaipur foot
    - B. Cross leg sitting is possible with the Jaipur foot
    - C. Squatting is possible with the SACH foot
    - D. The Jaipur foot prosthesis does not facilitate eversion/inversion at the subtarsal level
    - E. Walking on uneven terrain is easier with the SACH than the Jaipur foot

PROSTHETICS AND ORTHOTICS STRUCTURED SBA ANSWERS

1. Answer A. **Constant friction knee**
   The constant friction knee utilises a hinge with a rubber pad to apply friction to the knee to decrease knee swing. This only allows a single speed of walking. It is durable and cheap. Stance-phase control knee mechanism is particularly beneficial in the elderly population. Polycentric knees are ideal for the active adult, but they are very costly and heavy.

2. Answer D. **The affected knee is maintained in slight flexion with ipsilateral toe walking**
   Minimal knee flexion is the typical sign seen in knee arthritis with ipsilateral toe walking. Both these measures are quadriceps-avoidance mechanisms to reduce the tension on the knee capsule. In ankle arthritis, the ipsilateral step length would be increased to increase the swing phase and reduce the time of weight bearing on the affected ankle. Patients lean their trunk laterally over the affected side in hip arthritis. This decreases the moment arm of body weight and reduces the joint reaction force on the hip joint. The swing phase of gait is increased on the ipsilateral side in hip arthritis.

3. Answer A. **The metabolic demand is 100% above normal in transfemoral (TF) amputations related to peripheral vascular disease**
   The metabolic demand is 100% above normal in TF amputations in patients with peripheral arterial disease. This puts a strain on the heart and also leads to them being easily fatigued. Vascular versus traumatic BKA results in increased energy expenditure of 40% and 25%, respectively. The metabolic demand in TF amputation is approximately 68%.

4. Answer E. **Socket pain medial proximally and lateral distally**
   As seen in the diagram in Figure 29.1, a foot that is placed too far inset will cause the prosthesis to tilt into varus. This will create a lever arm effect, with the proximal medial leg acting as the fulcrum. As a result, the lateral distal part of the prosthesis will also cause compression. Choke syndrome is associated with a prosthesis that is too snug. Increased knee extension occurs when the foot component is placed too anterior.

5. Answer D. **Swing-through gait**
   Swing-through gait describes the fastest gait pattern. Both crutches are placed forward, followed by both feet swinging ahead of the crutches. This

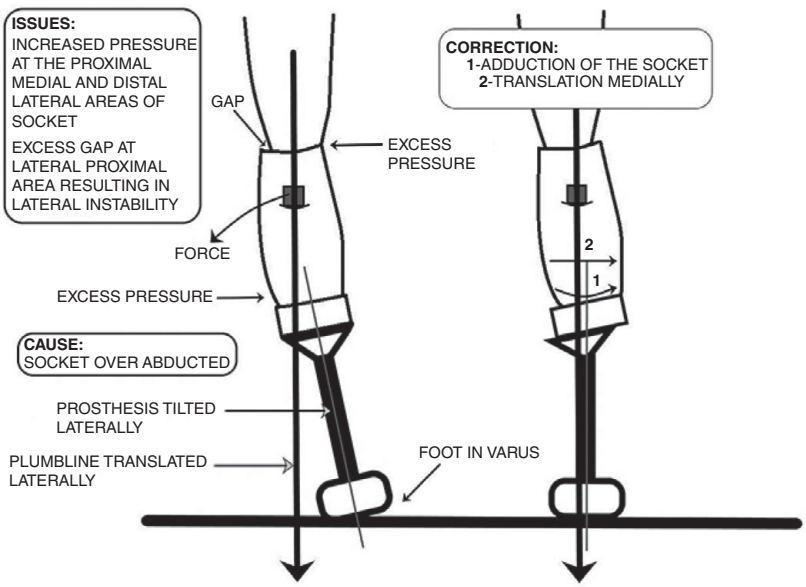


Figure 29.1 Foot placed too far inset

requires a high consumption of energy. It is even faster than normal gait. Four-point gait is a very slow walking speed and three points (left crutch, right foot, right crutch, left foot repeat) are in contact with the ground at all times. Three-point gait involves moving both crutches and the weaker limb while bearing all the weight on the crutches, followed by the stronger limb moving forward. Swing-to gait occurs with bilateral lower limb weakness in which both the crutches move forward, followed by both limbs swinging just behind the crutches.

6. Answer B. **Body-powered prosthesis (terminal device activates with shoulder abduction and flexion)**
Shoulder abduction and flexion are necessary to clear the upper limb away from the body, and this position would best serve to activate the terminal device in heavy labourers. Myoelectric prosthesis requires a lot more maintenance and is not suitable for heavy labour. It is more cosmetically appealing and has two main types: a 2-site, 2-function device in which there are separate electrodes for flexion/extension and a 1-site, 2-function device in which there is one electrode for flexion/extension.

7. Answer B. **The piston mechanism in the hydraulic knee allows variable cadence**
The piston mechanism in the hydraulic knee allows variable cadence when the knee flexes, depending on the walking speed. The hydraulics (liquid) adjust to control the speed at which the pylon flexes and extends. The polycentric knee has a variable centre of rotation. When the COR is posterior to the line of weight bearing, it allows control in the stance phase and when it is anterior, flexion is improved. The polycentric knee is best suited for an active individual.

8. Answer D. **Insole with medial hindfoot post**
A medial hindfoot post can be used to correct hindfoot valgus, which occurs in posterior tibial tendon dysfunction. Knee–ankle–foot orthosis will not properly correct her weight-bearing axis, as the pathology is at the level of the ankle. Medial arch support orthotic is frequently required in posterior tibial tendon dysfunction.

9. Answer C. **Elbow movement is controlled by shoulder extension and depression**
Elbow movement in an upper limb prosthesis is activated when the shoulder extends and depresses while the terminal device is activated by shoulder abduction and flexion.

10. Answer D. **Walker in front => weaker leg follows through => stronger leg**
The person places the walker in front of them, then steps forward with the weaker leg. The stronger leg follows through last.

11. Answer D. **Tight proximal and loose distal socket**
Choke syndrome is caused by obstructed venous outflow due to a socket that is too tight proximally and loose distally. Blood flows distally via the arterial system into the limb, but venous return is impaired by a tight proximal socket. This leads to swelling and fluid retention in the stump, causing an 'orange peel' appearance. Treatment is aimed at increasing the internal diameter of the socket to accommodate venous return.

12. Answer A. **Equinus deformity**
Chopart amputation involves disarticulation of the calcaneocuboid and talonavicular joints.
A common issue that occurs is an equinus deformity due to unopposed action of the Achilles tendon. The tibialis anterior tendon should be reinserted into the talar neck to avoid this deformity.

13. Answer C. **Posterior leaf spring ankle–foot orthosis (AFO)**
Surgery would result in many complications including infection and wound breakdown in this gentleman with significant circulatory problems. Palmaris autograft can be considered in a younger patient with no circulatory issues or peripheral neuropathy. There is normal power in the tibialis anterior so a posterior tibial tendon transfer will not be indicated. SACH is a foot prosthesis for patients with amputations in which a terminal device is indicated. An AFO will keep the foot perpendicular to the long axis of the tibia. In this way, the foot will clear the ground during the swing phase of gait and aid in stability during stance.

14. Answer A. **Recessed first ray with lateral hindfoot post**
A common cause of a cavovarus deformity at this age is Charcot–Marie–Tooth disease. Patients present with a hindfoot varus, plantar-flexed first ray and possible claw toes.

A positive Coleman block test is indicative of a forefoot-driven deformity (plantar-flexed first ray). A semi-rigid insole can help correct the deformity with a recess for the 1st metatarsal head and a lateral post to correct the heel varus.

15. Answer A. **A cane held in the contralateral hand reduces joint reaction forces through the affected hip up to 50% by reducing abductor muscle pull**
The cane held in the contralateral hand exerts a force whose direction of moment is the same as that of the affected hip abductors. This therefore reduces the force required by these abductors by 50% during gait.

16. Answer A. **Articulated dynamic response foot with lengthened keel**
A lengthened keel in a dynamic response foot prosthesis is indicated for very high-demand athletes. An articulated dynamic response foot with a sagittal split keel allows for eversion and inversion. This is ideal when walking on uneven ground. A shortened keel is indicated for individuals who engage in a fair amount of walking. Structurally, foot prostheses can be divided into two types: articulated and non-articulated. SACH and elastic keel configurations are the two simplest types of non-articulated foot prostheses. They are inexpensive and durable. They do not store and return energy.

17. Answer A. **Boyd**
Children with severe fibula deficiency involving the foot may require amputation followed by a prosthesis foot. Syme's amputation involves an ankle disarticulation with preservation of the heel pad, while the Boyd amputation involves a modified ankle disarticulation where the calcaneus along with the heel pad are preserved. The retained calcaneus is fused to the distal tibia. A Chopart amputation involves amputation at the level of the calcaneocuboid and talonavicular joints. A Gritti–Stokes amputation is through the knee.

18. Answer B. **Loose flexion gap**
This usually happens when the knee with a loose flexion gap goes into hyperextension. The cam rotates over the tibial post and dislocates. This should be addressed immediately via closed reduction. Afterwards, the loose flexion gap must be addressed soon, in which the posterior femur needs to be augmented.

19. Answer B. **Excessive knee flexion**
A prosthetic heel that is too rigid results in excessive knee flexion and lateral rotation of the toes, while a very soft heel leads to excessive knee extension.

20. Answer A. **60–70° external rotation (ER) on the affected side, 30° ER on the unaffected side, 10–15° dorsiflexion bilaterally**
After serial casting via the Ponseti method, an Achilles tenotomy is frequently performed. Following this, the affected side is placed in 60–70° ER and the unaffected limb is placed in 30° ER. Dorsiflexion is required to prevent the hindfoot from going into an equinus deformity. ER is necessary to prevent recurrence of the cavovarus deformity.

21. Answer B. **Active finger extension, dynamic splint-assisted passive finger flexion**
Both the Duran and Kleinert protocols are low-force and low-excursion methods in dealing with flexor tendon injuries. Both methods involve active finger flexion and passive finger extension movements. The Kleinert utilises dynamic splinting, while the Duran involves static splinting.

22. Answer D. **Anterior straps flex the hip to 90–100°, posterior straps prevent adduction of the hip**
Positioning of the Pavlik orthotic harness is very important in treating developmental dysplasia of the hips. Excessive flexion can lead to a transient femoral nerve palsy. Excessive hip abduction (usually beyond 60°) can lead to avascular necrosis of the femoral head secondary to impingement of the posterior superior retinacular branch of the medial circumflex femoral artery. The posterior straps prevent hip adduction.

23. Answer C. **Milwaukee brace**
The Milwaukee brace is a type of cervical-thoracic-lumbar-sacral orthosis (CTLSO) invented in

the 1940s. It is very bulky and no longer frequently used. However, in high thoracic curves it may still be indicated. TLSO, Boston-style brace and Wilmington brace are thoracolumbosacral orthosis braces and are indicated for curves where the apex is below T7. The Wilmington brace is a custom-made brace specific to the patient, whereas the Boston style brace is prefabricated. The Charleston brace is a night-time brace, custom designed to fit the patient while they are lying down but not standing up.

24. Answer B. **Fluid-controlled hydraulic knee**
Cadence is also known as stride rate, i.e. the number of steps a runner takes per minute. Fluid-controlled knees are of two types: pneumatic (air) and hydraulic (fluid) controlled. Pistons move through the medium as the knee flexes and extends, leading to various resistances throughout the gait. This allows the user to walk comfortably at various walking speeds. The main disadvantage is its heaviness and cost. The variable-friction knee also provides variable resistance and hence cadence when the knee flexes from an extended position. However, it requires frequent adjustment and replacement of parts, making it less advantageous than the fluid-controlled hydraulic knee. The stance phase control knee is commonly used in prosthetics, especially those with above knee amputations. The knee needs to be unloaded to initiate swing or for one to sit. The constant friction knee only allows a single speed of walking. The manual locking knee is the most stable knee used in prosthetics. The knee is locked during gait and then unlocked when the patient wants to sit down.

25. Answer A. **It can be used to treat type II odontoid fractures in younger patients**
Halo traction is useful in the paediatric population to treat upper cervical spine injuries including type II odontoid fractures, atlanto-occipital dislocations, C1–C2 dislocations and atlas fractures. Halo orthosis connects the skull to the upper torso via an external frame. It is used for upper cervical spine injuries. It has good control over rotational movements. It is inadequate for lower cervical segment injury, and a 'snaking phenomenon' can occur in which there is focal kyphosis in the mid cervical spine. Adults require a total of 4 pins in the skull as compared with the paediatric population (6–8 pins). Abducens nerve palsy is the most common nerve palsy and is due to excessive traction. Dural puncture is uncommon and accounts for less than 1% of complications associated with skull pin placement.

26. Answer A. **Dorsal splint to flex the metacarpophalangeal joint (MCP) joint of the ring and middle fingers to 35–45°**
A low-level ulna claw hand results in hyperextension of the MCP joints of the ring and middle fingers due to intrinsic weakness and unopposed action of the extensors. This results in loss of function of the hand. The function of the splint is to: (1) passive flex the MCP joint; (2) prevent shortening of the MCP collateral ligament; and (3) allow active IP flexion. The dynamic splint prevents extension at the MCP joint.

27. Answer B. **Capener splint**
This injury would result in a boutonnière deformity. This is best treated with a Capener splint, which splints the PIP joint in full extension. Active DIP flexion and extension exercises are encouraged to prevent contracture of the oblique retinacular ligament. The mallet splint is used for extension tendon injuries at the distal phalanx. These injuries result in the DIP joint being flexed. The splint keeps the DIP joint in extension to encourage healing of the tendon back to its insertion. Buddy strapping is usually used for undisplaced phalangeal injuries. Extension block splinting is used for stable PIP joint dislocations after reduction is achieved. The extension block splint is applied with the PIP joint at 45° flexion. Sugar tong splinting is used in the acute management of distal radial and ulna fractures.

28. Answer D. **Hamilton Russell traction**
The Hamilton Russell traction combines suspension of the distal fragment as well as traction to the femur. The sling prevents posterior angulation of the distal fragment. Skin traction is applied to the leg or a Buck's traction splint may be utilised. This form of traction is used for femur shaft traction when the duration of splinting

anticipated is greater than 24 hours, as in this case. Buck's traction is sometimes used preoperatively for femur shaft fracture using tape or a premade boot. It is not used to maintain or hold reduction. It is used to prevent contractures of the hip or knee and no more than 10lb can be attached. Bryant's traction combines Buck's traction and Gallows traction, although used rarely in femur shaft fractures in infant or small children. Thomas splint is used when transporting patients with injuries to the thigh and hip. The Thomas half-ring splints consist of a padded half-circle of steel that is strapped to the hip. A U-shaped rod is attached to the ring and extends along both sides of the leg. An ankle strap may be fashioned from cloth and tied or twisted to apply traction force.

29. Answer B. **Double rocker sole modification footwear**
The management of a Charcot foot is dependent on the stage and location of the disease. Eichenholtz stages I and II are initially managed via total contact casting and a CROW walker, respectively. Stage III disease requires accommodative footwear. Midfoot collapse is managed with a double rocker sole modification footwear. This decreases pressure in the plantar midfoot. A heel-to-toe rocker sole is utilised when the hindfoot is rigid/fused and one requires increased propulsion at toe off.

30. Answer B**. It occurs during the initial and middle of the prosthetic swing phase**
Vaulting occurs for several reasons: (1) prosthesis is too long, (2) prosthesis is too posteriorly aligned, (3) patient is fearful of not being able to clear the ground during gait. Vaulting involves increased plantar flexion of the contralateral ankle in order to elevate the hip on the prosthetic side. This aids in clearance during the initial and middle parts of the prosthetic swing phase. It inevitably places excessive stress on the metatarsal heads and ankle joint of the contralateral limb.

31. Answer D. **Knee axis of the prosthesis is in excessive external rotation**
A medial whip is defined as movement of the heel medially during toe off. Causes can be broadly classified into prosthetic cause and amputee cause. Prosthetic causes include excessive external rotation of the knee, shank or foot. Amputee causes include a habitual gait in which the hip externally rotates at toe off or a socket that is donned in external rotation.

32. Answer C. **Stage IIb posterior tibial tendon dysfunction (PTTD)**
The UCBL brace is a rigid brace designed to correct flexible hindfoot deformities such as valgus secondary to PTTD. It limits subtalar motion and controls calcaneal eversion in the frontal plane and forefoot abduction in the transverse plane. It will therefore only work if the deformity is flexible. Stages III and IV PTTD result in a rigid subtalar joint and hindfoot valgus. This orthotic will therefore not work. Stage IIb PTTD deformity is flexible and the subtalar joint is correctable. This brace will therefore be ideal in correcting the deformity.

33. Answer C. **At the forefoot, the trim line must be distal to the 5th metatarsal head**
The forefoot trim line must be distal to the metatarsal head to avoid metatarsus adductus. In forefoot adduction, the trim line must be proximal to the 5th metatarsal head. The trim line must also be 2cm under the fibula head to prevent compression/irritation of the common peroneal nerve. In forefoot abduction, there must be decreased coverage at the level of the lateral malleoli to ease donning.

The trim line is the border of the trimmed section of the orthotic that is important in determining stiffness of an ankle–foot orthotic.

34. Answer A. **A long transradial amputation allows up to 60° pronation and supination and maintains strong elbow flexion**
There are three main levels of transradial amputation:
(1) Short: 0–35% length preservation.
(2) Medium: 35–55% length preservation/pronation and supination are lost.
(3) Long: 55–90% length preservation/pronation and supination up to 60° and maintenance of strong elbow flexion.

35. Answer B. **Night splinting with elbow in 45° flexion and forearm neutral**
Night bracing may be effective in early cases of cubital tunnel syndrome in which there are no signs of muscle wasting and a functioning flexor

carpi ulnaris. It is effective in approximately half of all patients. The ulna nerve is under least tension when the elbow is flexed between 40° and 50° in a neutral position. Surgery will be necessary if symptoms persist. The ulna nerve can be compressed in the elbow at the arcade of Struthers, between Osborne's ligament and MCl, two heads of the FCU and medial intermuscular septum.

36. Answer A. **Externally rotate the prosthetic foot**
The term 'drop off' essentially means excessive knee flexion when transitioning from mid stance to terminal stance and is often a complication with transtibial prosthesis. Any modification which places the terminal device (prosthetic foot) too posterior will lead to 'drop off'.

37. Answer A. **Abducens nerve**
The Abducens nerve (CN VI) innervates the lateral rectus. Damage to this nerve leads to loss of lateral gaze on the affected side.

38. Answer A. **Aeroplane splint**
Erb's palsy involves the upper brachial plexus trunk (C5-C6). There is paralysis or limpness of the shoulder, arm and elbow. The aeroplane splint is a static orthosis that allows for improved positioning of the shoulder in varying degrees of abduction. It also helps prevent subluxation of the glenohumeral joint. The Turnbuckle splint is a type of splint used in cases of upper limb contractures to produce gradual stretching over a contracted joint by its turn buckle mechanism, e.g Volkmann's ischaemic contracture.

39. Answer C. **Multi-axis foot**
K-levels are a rating system used to indicate a person's rehabilitation potential with a prosthetic device. This system has a rating from 0–4. K0 indicates the lack of ability to walk or transfer even with assistance and a prosthesis unfortunately does not add any functional benefit while K4 users require prosthesis to support high activity levels such as in a child, active adult or athlete. The K2 user has ability to traverse low-level environmental barriers such as curbs, stairs or uneven surfaces. This is typical of the limited community ambulator. In addition to offering dorsiflexion and plantar flexion, multiaxial ankles also provide inversion-eversion, some degree of transverse rotation, and are hence well adapted to K2 and K3 function. SACH foot is indicated for less active users such as K1 users. 'J' shaped blades are more commonly used by sprinters; this shape allows for a quick return of energy helping you to achieve higher speeds.

40. Answer B. **Cross leg sitting is possible with the Jaipur foot**
The Jaipur foot has movement in several axes including dorsiflexion/plantarflexion making squatting possible, eversion/inversion at the subtarsal joint making walking on uneven terrain possible, and forefoot adduction making cross leg sitting possible. This is the exact opposite for the SACH foot. The Jaipur foot can also be used without shoes thus making bare foot walking possible.

Chapter 30

Biomechanics Structured SBA

Edward Jeans and Richard Hutchinson

BIOMECHANICS STRUCTURED SBA QUESTIONS

1. When stabilising a mid diaphyseal femoral fracture using an intramedullary nail, locking bolts are passed proximal and distal to the fracture.
   The main function of these locking bolts is which of the following?
   A. Allow for easier nail extraction
   B. Increase the bending stiffness of the construct
   C. Increase the torsional stiffness of the construct
   D. Increase the working length of the construct
   E. Reduce the risk of proximal/distal nail migration

2. A surgeon implants a cemented stainless steel femoral stem during a total hip arthroplasty. In error, the surgeon then applies a cobalt-chrome head to the trunnion before reducing and closing the hip.
   What mechanism of corrosion could have been avoided if a stainless steel head had been used?
   A. Crevice corrosion
   B. Fretting corrosion
   C. Galvanic corrosion
   D. Pitting corrosion
   E. Stress corrosion

3. A cobalt-chrome head and a ceramic femoral head are being tested in a lab. During one test, a sharp object is run along each material's surface. The size and depth of the resultant scratch is assessed.
   What material property is being tested for in this scenario?
   A. Elasticity
   B. Hardness
   C. Stiffness
   D. Strength
   E. Toughness

4. During the manufacturing process of cross-linked UHMWPE, vitamin E is added to the polymer.
   What is the primary role of vitamin E in cross-linked UHMWPE?
   A. Acts as a bactericidal agent
   B. Increases cross-linking
   C. Increases risk of delamination
   D. Reduces surface roughness
   E. Works as an antioxidant agent

5. An implant company are designing a new uncemented femoral stem. They decided to use a titanium alloy, as its Young's modulus is significantly lower than a stainless steel option.
   A lower Young's modulus is advantageous in this case because of which of the following?
   A. Allows for better osseointegration
   B. Allows for greater stress relaxation
   C. Increases implant stiffness
   D. Reduces stress shielding
   E. Reduces the risk of implant corrosion

6. **Which of the following statements best describes the 'yield point' of a material?**
   A. The point at which elastic deformation starts to occur
   B. The point at which necking starts to occur
   C. The point at which plastic deformation starts
   D. The point at which work-hardening starts to occur
   E. The point of failure

7. A surgeon doing a total hip replacement decides to use a larger diameter femoral head to reduce the risk of future dislocation.

How does increasing head diameter most improve hip stability?
A. Increases jump distance
B. Moves the centre of rotation medially
C. Reduces the head–neck ratio
D. Reduces the range of the primary arc
E. Tightens surrounding soft tissue restraints

8. A surgeon inserting a femoral broach into a tight femoral canal decides to pause between each strike of the hammer for 10 seconds in order to reduce the risk of femoral fracture.
Which of the following viscoelastic features best explains the surgeon's logic?
A. Creep
B. Hysteresis
C. Strain-rate dependence
D. Strain relaxation
E. Stress relaxation

9. A surgeon wishes to maximise the stability of a total hip replacement by increasing the primary arc range of motion, and thus reducing the risk of impingement.
Which of the following does not increase the primary arc?
A. Increasing femoral head size
B. Increasing head–neck ratio
C. Reducing femoral neck diameter
D. Removing acetabular osteophytes
E. Using a liner with a 10° posterior lip

10. **What is the most important mechanism of wear leading to osteolysis in a metal-on-polyethylene total hip joint bearing surface?**
A. Abrasive wear
B. Adhesive wear
C. Corrosive wear
D. Erosive wear
E. Third body wear

11. A metal is being tested for its material properties in a laboratory by undergoing cyclical loading, with increasing loads on each cycle. It is noted once loads are applied that exceed the material's yield point, the stress required to cause further plastic deformity goes up with each loading cycle.
Which of the following best describes the cause for this phenomenon?
A. Hooke's law
B. Increasing grain size
C. Necking
D. Stress-shielding
E. Work-hardening

12. In Ponseti casting, a moulded plaster applies a constant stress to the soft tissues of the foot and ankle. Over a period of time, this constant stress results in a gradual correction of the deformity.
Which viscoelastic material property is being demonstrated in this treatment?
A. Creep
B. Hysteresis
C. Strain-rate dependence
D. Strain-relaxation
E. Stress-relaxation

13. **Which of the following best describes the primary role of the patella?**
A. Increases both flexion and extension moment arms
B. Increases the extension moment arm
C. Increases the flexion moment arm
D. Reduces the extension moment arm
E. Reduces the flexion moment arm

14. **The primary role of the femoral and tibial stems in a hinged knee replacement is to do which of the following?**
A. Increase implant stiffness
B. Increase the surface area of the implant–bone interface
C. Maintain joint stability
D. Prevent periprosthetic fracture
E. Reduce wear at the bearing surface

15. An uncemented total hip replacement is being revised for aseptic loosening. On extraction it is noted there is significant backside wear of the polyethylene.
Which of McKellop's modes of wear is best described in this case?
A. Mode 1
B. Mode 2
C. Mode 3
D. Mode 4
E. Mode 5

16. Cross-linking in polymers is known to increase material strength and stiffness.
Which type of bond is formed between long monomer chains during cross-linking?
A. Covalent
B. Hydrogen
C. Ionic
D. Peptide
E. Van der Waals

17. A block of PMMA cement is being tested for its response to different loads.
With regard to the mechanical properties of PMMA cement, which of the following statements is correct?
A. It does not undergo creep
B. It is strongest against compression
C. It is strongest against shear
D. It is strongest against tension
E. It is strongest against torsion

18. An implant engineer is trying to design a hard-on-hard bearing surface for a THR that achieves hydrodynamic fluid-film lubrication.
Which of the following will most help increase the probability of them achieving this?
A. Increasing acetabular cup outer diameter
B. Increasing femoral head diameter
C. Reducing liner diameter
D. Using a congruent bearing design
E. Using highly cross-linked polyethylene

19. A patient with cuff arthropathy is offered a reverse-polarity shoulder replacement.
Which of the following statements is NOT true in reverse shoulder replacements (RSA)?
A. RSA allows some of the fibres from the anterior and posterior deltoid to act as shoulder abductors
B. RSA increases deltoid tension through lowering the centre of rotation
C. RSA increases the deltoid lever arm
D. RSA lateralises the centre of rotation, improving cuff function
E. RSA reduces torque at the implant–bone interface, compared with anatomical designs

20. Figure 30.1 shows the stress–strain curves for three different materials.

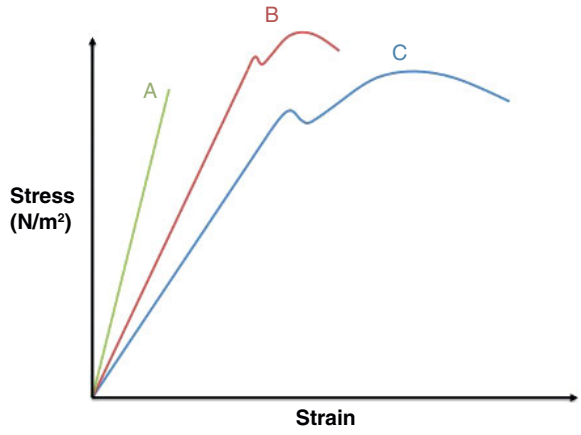


Figure 30.1 Stress–strain curve

Regarding this chart, which of the following statements is true?
A. Material B has the highest Young's modulus
B. Material B is the most ductile
C. Material C is the stiffest material
D. Material C is the toughest material
E. Material A has the greatest yield strength

21. Figure 30.2 shows a schematic diagram of fracture fixed with a plate.
Which letter corresponds to the working length of the plate?
A. A
B. B
C. C
D. D
E. E

22. **Which of the following increases the working length of a screw fixed into a bone?**
A. Ensuring the screw is bicortical
B. Increasing the number of screw threads
C. Increasing the screw core diameter
D. Increasing the screw thread diameter
E. Reducing the distance between two adjacent screws

23. A 9-year-old boy sustains a transverse femoral fracture, which is being managed with elastic nails.
All of the following are important principles in maintaining a balanced construct in elastic stable intramedullary nailing (ESIN) EXCEPT which?
A. Avoiding ESIN in highly comminuted fracture patterns

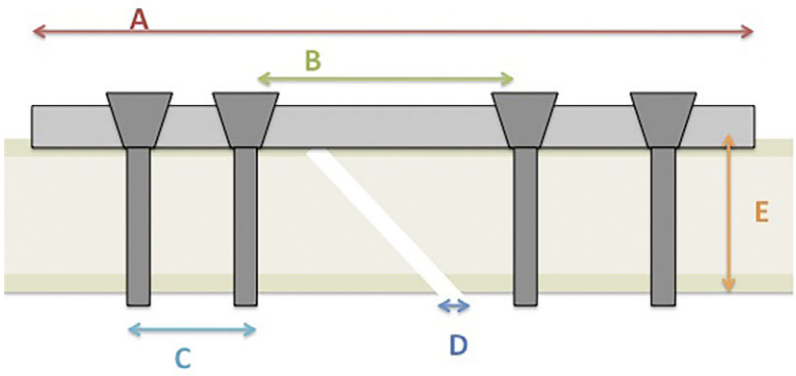


Figure 30.2 Plate fixation fracture

B. Bending both nails at the same level
C. Cutting both nail ends flush with the bone
D. Using two nails of the same diameter
E. Using two nails of the same material

24. A surgeon fixes a Weber B lateral malleolar fracture using a lag screw and a one-third tubular plate in neutralisation mode.
What is the primary role of a neutralisation plate?
A. Protects against bending forces
B. Protects against compressive forces
C. Protects against shear forces
D. Protects against tension forces
E. Protects against torsional forces

25. Figure 30.3 demonstrates an S–N curve for a metal.

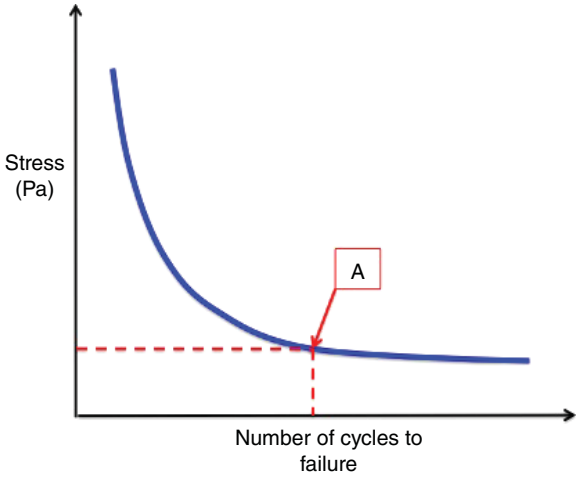


Figure 30.3 S–N curve

What does point A represent?
1. Endurance limit
2. Fatigue life
3. Fatigue strength
4. Ultimate tensile strength
5. Yield strength

26. **Which of the following will not affect the bony integration of uncemented femoral stems?**
A. Early mobilisation
B. HA coating
C. Pore size
D. Previous radiotherapy to region
E. Surface roughness

27. You are required to fill a bone defect in a weight-bearing region. The defect is 2cm and has a healthy soft tissue cover.
Which of the following is the most appropriate?
A. Cancellous allograft
B. Cancellous autologous
C. Bone morphogenetic protein (BMP)
D. Hydroxyapatite scaffold
E. Tricortical autograft

28. You are performing a long femoral nail in a 70-year-old for a subtrochanteric fracture. The distal tip of the nail is short, sitting proximal to the metaphysis.
Why might this cause an issue?
A. Distal locking is more technically difficult due to overlying muscle
B. Finishing the nail in the diaphysis creates a stress riser

C. The nail is likely to be anterior and penetrate the cortex
D. The rotational stability of the fracture will be less with screws placed in the diaphysis versus the metaphysis
E. The shorter working length will make the nail an absolute stability device and unsuitable for this type of fracture

29. When performing arthroplasty or nailing in hip fracture patients we will often note that the canal is capacious.
Why as patients get older does the femur expand?
A. Change in the ratio of active osteoclasts to osteoblasts
B. Increased surface area improves fracture toughness
C. Slower bone turn over
D. The increase in radius deceases the bending moment on the femur
E. With an increase in radius, the same torsional rigidity can be achieved with less cortical bone

30. A patient has had an MRI safe external fixator applied following a knee dislocation. Post-operatively the patient is sent for an MRI. The MRI rings up to say the half pins are stainless steel and therefore the patient can't have the MRI.
Are they correct?
A. No, as the pins are anchored in the bone, it is safe to proceed
B. No, ask to use a 1.5 Tesla MRI rather than the standard 3T and it will be safe to proceed
C. No, the pins are non-magnetic steel and MRI safe
D. Yes, delay the MRI until the external fixator is removed
E. Yes, the half pins will have to be changed and commence litigation

31. 316L steel is used in many orthopaedic applications.
It contains chromium to give it which property?
A. Improve fatigue life
B. Increase ductility
C. Increase resistance to corrosion
D. Increase surface hardness
E. Reduce scratch sensitivity

32. Metals can be hardened in several ways.
Which of the following is not one of them?
A. Alloying
B. Annealing
C. Cold working
D. Grain size reduction
E. Solid solution

33. **What type of lubrication best describes the following: 'Two surfaces separated by a fluid film that do not deform on loading'?**
A. Boosted
B. Boundary
C. Elastic hydrodynamic
D. Hydrodynamic
E. Weeping

34. Which of these is NOT true of the friction between two surfaces?
A. Friction is increased with sliding speed
B. Friction is proportional to load
C. Friction is the resistance to movement between two surfaces
D. Increasing the contact area has no effect on friction
E. It is in the opposite direction of motion between the two surfaces

35. A patient is undergoing a knee arthroscopy. You encounter a cartilage defect of $<1cm^2$ and decide to perform microfracture.
Which of the following best describes the process that occurs?
A. Chondrocytes are released and form hyaline cartilage
B. Haematopoietic stem cells are released and form fibrocartilage
C. Mesenchymal stem cells are released and form fibrocartilage
D. Platelets are released and form a plaque that remodels into hyaline cartilage over time
E. Type II collagen is released and forms a scaffold for chondrocytes to form fibrocartilage

36. Articular cartilage has a specialized structure and composition in order to give a durable surface

with minimal gliding resistance. Articular cartilage contains hoops of type II collagen running from the deep to superficial layer, proteoglycans give a negative charge to the extracellular matrix.
How does this improve the material properties of articular cartilage?
A. Improves resistance to tensile loads
B. Negatively charged molecules repel each other and allow shearing without damage
C. Retention of water and swelling pressure, allowing cartilage to resist compression
D. The hoops allow cartilage to plastically deform under loads
E. The increased hydrostatic pressure improves resistance to shear forces

37. Figure 30.4 is a picture of a proteoglycan polymer.

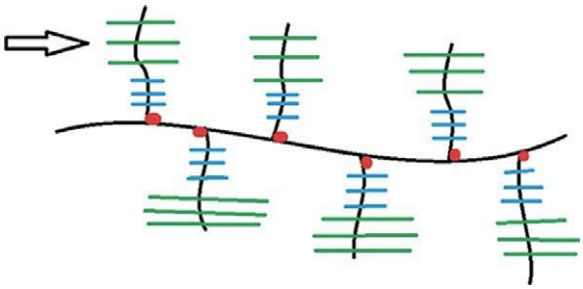


Figure 30.4 Proteoglycan polymer

Name the molecule arrowed.
A. Chondroitin sulphate
B. Core protein
C. Hyaluronic acid
D. Keratan sulphate
E. Link protein

38. Which of the following is true of the calcified zone?
A. Cartilage is connected to subchondral bone via Sharpey's fibres
B. It gets thinner with ageing
C. It has Haversian canals that allow nutrition of the deeper cartilage layers
D. Hydroxyapatite crystals anchor cartilage to subchondral bone
E. Type VI collagen is present

39. When loading and unloading a tendon during tensile testing, the curve in the elastic region is not linear.
What property is this and why does it occur?
A. Creep; as tendon is viscoelastic, it loads and unloads at different rates
B. Creep; even in the elastic region of a biological tissue, there is movement in molecules
C. Hysteresis; as tendons are loaded, they lose water content and become stiffer, causing a change in properties on unloading
D. Hysteresis; as tendon is viscoelastic, it loads and unloads at different rates
E. Hysteresis; it is the energy lost to internal friction

40. Polyethylene is manufactured in an inert atmosphere or vacuum.
This prevents which detrimental process?
A. Cross-linking of macromolecules
B. Delamination
C. Introduction of air pockets into the material
D. Oxidation
E. Polymerisation

41. A 30-year-old cyclist falls and is diagnosed with an acute scapholunate ligament injury. They opt not to undergo operative repair.
Which of the following can be expected to provide dynamic support for the scaphoid?
A. BR
B. ECRB
C. EPL
D. Radioscaphocapitate ligament
E. STT joint

42. A patient undergoes a zone I FDP repair of the ring finger. At follow up they are noted to have developed reduced flexion of the middle finger. The rest of the hand is normal.
What is the cause of this?
A. Complex regional pain syndrome
B. Failure of repair
C. Inadequate post-operative physiotherapy
D. Post-operative splinting of the hand with the DIP and PIPJ in flexion
E. Quadriga effect

43. **The failure of which structure is thought to lead to degenerative changes in the 1st CMC joint?**
A. Deep anterior oblique or beak ligament
B. Radioscaphocapitate ligament

C. STT joint
D. Ulnar collateral ligament
E. Volar 1–2 intermetacarpal ligament

44. A 14-year-old male with a diagnosis of Duchenne muscular dystrophy (DMD) presents with a tibial and fibular fracture following a fall. This is an isolated injury, the boy is normally ambulatory, has had no recent chest infections and is on long-term steroids.
What is the most appropriate management for him?
A. Elastic nailing followed by protected weight bearing
B. IMN and full weight bearing
C. MUA and cast with NWB for 6 weeks
D. Sarmiento cast brace and protected weight bearing
E. Treatment on skeletal traction

45. A patient falls from a bike and sustains an elbow dislocation with no fracture. You are making a referral to physiotherapy for rehabilitation.
Which of the following would be the most appropriate regime?
A. Active assist with valgus stress on the forearm
B. Active movements in a hinged brace locked at 0–90°
C. Active movements with the arm in an overhead position
D. Active movements with the arm in extension
E. Passive movements between 90° and 120°

46. A 24-year-old patient presents with a fracture subluxation of the ankle as shown in Figure 30.5. The soft tissue envelope is suitable for internal fixation.
Which of the following will produce the most biomechanically advantageous fixation?
A. Close contact cast
B. Fibular nail with syndesmosis screw
C. Fixation of the fibular and syndesmosis only
D. Fixation of the posterior malleolus fracture with plate and screw and fibular fixation
E. Fixation with AP lag screw and fibular fixation

47. **Which of the following statements is true of the differences between a ligament and a tendon?**

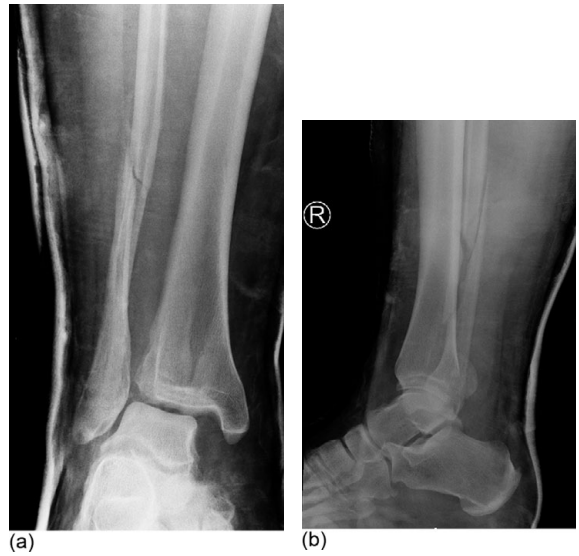


Figure 30.5 (a) Anteroposterior (AP) and (b) lateral radiographs right ankle

A. Ligaments have more highly aligned collagen fibres than tendons
B. Tendons are more cellular than ligaments
C. Tendons are more metabolically active than ligaments
D. Tendons contain more elastin than ligaments
E. Tendons display less hysteresis than ligaments

48. A patient sustains an injury to the L1 vertebra (as shown in Figure 30.6) during a high speed car accident.
Which of the following best describes the instability pattern of this injury?
A. Anterior column support is lost but the posterior tension band remains intact, the fracture is stable
B. Both the anterior column and posterior tension band are disrupted. Due to surrounding musculature this will remain stable
C. Both the anterior column and posterior tension band are disrupted. This is likely to be an unstable fracture
D. Stability will depend on the plane of the disruption with a ligamentous and disc injury being more stable than a bony one
E. The posterior tension band only is disrupted and is a stable fracture

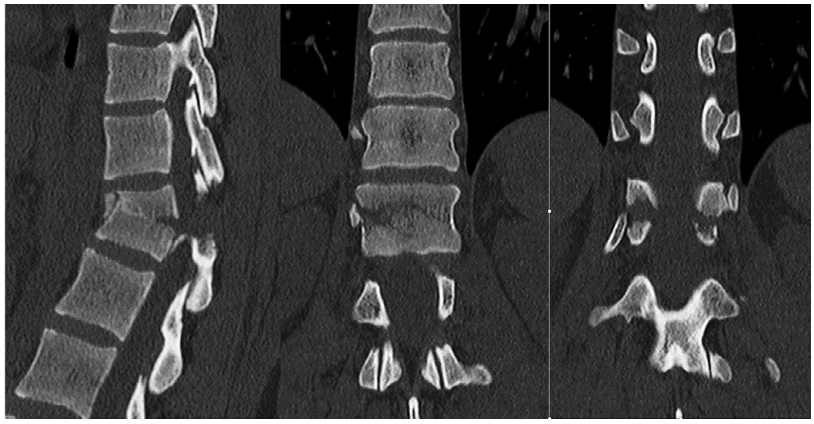


Figure 30.6 CT scan images

49. **During the push off stage of gait with the mid foot joints locked what type of lever is the 1st MTP joint?**
    - A. The same type of lever as the hip joint
    - B. The same type of lever as the shoulder
    - C. The two forces acting on the lever are in the same direction but on opposite sides of the fulcrum
    - D. The two forces are on the same side of the fulcrum but in opposite directions. Body weight acting closer to the fulcrum
    - E. The two forces are on the same side of the fulcrum but in opposite directions with the body weight acting further away from the fulcrum

50. A failed metal on metal total hip arthroplasty was revised due to a large pseudocyst.
    What is the cause of a pseudocyst formation?
    - A. Activation of macrophages or lymphocytes
    - B. Direct osteoclast activation by metal ions
    - C. Infection in the presence of local immunosuppression from metal ions
    - D. Malignant change
    - E. Mitochondrial dysfunction leading to apoptosis

51. **Which of the following is not part of the process of nerve regeneration after complete nerve transection?**
    - A. Aligned Schwann cells and their extracellular matrix provide pathways for guided axonal regrowth
    - B. Bands of Büngner formation
    - C. Fibroblast growth factor (FGF) determines the proximal distal axis
    - D. In animal models about 30–40% of sensory grey matter cells die off after injury – thought to be the result of the interruption of retrograde transport of nerve growth factor
    - E. Proximally growth cones sprout from axons

52. A patient falls from 40 feet. Initial X-ray shows there is vertical translation of the right hemi pelvis with displacement of the SI joint, and vertically aligned fracture of the superior–inferior pubic rami on the ipsilateral side. The left hemi pelvis is normal.
    What of the following best describes the biomechanics of this injury?
    - A. Posterior fixation only with SI screws is recommended
    - B. The fracture is rotationally unstable
    - C. The fracture is vertically and rotationally unstable
    - D. The fracture is vertically unstable
    - E. The sacrospinous and sacrotuberous ligaments are likely to be intact conferring some stability

53. **Which of the following statements best describes passivation of implants?**
    - A. A layer of oxide formed on a metal surface that prevents further reaction between the metal and environment.
    - B. Is an effective way to deal with fretting corrosion
    - C. The addition of a reactive substance to the surface of the implant that will preferentially corrode rather than the implant

D. The application of a surface finish to improve fracture mechanics
E. The heating and cooling of an implant to reduce the internal strain

54. You are revising an old cemented polyethylene acetabular cup for eccentric wear and osteolysis. Once the femoral component is dislocated you notice the steel head is worn and has been articulating with the cement.
What mode of wear is this?
A. Abrasive
B. Adhesive
C. Type 2
D. Type 3
E. Type 4

55. You see a patient for 1-year follow up of a cemented taper slip style hip arthroplasty. The X ray taken on arrival shows subsidence of the stem and lucency around the implant shoulder in Zone 1.
What property of cement causes this?
A. Creep
B. Hoop stress
C. Hysteresis
D. Low endurance limit
E. Stress relaxation

56. An 18-year-old comes to your clinic having had a 5th shoulder dislocation; all have occurred during normal everyday activity.
Which of the following would not be likely to contribute to ongoing issues with stability?
A. Coordination of muscle contraction
B. Dysfunctional proprioception
C. Glenoid bone loss
D. Labral deficiency
E. Weakness of the shoulder girdle muscles

57. A 60-year-old presents to your clinic with pain in the medial aspect of the ankle and loss of medial arch. When asked the patient is unable to single leg heel raise.
Why is this?
A. Achilles tendon rupture
B. Dysfunction of the peroneus longus muscle and inability to unlock the mid tarsal joint
C. Dysfunction of the posterior tibialis muscle and inability to lock the mid tarsal joint.
D. Mid foot OA causing pain when loaded
E. Subluxation of the FHL sesamoids

58. You are performing a total hip replacement through the posterior approach.
Which of the following repair of the short external rotators will give the lowest risk of dislocation?
A. No repair
B. Osteotomy and wiring of the greater trochanter
C. Tendon to bone with sutures through drill holes
D. Tendon to muscle
E. Tendon to tendon

59. A patient presents to your clinic with an abnormal gait. They have an asymmetrical gait pattern, most noticeably with absent first rocker and loading response in stance, with increased hip flexion in mid-swing on the right leg. There is also an early heel rise on the left leg.
Which of the following pathologies is most likely to cause this gait abnormality?
A. A right sided degenerative disc prolapse at L4/5
B. Cervical myelopathy
C. High lumbar myelomeningocele
D. Right knee osteoarthritis
E. Spastic diplegic cerebral palsy

60. A child with spastic diplegia, secondary to cerebral palsy (CP), is being assessed in the gait lab. His 3D gait analysis data suggests he is in a crouch gait pattern.
Which of the following statements about crouch gait is correct?
A. It is predominantly an issue of hamstring contracture
B. It often improves as the child gets older
C. Reducing calf spasticity improves function
D. There is a prolonged period where the ground reaction force lies anterior to the knee
E. There is excessive tibial progression during mid stance

BIOMECHANICS STRUCTURED SBA ANSWERS

1. Answer C. **Increase the torsional stiffness of the construct**
   Locking bolts significantly increase the torsional stiffness of intramedullary nails. In unlocked nails, the main resistance to torsion comes from the frictional effect at the implant–bone interface. Though locking bolts may have some effect on bending stiffness and preventing nail migration, this is not their primary function. Locking bolts do not allow easier extraction.

2. Answer C. **Galvanic corrosion**
   Corrosion involves the loss of material due to electro-chemical reactions. In all types of corrosion, one portion or type of material is lost (from the 'anode') in favour of a separate portion or material type (called the 'cathode'). Galvanic corrosion occurs when two different metals (with different electro-chemical potentials) are in direct contact with each other, sharing an electrolyte fluid. Here electrons pass from the metal with the most negative electro-chemical potential (anode), into the more positive metal (cathode), resulting in loss of material from the anode. Pitting corrosion occurs when a metal covered in a protective 'corrosion-resistant' layer (also known as a passivation layer) has a small portion of that protective coating removed. The exposed area then acts as an anode, with the protected area acting as the cathode. Crevice corrosion occurs due to differing oxygen potentials between the outer portion and inner portion of any crevice found in a material (e.g. the crevice formed between a screw head and the plate). The low oxygen environment at the deepest point of the crevice acts as the anode, with the relatively better-oxygenated area at the entrance to the crevice acting as the cathode. Crevice corrosion can occur between the trunnion and femoral head; however, this could occur regardless of whether a stainless steel head or cobalt-chrome head was used.

3. Answer B. **Hardness**
   The hardness of a material describes its resistance to point loading This is an important property on articulating surfaces, as scratches can have a significant effect on surface roughness and wear characteristics (see Figure 30.7). Ceramic heads are significantly harder than cobalt-chrome.

   Elasticity = the ability of a material to regain its original shape following deformation.

   Stiffness = the ability for a material to resist elastic deformation.

   Strength = the ability for a material to resist plastic deformation.

   Toughness = the amount of energy absorbed by a material prior to fracture.

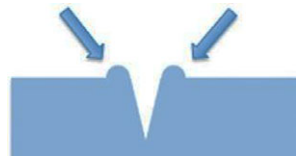


Figure 30.7 This schematic diagram of a scratch on a steel bearing surface shows how material from within the defect is left heaped up at its base. These act as large surface asperities and significantly increase friction at the surface, resulting in more wear. This 'shouldering' does not occur in ceramic material.

4. Answer E. **Works as an antioxidant agent**
   Vitamin E primarily acts as an antioxidant agent in the manufacturing of UHMWPE. In cross-linking, covalent bonds are formed between the long polyethylene chains. This has a significant effect on the material's strength and in turn its resistance to wear. Cross-links are produced by exposing the polymer to gamma-radiation; however, this exposure also leads to the production of free radicals, which leads to oxidation. This causes polymer chain fragmentation, which makes the material more susceptible to wear. Vitamin E as a free radical scavenger reduces these oxidation reactions and chain scission. Vitamin E does not increase cross-linking; this is caused by gamma-radiation. Though some studies do suggest vitamin E has an immunoregulatory effect, this is not its primary role in UHMWPE manufacturing.

   Duan W, Wu M, Han J, Ni Z. Research into the thermal stability and mechanical properties of vitamin E diffusion modified irradiation cross-linked graphene oxide/ultra-high molecular weight polyethylene composites. *RSC Advances* 2020;**10:**4175–4188.

5. Answer D. **Reduces stress shielding**
   Young's modulus (E) is a material property measured in N/m^2. The greater the E, the stiffer the

material (i.e. the greater the material's ability to resist elastic deformation). Figure 30.8 displays estimates of E for bone, titanium and stainless steel. A greater mismatch in E between bone and the femoral stem leads to a greater chance of stress shielding. This is because the stiffer prosthesis bears the majority of the load going through the femur, reducing the loads at the cortex and leading to bone resorption in accordance with Wolff's law. If a material has an E closer to that of cortical bone, there is more load shared between the implant and cortex, reducing the stress shielding effect. Though titanium does allow for better osseointegration, which is favourable in uncemented stems, the osseointegration is not a direct product of titanium's E. Titanium's anti-corrosion properties are also not a product of E. Titanium alloys tend to have a greater ultimate tensile strength than stainless steel alloys, meaning they require more applied stress to produce implant failure, but this quality is a function of titanium's strength (i.e. ability to resist plastic deformation) rather than stiffness (ability to resist elastic deformation). Stress relaxation is a feature of viscoelastic materials (e.g. bone) not metals.

	Young's modulus (GPa)
SS (316L)	200
Ti	110
Cortical bone	20

Figure 30.8 Estimates of the Young's modulus for stainless steel (SS), titanium (Ti) and cortical bone

6. Answer C. **The point at which plastic deformation starts to occur**
The yield point marks the amount of stress required to start causing plastic deformation within a material. It is at this point on the stress–strain curve (see Figure 30.9) that intermolecular bonds within the material's lattice structure start to break, forming new bonds elsewhere within the material. This ultimately causes permanent change to the shape of the object. Knowing this is critical, as once a material starts to yield, and the object's original shape is lost, the function of the object (e.g. stabilising a fracture) is compromised. Elastic deformation occurs as soon as the object is loaded. In elastic deformation, the intermolecular bonds are stretched but not broken, so when the load is removed the object returns to its original shape. Work-hardening occurs at stresses above the yield point, but below the ultimate tensile strength. Necking occurs in ductile materials (e.g. metals), at stresses beyond the ultimate tensile strength. Failure is the point at which the material fractures.

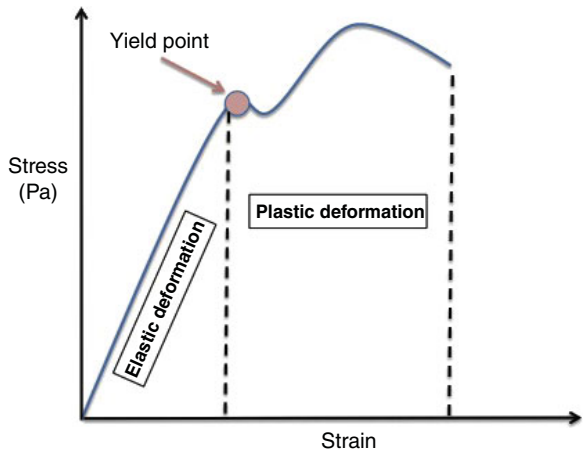


Figure 30.9 A stress–strain curve demonstrating the junction between elastic and plastic deformation (also known as the yield point)

7. Answer A. **Increases jump distance**
Jump distance is the minimum amount of femoral head translation required to cause dislocation. It is equal to the radius of the femoral head. Increasing femoral head diameter increases head–neck ratio and the primary arc range. Soft tissue tightness is influenced mostly by changing the length or offset of the hip, not by increasing head diameter. Increasing head size has no significant effect on the centre of rotation. There is a trade off between dislocation risk and head size in metal on ploy bearings. It appears from analysis of registry data that there is no further decrease in dislocation beyond 36mm heads.

Tsikandylakis G et al. Head size in primary total hip arthroplasty. *EFORT Open Reviews* 2018;**3**:225–231.

8. Answer E. **Stress relaxation**
Most biological tissues, including bone, are viscoelastic. Answers A to D are all features seen in viscoelastic materials. Stress relaxation means that under a constant strain, stress decreases with time. Inserting a femoral broach into the canal relies on stress relaxation. The broach is tapped into a level,

where it puts a deforming strain (with an associated stress) on the canal, expanding it slightly. If the broach is tapped in too quickly, the stress levels may rise high enough to cause fracture, but if there is some delay before passing the broach further (i.e. strain remains constant for some time), stress levels have a chance to drop, reducing fracture risk.

Creep describes when an object is under a constant stress, causing an increase in strain over time. Hysteresis describes how the energy put into an object to deform it is greater than the energy released when the object is unloaded.

9. Answer E. **Using a liner with a 10° posterior lip**
The primary arc is the range of angular motion the hip can go through before the femoral neck impinges. It is an important factor in hip stability, as impingement can lead to dislocation as the head is levered out of the socket (Figure 30.10). Though using a liner with a posterior lip can reduce the risk of posterior dislocation, it actually reduces the primary arc, and potentially can increase the risk of anterior dislocation through neck impingent on the lip. Increasing femoral head size or reducing femoral neck diameter increases the head–neck ratio, increasing the primary arc. Acetabular osteophytes can be a source of femoral neck impingement, therefore removing them increases the primary arc.

10. Answer B. **Adhesive wear**
All the mechanisms of wear in the question can be found in a metal-on-poly total hip arthroplasty; however, adhesive wear has been shown to be the most important factor in producing particles associated with osteolytic loosening.

Jasty M et al. Wear of polyethylene acetabular components in total hip arthroplasty: an analysis of one hundred and twenty-eight components retrieved at autopsy or revision operations. *J Bone Joint Surgery* 1997;**79**:349–358.

Nusbaum HJ, Rose RM, Paul IL, Crugnola AM, Radin EL. Wear mechanisms for ultrahigh molecular weight polyethylene in the total hip prosthesis. *J Appl Polym Sci.* 1979;**23**:777–789.

11. Answer E. **Work-hardening**
Work-hardening (aka strain-hardening or cold working) is the process in which a material becomes more resistant to plastic deformation, as it is taken to stress levels beyond the yield point but below the ultimate tensile strength. Each time a material plastic deforms (i.e. it is stressed beyond its yield point), microscopic 'dislocations' occur in the lattice structure. Each of these dislocations has a surrounding strain-field. These strain-fields produce forces within the material's structure that resist dislocation propagation. As the number of dislocations in a material increase (through repeated bouts of plastic deformation), more force is required to produce further dislocations. This means the yield strength of the material increases, but importantly the ultimate tensile stress remains constant. This means with work-hardening a material becomes stronger, but more brittle. The effects of work-hardening can be reversed by heating the material below its melting point, a process called annealing.

12. Answer A. **Creep**
In creep, under a constant stress, strain increases over time. Ponseti casting works by applying a constant stress over a period of time, eventually

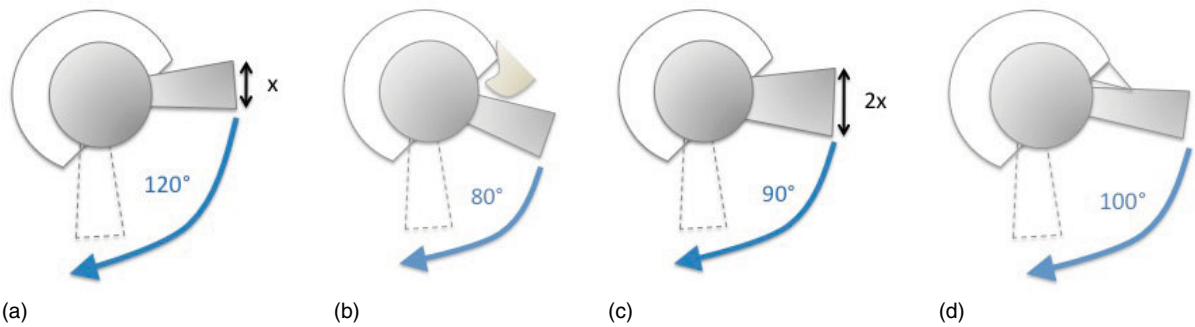


Figure 30.10 (a) Shows the primary arc, (b–d) show how marginal osteophytes, head–neck ratio and lipped liners can all reduce the primary arc

leading to strain in the contracted tissues, correcting the deformity gradually over time.

13. Answer B. **Increases the extension moment arm**
The patella is the largest sesamoid bone in the body. All sesamoid bones aim to increase the moment arm of the tendon they are contained within. In the case of the patella, it lies within the quadriceps tendon, and therefore increases the extension moment arm across the knee.

14. Answer B. **Increase the surface area of the implant–bone interface**
Higher constraint at the joint leads to greater forces transmitted over the implant–cement–bone interfaces. Hinged knees are highly constrained; therefore, to reduce the risk of early loosening, they are stemmed. These stems increase the surface area of the implant–bone interface, which in turn reduces the stresses acting on the bone.

15. Answer D. **Mode 4**
There are four modes of wear described by McKellop (Figure 30.11).
Mode 1 = wear between two articulating bearing surfaces (e.g. the femoral head and the liner).
Mode 2 = wear between one articulating bearing surface and a surface not intended for articulation (e.g. the trunnion on the liner following a ceramic head fracture).
Mode 3 = third body wear. Material between two articulating bearing surfaces causing wear (e.g. cement debris between femoral head and liner).
Mode 4 = wear between two surfaces not intended for articulation (e.g. backside wear: between the backside of the liner and the cup).

16. Answer A. **Covalent**
Ultra-high-molecular-weight polyethylene (UHMWPE) is a common bearing material in joint arthroplasty. Long chains of carbon and hydrogen are held together by covalent bonds to form monomers. In earlier-generation UHMWPE, these monomers are mostly held together by relatively weak van der Waals bonds.* In recent years there has been a shift towards using highly cross-linked UHMWPE due to its increased strength and stiffness. Cross-linking occurs after the UHMWPE is gamma irradiated. The gamma radiation causes covalent bonds to form between the long monomer chains. As covalent bonds** are much stronger, there is greater force required to disrupt the polymer structure.
*Van der Waals bonds are weak intermolecular bonds that form due to a transient polarisation of two neighbouring atoms, which is due to the relative position of each atom's electron field.
**Covalent bonds form between two or more non-metallic atoms, by a process of shared electron pairs.

17. Answer B. **It is strongest against compression**
PMMA shows anisotropic properties (i.e. its resistance to load is dependent on the direction the load is being applied). It has been shown to be relatively weak against tension and shear forces, but strongest in compression. It is also viscoelastic, which means the deformity that occurs under load is time dependent. This means it will undergo creep.
Lewis G. Properties of acrylic bone cement: state of the art review. *J Biomed Mater Res.* 1997;**38**:155–182.
Saha S, Pal S. Mechanical properties of bone cement: a review. *J Biomed Mater Res.* 1984;**18**:435–462.

18. Answer B. **Increasing femoral head diameter**
Three factors can influence the ability of a joint to achieve hydrodynamic lubrication.

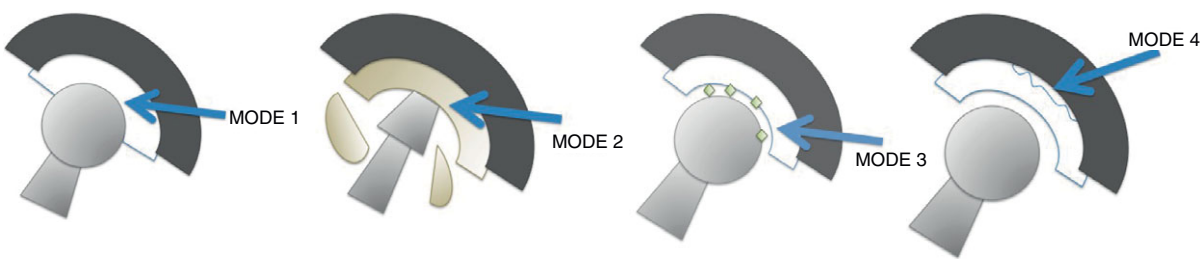


Figure 30.11 Modes of wear

1. Lubricant viscosity – a more viscous fluid provides a thicker fluid-film (e.g. oil provides a better lubricant than water).
2. Load on the bearing – higher loads pushing the bearing surfaces together reduce the chance of fluid-film lubrication (e.g. a heavier patient or increased joint reaction forces from cup malposition).
3. Sliding speed of the bearing surfaces.

If the sliding speed of the two surfaces is great enough, the fluid between them allows them to 'aqua-plane' over each other due to fluid-film lubrication. Increasing femoral head diameter increases the sliding speed across the joint. This is why the metal-on-metal THA designs utilised very large femoral heads.

Wrong answers:

A. This on its own would not have a significant effect on bearing lubrication.

C. Reducing liner diameter would mean reducing head diameter, therefore reducing sliding speed.

D. Congruent bearings prevent fluid flow into the joint, so reduce the chance of fluid-film lubrication.

E. Using HMWPE is unlikely to give hydrodynamic lubrication as it has a high surface roughness; hence, the focus of fluid film lubrication in THA has been with hard-on-hard designs.

19. Answer D. **RSA lateralises the centre of rotation, improving cuff function**

RSA utilises a hemispherical glenoid component (glenosphere) with a concave humeral component. This acts to medialise and lower the centre of rotation (COR). This creates a number of advantages in the cuff deficient shoulder:

- Medial COR increases the deltoid level arm. An increased lever arm means less force is required by the muscle to achieve the same moment (or torque) around the joint.
- Lower COR increases tension on the deltoid, which helps improve muscle power.
- A more medial COR means now some anterior and posterior muscle fibres lie lateral to the COR, which in turn recruits them as additional abductors.
- The COR in RSA lies at the base of the glenosphere; this means there is very little torque created at the bone–implant interface (though the interface will still encounter shear forces).

Rugg CM, Coughlan MJ, Lansdown DA. Reverse total shoulder arthroplasty: biomechanics and indications. *Curr Rev Musculoskelet Med.* 2019;**12**:542–553.

20. Answer D. **Material C is the toughest material**

Stress–strain curves can demonstrate a number of material properties for any given material. Different portions of the curve can show how stiff, strong, tough, brittle or ductile a material is. Therefore, it is important to understand the 'anatomy' of the stress–strain curve (see Figure 30.12). The curve can broadly be divided into an elastic and plastic region. In the elastic region, strain is proportional to stress (forming a straight line). Here, any deformity encountered

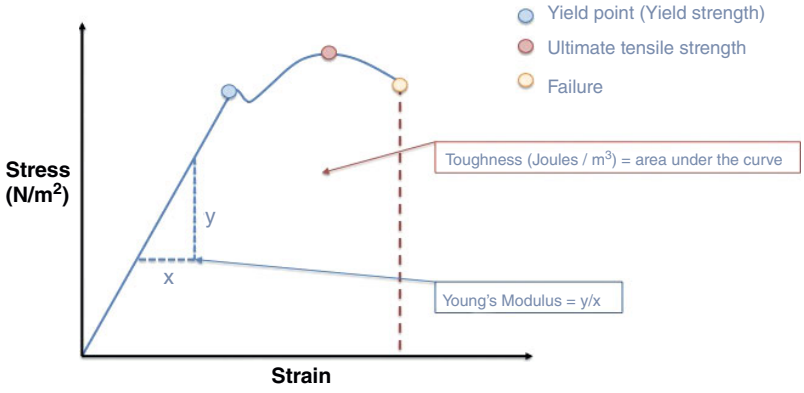


Figure 30.12 Shows a typical stress–strain curve for a metal

by the material is completely reversed once the load is removed. The gradient of this portion of the curve is equal to the Young's modulus (a measurement of material stiffness). The point at which the line starts to curve is known as the yield point. This is the beginning of (permanent) plastic deformity. The highest point the curve reaches is known as the ultimate tensile strength. Ductile materials can undergo a large amount of plastic deformation prior to failure; hence, they have a larger plastic region. Toughness is a measure of the amount of energy a material can absorb before failure.

This is calculated as the total area under the curve. Therefore, in Figure 30.1:

- Material A is the stiffest (highest Young's modulus) but very brittle, as it undergoes no plastic deformation prior to failure.
- Material B has the highest yield point and greatest ultimate tensile strength. This makes it the strongest material.
- Material C is the toughest material, and also the most ductile.

21. Answer B. **B**
The working length of a plate is the distance between the two screws either side of the fracture (line B on Figure 30.2). A shorter working length leads to a stiffer construct.

22. Answer A. **Ensuring the screw is bicortical**
The working length of a single screw should not be confused with the working length of a plate. Screw working length correlates to the distance between the most proximal and most distal point of screw–bone contact. Therefore, as shown in Figure 30.13a and 30.13b, a bicortical screw has a significantly greater working length when compared with a monocortical screw. Also, of note is the effect cortical thickness has on screw working length in monocortical screws; hence, in osteoporotic patients bicortical fixation is much preferred (Figure 30.13c).

23. Answer C. **Cutting both nail ends flush with the bone**
ESIN works by creating equal and opposite bending moments across the fracture site. Each nail in itself creates a bending moment, which, if put in isolation, would deform the fracture in the direction of that moment (Figure 30.14a). However, when a second nail is placed in the opposite direction, the two opposing bending moments cancel each other out and the fracture alignment is maintained (Figure 31.14b).

24. Answer E. **Protects against torsional forces**
Though neutralisation plates may have some role in protecting the lag screw from all of the forces named in the question, the primary role of a neutralisation plate is to protect the lag screw from torsional forces across the fracture.

25. Answer A. **Endurance limit**
An S–N curve demonstrates how a material behaves under cyclical loading. Fatigue failure occurs when a material fractures after enduring multiple cycles of loading at stress levels below the material's normal yield strength. In certain materials, when the stresses applied are low enough, the material will never fail regardless of how many times the material is loaded. The highest stress at which infinite cycles can be applied without causing failure is called the endurance limit. Fatigue life is the number of

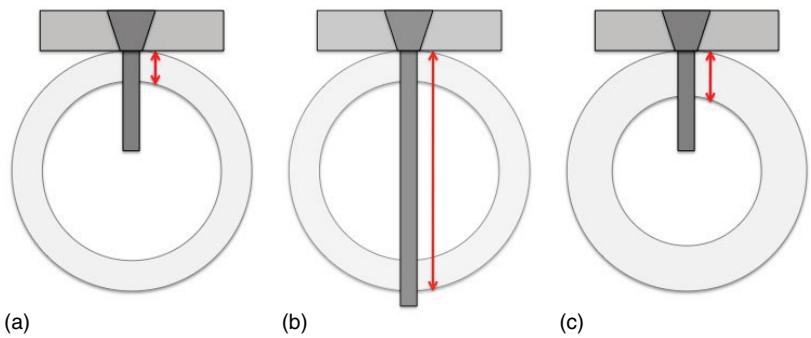


Figure 30.13 (a–c) Red line demonstrates screw working length

Figure 30.14 Demonstrates how stability from ESIN comes from equal and opposite bending moments created by the two nails

cycles that will lead to failure at a selected level of stress. Fatigue strength is the stress that needs to be applied for failure to occur after a specific number of cycles.

26. Answer A. **Early mobilisation**
There is a positive correlation between surface roughness and implant longevity in cementless stem designs. Early mobilisation has not been shown to decrease implant longevity, though surgical technique and implant design should aim to limit micro-motion to less than 50–150μm. HA coating has been shown to improve implant survivorship. Increased pore size improves vascular ingrowth but beyond a certain point there is no further benefit. A more open pore structure may also impact the mechanical properties of the implant. Healthy bone is essential for osteointegration.

Bodén H, Adolphson P. No adverse effects of early weight bearing after uncemented total hip arthroplasty: a randomized study of 20 patients. *Acta Orthop Scand.* 2004;**75**:21–29.

Botterill J, Khatkar H. The role of hydroxyapatite coating in joint replacement surgery – key considerations. *J Clin Orthop Trauma.* 2022;**29**:101874.

Liu Y, Rath B, Tingart M, Eschweiler J. Role of implants surface modification in osseointegration: a systematic review. *J Biomed Mater Res A*. 2020;**108**:470–484.

Murr LE. Strategies for creating living, additively manufactured, open-cellular metal and alloy implants by promoting osseointegration, osteoinduction and vascularization: an overview. **J Mater Sci Mater Med.** 2019;**35**:231–241.

27. Answer E. **Tricortical autograft**
When thinking about bone grafts, it is important to have a few definitions:

Osteoconductive: Purely a framework to allow bone ingrowth by creeping substitution.

Osteoinductive: Contains growth factors that stimulate bone formation.

Osteogenic: Material contains cells able to produce bone directly.

The next is what your graft wishes to achieve, the four pillars method set out by Giannoudis et al. (2016) is useful. All four are required for integration and healing.

- Osteogenic cells.
- Growth factors.
- Osteoconductive scaffold.
- Mechanical environment.

As there is a healthy soft tissue envelope, the main consideration is that the graft contains the correct growth factors and can provide a scaffold for ingrowth. As the graft is in a weight-bearing region, mechanical strength is also an important consideration. Both the cancellous grafts, while providing growth factors (allograft to a much lesser degree then autograft) and a scaffold, do not have the required mechanical characteristics. BMP only provides growth factors and not the scaffold or any mechanical strength. HA scaffolds and calcium triphosphate provide good mechanical properties and a scaffold but not the growth factors required. They also take a long time to incorporate. Therefore, the most suitable is the tricortical autograft.

Giannoudis PV, Harwood PJ, Tosounidis T, Kanakaris NK. Restoration of long bone defects treated with the induced membrane technique: protocol and outcomes. *Injury* 2016;**47**(Suppl. 6): S53–S61.

28. Answer B. **Finishing the nail in the diaphysis creates a stress riser**
Stress risers can also be formed when there is a narrow transition between material properties or by geometry (e.g. a sharp edge). Brittle materials are more susceptible to stress risers as they can't plastically deform to redistribute the stress. The cortical bone of the diaphysis is more brittle than metaphyseal bone. It is therefore advisable to have a nail finish in the metaphysis. The nail being more anterior will be due to entry point and radius of the nail not where the nail finishes. The addition of screw will improve the rotational stability and torsional stability is not the concern with a short nail. Even with a short working length a nail will not provide interfragmentary compression required for absolute stability.

29. Answer E. **With an increase in radius, the same torsional rigidity can be achieved with less cortical bone**
A nail with a larger radius is better, and the same concept applies here. Both the moment of inertia (resistance to bending) and the polar area (resistance to torque) for a circle are directly proportional of the radius. As you age, the cortex thins; therefore, to compensate, the radius increases to maintain strength.

30. Answer C. **No, the pins are non-magnetic steel and MRI safe**
The pins will be made from austenitic steel. It has a specific microstructure (face-centred cubic) produced by the addition of manganese, nitrogen and nickel and is non-magnetic. 316L steel, commonly used in orthopaedic implants, is austenitic as are pretty much all stainless steels. A 1.5 Tesla MRI is used for the acquisition of metal artefact reduction sequences (MARS) and will not help in this case.

31. Answer C. **Increase resistance to corrosion**
Chromium is added to stainless steel as it forms an oxide on the surface and prevents corrosion, a process called passivation.

32. Answer B. **Annealing**
All methods of hardening aim to prevent plastic deformation, which is the movement of dislocations within the lattice. A dislocation is an imperfection in a uniform crystal lattice. Alloying and solid solutioning are two names for the same thing; the addition of other elements into a lattice. This produces strain fields that resist the movement of dislocations. Grain size reduction increases the number of grain boundaries in a material. As different grains have different lattice orientations, it is more energetic for a dislocation to pass from one grain to another. In cold working, a material is deformed, introducing dislocations. As each dislocation has its own strain field, they tend to repel other, again resisting movement in a lattice. Annealing is the opposite of cold working, in which the material is heated and the strain in the lattice reduced.

33. Answer D. **Hydrodynamic**
In hydrodynamic lubrication, a layer of fluid is interposed between two surfaces in relative motion. Ideally, the fluid film will be thicker than the height of the asperities of the two surfaces, so they are not in contact. Elastic hydro-dynamic lubrication essentially assumes the same but allows that the two surfaces elastically deform under load. Boundary lubrication assumes that the asperities of each surface are in contact, but that a lubricant, chemically bound to the surface, reduces friction. Weeping lubrication is one of the theories of cartilage lubrication. It states that cartilage is permeable, and that synovial fluid can move in and out on loading and unloading. Fluid is pushed out on loading and separates the two joint surfaces. In boosted lubrication, synovial fluid is forced into subchondral bone under load at the periphery of the contact area and the high-molecular-weight molecules are left behind, causing an area of relatively high viscosity, which reduces friction.

34. Answer A. **Friction is increased with sliding speed**
All are true of friction between two surfaces accept answer A, as friction is independent of sliding speed. The equation for this is $F = mR$ where F is the frictional force, m is the coefficient of friction and R the normal reaction force. The total frictional force is the sum of friction due to adhesion (cold-welded surface asperities) and deformation (asperities in contact on two conjoining surfaces that then plough through each other).

35. Answer C. **Mesenchymal stem cells are released and form fibrocartilage**
It is mesenchymal stem cells that are released that form fibrocartilage. They are still in their pluripotent form, so they can theoretically form muscle, bone or cartilage. The influences of BMP-4 and FGF-2 have been shown to regulate differentiation of mesenchymal stem cells into chondrocytes.

Hurst JM, Steadman JR, O'Brien L, Rodkey WG, Briggs KK. Rehabilitation following microfracture for chondral injury in the knee. *Clin Sports Med.* 2010;**29**:257–265.

36. Answer C. **Retention of water and swelling pressure, allowing cartilage to resist compression**
Proteoglycans are highly hydrophilic and readily take on water. The high tensile strength of the collagen matrix resists expansion. This creates what is called the swelling pressure in the cartilage and allows it to resist compressive loads.

Yanagishita M. Function of proteoglycans in the extracellular matrix. *Acta Pathologica Japonica* 1993;**43**:283–293.

37. Answer A. **Chondroitin sulphate**
Proteoglycan aggregate and aggrecan structure is bread-and-butter basic science material that needs to be learnt. Learn how to draw and label quickly while talking. (Figure 30.15).

38. Answer D. **Hydroxyapatite crystals anchor cartilage to subchondral bone**
The calcified zone is a barrier to diffusion to the subchondral bone; this is why during microfracture you must breach into the subchondral bone in order to allow the release of stem cells. It is type X collagen that is present in the calcified zone. Type VI is in the pericellular region and increases in early OA. Sharpey's fibres connect the periosteum to bone and consist of mainly type I collagen.

39. Answer E. **Hysteresis; it is the energy lost to internal friction**
When loading a sample that has viscoelastic properties, a hysteresis loop will be seen. This is due to differences in energy between the loading and unloading cycles. This energy is lost as heat due to internal friction.

40. Answer D. **Oxidation**
Gamma irradiation is used both in the manufacture and sterilisation of polyethylene. If performed in the presence of oxygen, this causes free radial production. Free radicals cause chain scission where the long polymer chains are broken into shorter chains. Implants that have undergone oxidation are more prone to failure. Steps are now taken to prevent this with irradiation performed in a vacuum or in the presence of inert gases during manufacture. Packaging is sealed to prevent ingress of oxygen. If you look at the shelf life of a poly cup versus a metal stem for the same implant you will notice the use by date is significantly shorter for the poly cup.

41. Answer B. **ECRB**
The important word in the question here is dynamic, b and c are static stabilisers of the scaphoid and ERCB provides dynamic stability along with FCR, ECU and EDC. It is incorrect to think that all SLL injuries will present acutely with flexion deformity of the scaphoid. It tends to be more a sign of chronic injury as over time the dynamic and static stabilisers will become incompetent. The natural history of scapholunate ligament injury is for degenerative changes to occur in the carpus.

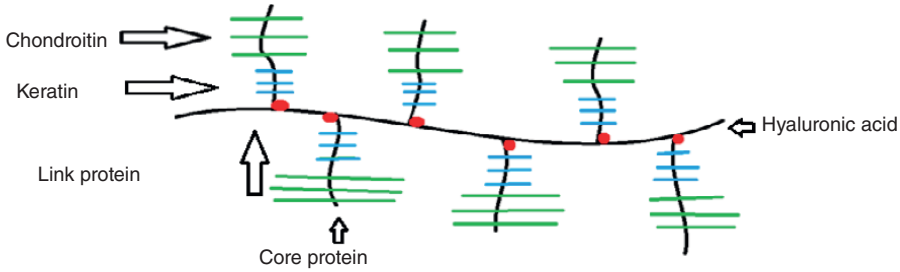


Figure 30.15 Proteoglycan aggrecan and aggregate structure

Pérez AJ et al. Role of ligament stabilizers of the proximal carpal row in preventing dorsal intercalated segment instability: a cadaveric study. *J Bone Joint Surg.* 2019;**101**:1388–1396.

Wahed K et al. Management of chronic scapholunate ligament injury. *J Clin Orthop Trauma.* 2020;**11**:529–536.

42. Answer E. **Quadriga effect**
This is an example of the quadriga affect. This is due to the FDP having a common muscle belly. Therefore if the tension on a repair is wrong it will lead to restriction of movement in adjacent fingers. This is most commonly seen in the ring and middle. A, B and C would be expected to lead to a global reduction in range of motion. E would cause an issue with the repaired finger not an adjacent one.

43. Answer A. **Deep anterior oblique or beak ligament**
There is a little bit of controversy about this which is why we did not give the dorsal-radial ligament as an option. The dorsal-radial ligament has been shown to be the strongest ligament of the thumb CMC joint but the beak ligament is the only intra-articular ligament and has a short course closest to the axis or rotation. It is thought to allow a screw-home mechanism during pinch and therefore may be the primary stabiliser of the CMC. It is interesting to look at the evolutionary biology of the first CMC and why degenerative changes are so common in humans. If you look at finite element studies of human versus other primate thumbs, humans are able to generate much higher grip strengths which has an advantage for tool use, the downside is that the joint reaction force is much larger therefore more prone to degeneration over time.

Key AJ, Dunmore CJ. The evolution of the hominin thumb and the influence exerted by the non-dominant hand during stone tool production. *J Hum Evol.* 2015;**78**:60–69.

Nanno M, Buford WL Jr, Patterson RM, Andersen CR, Viegas SF. Three-dimensional analysis of the ligamentous attachments of the first carpometacarpal joint. *J Hand Surg Am.* 2006;**31**:1160–1170.

44. Answer B. **IMN and full weight bearing**
Children with neuromuscular disorders are a bit like fractured neck of femur patients in that they have poor physiology (they will eventually die of complications related to weakness of cardiac and respiratory muscles) and decondition rapidly and will not recover lost mobility. We should therefore avoid management options that will require immobilisation or partial weight bearing as they will not tolerate it. Most DMD sufferers these days will be treated with long-term steroids. Here this means we are left with the only option that allows immediate weight bearing. I do accept that in children of this age IMN is sometimes not possible due to narrow canal and there maybe concern over growth arrest – the other option is then a submuscular plate.

45. Answer C. **Active movements with the arm in an overhead position**
In an elbow dislocation we must assume that the medial and lateral ligaments of the joint are disrupted. Therefore we will rely on the bony anatomy and active stabilisers. Bony stability of the elbow is much greater in flexion than extension hence in the initial stages keeping the elbow within this arc, will confer greater stability. Most elbow dislocation will be posterolateral and the result of a valgus force so we do not want to replicate this in rehabilitation. There are numerous studies showing that overhead exercise is safe and effective in cases of elbow instability and is the correct answer here.

Giannicola G, Polimanti D, Bullitta G, Sacchetti FM, Cinotti G. Critical time period for recovery of functional range of motion after surgical treatment of complex elbow instability: prospective study on 76 patients. *Injury* 2014;**45**:540–545.

Lee AT et al. The influence of gravity on the unstable elbow. *J Shoulder Elbow Surg.* 2013;**22**:81–87.

Manocha RHK, Banayan S, Johnson JA, King GJW. Overhead arm positioning in the rehabilitation of elbow dislocations: an in vitro biomechanical study. *J Hand Ther.* 2022;**35**:245–253.

46. Answer D. **Fixation of the posterior malleolus fracture with plate and screw and fibular fixation**
This is a trimalleolar fracture with a large posterior malleolar fracture. Biomechanical studies

show that the syndesmosis is best stabilised by fixation of this fragment with plate and screw construct, this is superior to fibular fixation with positional screw across the syndesmosis after reduction of the inferior fibular tibial joint. The AIM trail looking at close contact casting verses fixation was for unstable ankle fractures in the over 60s, so cannot be applied in this case.

Çağlar C, Akçaalan S, Akkaya M. Anatomically fixed posterior malleolar fractures in syndesmosis injuries without transsyndesmotic screw fixation. *Foot Ankle Int.* 2022;**43**:486–494.

Evers J et al. Leave it or fix it? How fixation of a small posterior malleolar fragment neutralizes rotational forces in trimalleolar fractures. *Arch Orthop Trauma Surg.* 2022;**142**:1031–1037.

Keene DJ et al. The Ankle Injury Management (AIM) trial: a pragmatic, multicentre, equivalence randomised controlled trial and economic evaluation comparing close contact casting with open surgical reduction and internal fixation in the treatment of unstable ankle fractures in patients aged over 60 years. *Health Technol Assess.* 2016;**20**:1–158.

47. Answer E. **Tendons display less hysteresis than ligaments**

Ligaments are more metabolically active then tendons and are more cellular due to this.

Ligaments contain more elastin than tendons as ligaments are more likely to experience sudden supra-normal loads; a certain amount of give in the system is needed so they don't just snap every time you fall. It is for a similar reason that ligaments have less highly aligned fibres to cope with varying directions of load while tendon will always be loaded along the muscle's line of pull.

Tendons have lower hysteresis than ligaments, efficient energy transfer between muscle and bone is advantageous therefore reducing the difference between loading and unloading curves (which we think is energy lost as heat due to internal friction) should be minimised in tendons.

48. Answer C. **Both the anterior column and posterior tension band are disrupted. This is likely to be an unstable fracture**

When we think of thoracolumbar spinal fracture, we always think of the two-column principle, the anterior compression and posterior tension band. The CT shows a bony Chance fracture so an AO type B, distraction type injury. This is likely to be an unstable fracture. In general injuries through the disc will be more unstable and are less likely to heal in a manner that can support physiological loads versus bony injuries.

Vu C, Gendelberg D. Classifications in brief: AO Thoracolumbar Classification System. *Clin Orthop Relat Res.* 2020;**478**:434–440.

49. Answer D. **The two forces are on the same side of the fulcrum but in opposite directions. Body weight acting closer to the fulcrum**

There are three types of lever in the body.

Class 1 lever: The load and effort point in the same direction, but lie on opposite sides of the fulcrum, e.g. the hip joint.

Class 2 lever: The load and effort lie on the same side of the fulcrum pointing in opposite directions, e.g. the 1st MTPJ.

Class 3 lever: The load and effort lie on the same side of the fulcrum pointing in opposite directions, e.g. the elbow joint.

50. Answer A. **Activation of macrophages or lymphocytes**

Adverse local tissue reaction (ALTR)/adverse reactions to metallic debris (ARMD) in association with large head metal-on-metal implants is a well-studied field and therefore a common exam question. It appears that ALTR/ARMD can either be driven by macrophages or lymphocytes.

Perino G et al. The contribution of the histopathological examination to the diagnosis of adverse local tissue reactions in arthroplasty. *EFORT Open Reviews* 2021;**6**:399–419.

51. Answer C. **Fibroblast growth factor (FGF) determines the proximal distal axis**

Answer C is actually talking about the embryological development of the limb bud where FGF influences the apical ectodermal ridge to set up the proximal distal axis. The rest are all part of nerve regeneration.

52. Answer C. **The fracture is vertically and rotationally unstable**

While most of us learn the Young and Burgess classification of pelvic ring fractures, which is

based on the mechanism, understanding the Tile classification is arguably more useful in thinking about how to fix them. I am biased here: when I was doing my pelvic and acetabular job my boss had been a Tiles fellow. Tiles classification has an A, B and C. Type A, are injuries that do not involve disruption of the pelvic ring. Type B injuries involve the ring and are rotationally unstable but vertically stable. Type C injuries are rotationally and vertically unstable. In this case where there has been vertical translation of the pelvis it will be a Type C and will require front and back fixation. The sacrospinous and sacrotuberous ligaments are key stabilisers of the sacroiliac joint (SIJ) and are unlikely to be intact given the description of vertical translation of the hemi pelvis through the SIJ.

Tile M. Acute pelvic fractures: I. Causation and classification. *J Am Acad Orthop Surg*. 1996;4:143–151.

53. Answer A. **A layer of oxide formed on a metal surface that prevents further reaction between the metal and environment**
Answer A describes passivation of an implant such as happens with stainless steel, titanium and cobalt chrome, the common orthopaedic alloys. Fretting is particularly problematic as the mechanical abrasion removes the protective oxide layer exposing the implant to chemical corrosion, a particular problem in the taper in large head hip prosthesis.

54. Answer C. **Type 2**
This question tests your knowledge of the modes of wear of which there are four.
- Relative motion between two designed surfaces – a head and cup of a total hip replacement.
- Relative motion between a designed surface and a non-designed surface – as in this example between the head (designed surface) and the cement (non-designed surface).
- Relative motion between two surfaces and third bodies – such as when small fragments of bone or cement are left in the joint following arthroplasty.
- Relative motion between two non-designed surfaces – the classic example is backside wear in a modular tibial component of a knee arthroplasty.

Modes of wear confusingly are different to types of wear, broadly split between mechanical and chemical. Adhesive and abrasive are both types of mechanical wear.

55. Answer A. **Creep**
Cement displays viscoelastic properties though over a long period of time. The stem has settled into cement mantel, meeting the definition of creep which is a change in strain at a constant stress. I always think of stress relaxation as the opposite, as it is a change in stress at a constant strain. Hoop stresses are generated when the stem is loaded and prevent stress shielding. Hysteresis is most commonly come across in orthopaedics in tendons and ligaments. It is the difference in the loading and unloading curves on a stress/strain graph.

56. Answer E. **Weakness for the shoulder girdle muscles**
Shoulder dislocation and issues arising from it are common exam fodder. Everyone coming to the exam should know about the Stanmore triangle and the types of instability. The common stem will be either a traumatic shoulder dislocation in a contact sport or multiple atraumatic dislocations.

A common misconception is that some muscles are weak and that strength training is required. This is wrong, as it is a muscle patterning and proprioception problem not a weakness issue. Even in multiple atraumatic dislocation patients there can be a structural component such as labral deficiency or anterior glenoid bone loss and this should be ruled out.

57. Answer C. **Dysfunction of the posterior tibialis muscle and inability to lock the mid tarsal joint**
This goes back to our principles of levers. They must be rigid in order to allow efficient energy transfer. In the foot the first ray is the lever you use to push off with. During push off phase of gait the mid tarsal joint must be locked and this is achieved by the contraction of the PT muscle. During stance where we need a degree of flexibility in the foot to accommodate uneven ground, this joint unlocks. Mid foot OA can cause a patient to lose their single leg heel raise but the pain will be mid foot and does not

classically have a flat foot deformity. Again, Achilles rupture could cause this but the examination does not fit. Lastly, subluxation of the sesamoids occurs in a hallux valgus.

58. Answer C. **Tendon to bone with sutures through drill holes**
Any repair is definitely better than no repair. In a retrospective study of 1515 THR the group with no repair had a dislocation rate of 4.8%, the repair group 0.7%. This was backed up by a meta-analysis in the *Lancet* of 125 papers on hip dislocation. A study of 213 hips showed a dislocation rate of 8% with tendon to tendon versus 1.8% in tendon to bone with sutures through drill holes. Osteotomy and wiring of the greater trochanter was the method described by Charnley when doing the lateral approach so not relevant to the posterior approach.

Kim Y, Kim Y, Hwang K, Moon J. The comparison for failure of short external rotator repair and dislocation rate according to repair techniques: a prospective comparative study. *Orthopaedic Proceedings* 2018;**100-B**(Suppl. 5):50.

Kunutsor SK et al. Risk factors for dislocation after primary total hip replacement: meta-analysis of 125 studies involving approximately five million hip replacements. *Lancet Rheumatol.* **2019**;**1**:e111–e121.

White RE Jr, Forness TJ, Allman JK, Junick DW. Effect of posterior capsular repair on early dislocation in primary total hip replacement. *Clin Orthop Relat Res.* 2001;**393**:163–167.

59. Answer A. **A right sided degenerative disc prolapse at L4/5**
This question is really testing your knowledge of the gait cycle. The gait pattern described is a right-sided foot drop.

Step = initial contact (IC) on one foot to IC on the opposite foot.

Stride = IC on one foot to IC on the same foot.

One gait cycle describes one stride. Therefore each gait cycle consists of a stance phase and a swing phase relating to one leg. The stance phase can be further divided into four stages:

1. Initial contact.
2. Loading response.
3. Midstance.
4. Terminal stance.

Table 30.1 Description of the three rockers of normal gait, and position of the fulcrum for each rocker. Note how during stance the fulcrum around which forward propulsion occurs moves from posteriorly in the heel at initial contact to the toes during push off.

Rocker	Description	Fulcrum
1st	Heel strike to foot flat	Calcaneal tuberosity
2nd	Tibial progression over flat foot	Tibio-talar joint
3rd	Push off	MTPJs (mostly via 1st MTPJ)

The swing phase can be divided into three stages:

1. Early swing.
2. Mid-swing.
3. Terminal swing.

In foot drop, there is weakness in the ankle dorsiflexors. This means the ankle cannot dorsiflex in terminal swing to preposition the foot ready for heel strike. Instead initial contact tends to be with the forefoot, eliminating the first rocker (see Table 30.1). Loading response occurs as the patient's centre of mass drops during the early portion of stance, it is usually marked by a period of knee flexion, which acts as a shock absorber. The absent first rocker tends to dampen the normal loading response, and instead the knee remains in near full extension through much of the stance phase. One of the crucial problems patients with foot drop face is tripping on the plantarflexed foot during swing. To combat this the patient makes certain compensations, including increasing their ipsilateral hip flexion (high stepping) and going up onto their toes early on the contralateral side (vaulting) to improve clearance.

Of the choices given here the most likely condition to give an ipsilateral foot drop is a disc prolapse at L4/5, causing L5 nerve root compression.

60. Answer E. **There is excessive tibial progression during mid stance**

3D gait analysis is becoming commonplace in the management of ambulant CP, and so is likely to appear more frequently in the FRCS exams.

It would be impossible to explain in detail the 'ins and outs' of gait analysis in CP here, but for the sake of the FRCS exam there are a few important facts worth noting.

Midstance is the portion of the gait cycle where in normal gait the tibia is moving forward over the foot, with the ankle joint as the fulcrum (also known as the 'second rocker'). This tibial progression is controlled by the plantar flexors of the ankle (in particular soleus), which undergo eccentric contraction to prevent the tibia moving too far forward in order to keep the ground reaction force (GRF) in front of the knee joint. Keeping the GRF in front of the knee during midstance is key to an energy efficient gait, as the GRF enacts an external extending moment on the knee. This means knee extension is achieved via the GRF rather than quadriceps contraction. Negating the need for quadriceps activation significantly reduces energy expenditure. This mechanism is known as the plantar flexion-knee extension (PFKE) couple.

Crouch gait is a walking pattern in which the knee never achieves full extension. Here the PFKE couple fails, the GRF falls behind the knee, necessitating quadriceps contraction. This leads to early fatigue in children with diplegia, who often have significant weakness in knee extensors. This problem often progresses as the child gets older and heavier.

There are multiple reasons for a child to be in crouch gait, but gait analysis data have implicated that hamstring contracture plays a minimal role (in fact hamstring length may be normal or even increased in cases of crouch gait). The key factor in preventing/correcting crouch gait is manipulating the GRF to remain anterior to the knee joint, utilising the PFKE couple. Spasticity in the calf muscle tends to exaggerate the PFKE couple and can therefore be protective against crouch.

Chapter 31

Evidence Management: Data Analysis and Clinical Trials Structured SBA

Munier Hossain

EVIDENCE MANAGEMENT: DATA ANALYSIS AND CLINICAL TRIALS STRUCTURED SBA QUESTIONS

1. **About the normal distribution, which of the following is the most appropriate?**
   - A. 50% of samples in the dataset lie above the mean value
   - B. Mean ± 1 standard deviation would capture 95% of the data
   - C. Mean and interquartile range are the best parameters to describe the data
   - D. A normal distribution is useful to plot categorical variables
   - E. There are no differences between mean, median and mode

2. **A paired sample t-test is appropriate for which of the following situations?**
   - A. Comparing bone mineral density between those with and those without ankylosing spondylitis
   - B. Investigating pain relief on a visual analogue scale before and after hip arthroplasty
   - C. Investigating the proportion of pain relief on a visual analogue scale before and after hip arthroplasty
   - D. Correlating patient satisfaction with radiological outcome after ankle fracture fixation
   - E. Comparing visual analogue scale scores after total hip arthroplasty and hip hemiarthroplasty following hip fracture

3. Researchers investigated pain relief and functional outcomes before and after resection arthroplasty of the shoulder. The level of pain was significantly decreased (t-test, $P < 0.001$).
   Which of the following is true?
   - A. Pain relief following resection arthroplasty was clinically noticeable
   - B. Resection arthroplasty can be recommended as a treatment option
   - C. Resection arthroplasty has a strong effect on pain relief
   - D. The very low P-value is indicative of a very low level of bias of the study
   - E. There was a <1% probability that the observed differences in pain relief were due to chance

4. **Which of the following is true?**
   - A. A wide confidence interval gives a more precise estimate
   - B. A small trial would result in a narrow confidence interval
   - C. The range of the confidence interval can be used to test the null hypothesis
   - D. If the confidence intervals of two different interventions do not overlap, this would suggest that there is a clinically significant difference in treatment effect
   - E. A 95% confidence interval is always used in research

5. **Which of the following is true?**
   - A. $P = 0.001$ means the intervention has a stronger effect than $P = 0.01$
   - B. $P < 0.05$ suggests that the treatment effect was clinically significant
   - C. The lower the P-value, the greater the strength of evidence against the null hypothesis
   - D. The threshold for P-value is fixed at <0.05
   - E. P-value is not affected by multiple statistical testing

6. In a case-control study 47 consecutive patients with a deeply infected hip arthroplasty were

compared with 200 randomly selected patients who had surgery in the same hospital around the same time with no deep infection in their hip arthroplasty.

Which of the following is true?

A. Random allocation would have been better to prevent bias
B. The study was free of selection bias
C. The study was free of confounding
D. The study was free of assessor bias
E. This was a retrospective study

7. Your colleague is interested in investigating the efficacy of a new treatment for knee pain. He wishes to conduct a randomised double-blind trial.

Which of the following is true?

A. Appropriate randomisation can only be performed using computer-generated random numbers
B. A double-blind design would help to minimise observer bias
C. The effect of confounding factors can be minimised if randomisation is adequately performed
D. Randomisation would be adequate if patients are allocated according to the day of the week of their presentation to the hospital
E. The study would be free from selection bias

8. A placebo-controlled trial was conducted to compare botulinum toxin to placebo in management of tennis elbow. Following botulinum treatment, patients had on average 19% improvement in grip strength in the affected arm compared with an average of 2% for placebo (P = 0.08, 95% CI 2.31–35.64). Both groups showed similar improvements in pain and quality of life.

Which of the following is true?

A. Botulinum toxin group did not benefit from the placebo effect
B. Improvement in the placebo arm was not due to natural variation of the disease
C. Placebo effects also modulated the treatment response
D. Treatment response was solely due to the intervention
E. Treatment response is the difference in grip strength between the intervention and placebo

9. Researchers investigated the efficacy of bandage vs ankle support for management of ankle instability. Mean MOXFQ score was noted before and after the procedure. Data were analysed using a t-test.

Which of the following is true?

A. Independent sample t-test would be an appropriate test for this trial
B. The authors were required to be satisfied that homogeneity of variance existed before undertaking the t-test
C. Data from the trial can be appropriately displayed in a box plot
D. Mann–Whitney U test is an appropriate test when data shows binary distribution
E. The MOXFQ score was normally distributed in this population

10. Data distribution of a variable was displayed using the chart below (Figure 31.1).

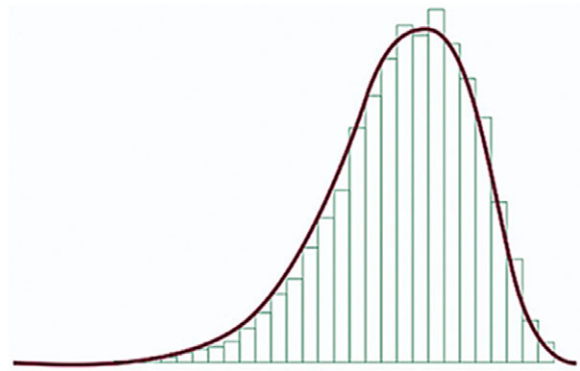


Figure 31.1 Data distribution

Which of the following statements is true?

A. A box plot is a suitable chart to describe the data
B. 95% confidence interval of the sample mean is a suitable measure
C. The mean value is to the left of the median value in Figure 31.1
D. One could utilise a Student's t-test to test for the null hypothesis
E. The dataset here can be adequately described by the sample mean and confidence interval

11. In a study involving patients with plantar fasciitis, the authors concluded that physiotherapy

was significantly likely to improve pain compared with watchful waiting (P = 0.02, mean VAS for physiotherapy was 4.2mm, and watchful waiting 5.3mm). The minimal clinically important difference (MCID) was 2mm.

Which of the following statements is true?

A. The majority of patients having physiotherapy reported a VAS score of 4.2mm
B. The difference in pain relief between physiotherapy and watchful waiting was clinically significant
C. There is a 2% probability that physiotherapy is more effective compared with watchful waiting
D. There is a 2% probability that the difference in pain relief between physiotherapy compared with watchful waiting was due to chance
E. A larger sample would have meant that the observed differences might reach clinical significance

12. The abstract of a paper reported 'the mean difference in pain relief between the intervention group and the control group as calculated using a 0–100mm VAS was 13.2mm (95% CI −8.1–31.1mm)'.

Which of the following statements is true?

A. 95% of the control group reported –8.1mm to 31.1mm pain relief
B. 95% of the intervention group reported –8.1mm to 31.1mm pain relief
C. 99% CI would give us a more precise estimate
D. The observed difference in pain relief between the two groups was probably due to chance
E. We need to calculate the P-value to determine the statistical significance

13. Researchers compared the vertebral bone strength between the control group and those treated with the balloon bone tamp or the polymer bone tamp. Results are presented in Figure 31.2.

Which of the following is true?

A. Data presented in this graph had a parametric distribution
B. Pre-augmentation control group had the most outliers
C. The graph shows the mean, interquartile range and extreme values

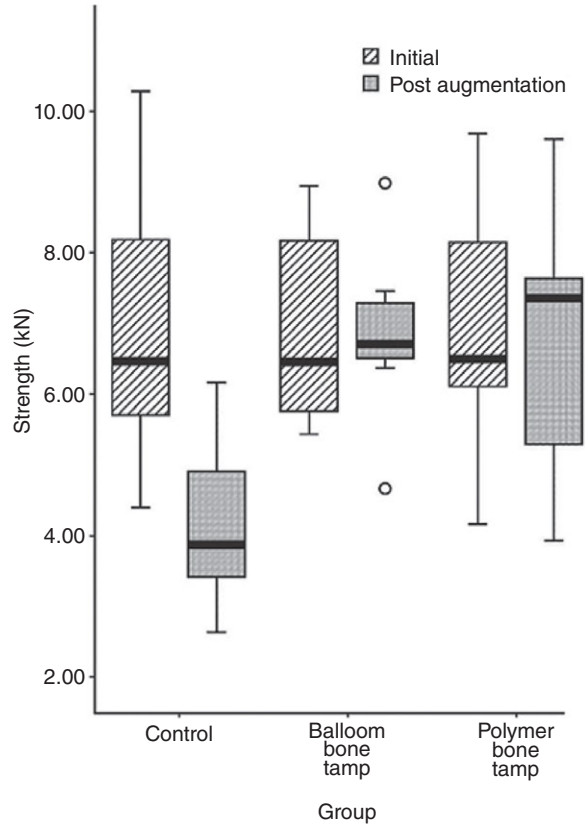


Figure 31.2 Box plot comparing vertebral body strength between three groups. Figure courtesy of Seel EH, Davies EM. A biomechanical comparison of kyphoplasty using a balloon bone tamp versus an expandable polymer bone tamp in a deer spine model. *J Bone Joint Surg Br.* 2007;**89**:253–257.

D. The graph shows the median, interquartile range and extreme values
E. There was a significant difference in bone strength between the control and the bone tamp group post-augmentation

14. Researchers found that heterotopic ossification (HO) did not significantly affect elbow range of movement after elective elbow arthroplasty (Mann–Whitney U test, P = 0.070).

Which of the following is true?

A. By performing a logarithmic transformation of the dataset, the researchers could have employed a paired sample t-test instead
B. The mean value is the appropriate measure of central tendency
C. There is at least a 7% probability that the difference in range of motion observed

between patients with or without HO was due to chance or random variation
D. There was no difference in the range of movement between those with and without HO
E. While analysing data, researchers made assumptions regarding the data distribution

15. Researchers concluded that patients with loose hip replacements had more pain and were more likely to have a history of fragility fracture, narrower femoral cortices and lower periprosthetic or lumbar spine bone mineral density (all t-test, $P < 0.01$) compared with those without a loose implant. They also had vitamin D deficiency (t-test, $P = 0.31$).
Which of the following is true?
A. There was no need to assess the distribution of the variables
B. It is likely that the difference in vitamin D levels between those with and without loosening after hip arthroplasty was due to random variation
C. Paired sample t-test was performed
D. There was a 31% difference in vitamin D level between patients with or without a loose hip implant
E. There was a 1% probability that someone with narrow femoral cortices will develop loosening after THA

16. Researchers concluded that patients with loose hip replacements also tended to be smokers (Chi square test, $P = 0.08$).
Which of the following is true?
A. Researchers compared a continuous variable between the two groups
B. Researchers compared a binary variable between the two groups
C. The Fisher exact test is not a suitable test for this cohort
D. Stem loosening and smoking status are not independent
E. There is around an 8% difference in smoking status between those with and without stem loosening

17. Researchers recruited 350 participants in each group for a randomised trial. The assessors were blinded. 269 patients in the control group and 250 patients in the intervention group completed the trial protocol. The results were analysed according to intention to treat analysis.
Which of the following statements is true?
A. Per protocol analysis is the best analysis option due to crossover
B. Intention to treat analysis is the best analysis option to minimise the effect of confounding
C. Since randomisation was appropriately performed, bias was eliminated from the trial
D. The trial was free from selection bias
E. The trial was at risk of observer bias

18. Researchers found that the odds ratio of union of periprosthetic femoral fractures when treated by impaction grafting and a long stem (IGL) compared with impaction grafting and a short stem (IGS) was 5.5 (95% CI 1.54–19.6; $P = 0.009$).
Which of the following statements is true?
A. Patients treated with IGL may be up to 20 times more likely to have union compared with those with IGS
B. Fractures treated with a long stem were nearly six times more likely to heal
C. Long stem implant was the critical intervention that helped in bony union
D. Impaction grafting was not beneficial for bony union
E. The odds ratio of union was calculated by dividing the rate of union in the IGL vs the rate of union in the IGS group

19. Researchers compared pain and functional outcome after total knee replacement between pessimist and non-pessimist patients. At 2 years after surgery, the odds ratio of pain among pessimists was 2.21 (95% CI 1.12–4.35; $P = 0.02$), odds ratio at 5 years was 1.21 (95% CI 0.51–2.83; $P = 0.67$).
Which of the following is true?
A. Pessimists reported less pain relief over the study period compared with non-pessimists
B. The short-term difference in pain relief was not sustained over the long term
C. The pessimist group reported more than twice the severity of pain compared with the non-pessimist group at 2 years
D. The non-pessimist group reported better pain relief at 5 years
E. The results were probably affected by confounding factors

20. In a study assessing the risk of symptomatic venous thromboembolism (VTE) following primary total hip replacement (THR), researchers found that among the patients undergoing THR, the risk of symptomatic VTE was 0.79% between 0 and 90 days after surgery. The adjusted relative risks of symptomatic VTE among patients undergoing THR were 15.84 (95% CI 13.12–19.12) during the first 90 days after surgery and 2.41 (95% CI 2.04–2.85) during 91–365 days after surgery, compared with a control group.

Which of the following is true?

A. The absolute risk of symptomatic VTE was large in the first 90 days after surgery
B. Symptomatic VTE was between 13 and 19 times more severe in the THR group initially
C. Patients who had THR may be 241% more likely to develop symptomatic VTE compared with the control group after the first 90 days
D. The probability of symptomatic VTE for a patient in the THR group was 15.84% in the first 90 days after surgery
E. The risk of symptomatic VTE after the first year was negligible

21. Researchers in a study found that Gram stain had a sensitivity of 65% and specificity of 40% for diagnosing septic arthritis of the knee.

Which of the following statements is true?

A. 65% of patients identified as having septic arthritis had actual septic arthritis
B. 40% of patients with septic arthritis were identified with the Gram stain
C. Gram stain was false positive in 35% of cases
D. Gram stain would not be a reliable test to rule out a septic arthritis
E. 40 out of 100 patients with septic arthritis of the knee would fail to test positive using Gram stain

22. Resting intra-articular hip pressure and hip pain were plotted in Figure 31.3.

Which of the following statements is true?

A. If the intra-articular pressure was 0, there will be no pain

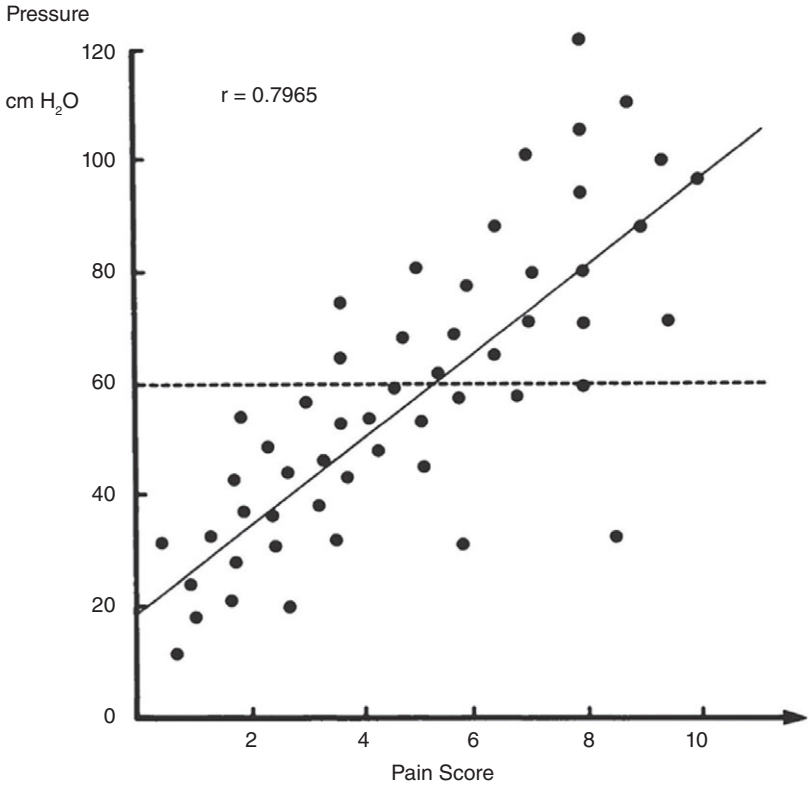


Figure 31.3 Resting hip pain vs intra-articular hip pressure. Figure courtesy of Goddard NJ, Gosling PT. Intra-articular fluid pressure and pain in osteoarthritis of the hip. *J Bone Joint Surg Br.* 1988;**70**:52–55.

B. Increasing intra-articular pressure caused increasing pain
C. If pressure exceeded 120mmHg, the pain would also increase accordingly
D. The given chart would demonstrate a correlation coefficient of >0
E. A linear regression equation would allow us to predict pain score beyond 120mmHg pressure

23. This is a chart showing the risk of revision of a total hip replacement implant (Figure 31.4).

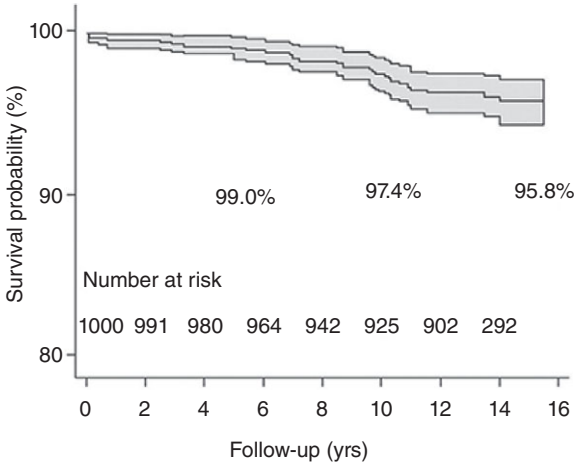


Figure 31.4 Kaplan–Meier survival analysis with 95% confidence intervals shown, of the first 1000 consecutive BHRs, including all ages, all diagnoses and both genders. Figure courtesy of Daniel J, Pradhan C, Ziaee H, Pynsent PB, McMinn DJ. Results of Birmingham hip resurfacing at 12 to 15 years: a single-surgeon series. *Bone Joint J.* 2014;**96-B**:1298–1306.

Which of the following is true?
A. Censored patients did not contribute data
B. Patients who were lost to follow up were removed from the data analysis
C. Patients who died before completing the trial were withdrawn from the data analysis
D. The graph allows a reliable estimate of mean survival time
E. As the study progressed, the uncertainty regarding the estimate of interest increased

24. Researchers conducted a pragmatic randomised trial to assess wrist function following wrist fracture in adults treated with K-wire or open reduction and internal fixation. A sample size calculation was performed based on 80% power to detect a 5-point difference in wrist function score. The required sample size was 250 patients. 250 patients were recruited. 230 patients completed the study. Wrist function was no different between the two groups (P = 0.056).

Which of the following is true?
A. The study was adequately powered to test the null hypothesis
B. By calculating a power analysis, the researchers avoided the risk of committing a type II error
C. Proposed 5-point difference was not the minimal clinically important difference between the two groups
D. It appears likely that there was no difference in wrist function between the two interventions
E. A study that is powered 100% would need to recruit the entire population

25. Researchers conducted a prospective, randomised, non-inferiority study to compare the safety and efficacy of cast immobilisation vs symptomatic treatment for management of 5th metatarsal base fracture. The authors concluded that immobilisation is no better than symptomatic treatment.

Which of the following is true?
A. The null hypothesis of the trial was: there was no difference in safety and efficacy between the intervention and the control arm
B. There was no null hypothesis since this was a non-inferiority trial
C. The aim of the study was to assess if symptomatic treatment was a viable alternative to cast immobilisation
D. Statistical significance was tested using the P-value
E. The 95% confidence interval of the median difference between the two treatment arms was calculated to assess the treatment effect

26. In a study comparing mechanical and chemical thromboprophylaxis vs mechanical thromboprophylaxis only for prevention of venous thromboembolic events after joint replacement surgery, researchers found reduction of DVT following the combined modality treatment with the number needed to treat (NNT) of 12 (95% CI 7.9–20.3).

Which of the following is true?

A. For every 8 patients treated with the combined modality compared with mechanical prophylaxis, 1 patient might be prevented from developing DVT
B. For every 100 patients treated with the combined modality, 12 patients might be prevented from developing DVT
C. NNT is the difference in DVT rate between the two modalities
D. For every 100 patients treated with the mechanical modality, 12 patients might develop DVT
E. For every 8 patients treated with the mechanical modality, 1 patient might develop DVT

27. **Which of the following is true?**

A. A paired sample t-test cannot be performed if the variables are not normally distributed
B. The independent samples t-test assumes that the sample sizes in the two groups are similar
C. A parametric test should not be performed if sample data are not normally distributed
D. A non-parametric test should be performed when sample data are not normally distributed
E. Minor departure from the bell-shaped curve is acceptable for assessing the normal distribution

28. Researchers conducted a randomised trial to assess whether low intensity pulsed ultrasound (LIPUS) accelerated or enhanced the rate of bone healing in lower limb fractures. 62 patients were recruited (32 = intervention, 30 = placebo). There were 2 protocol violations in the treatment group and 5 in the placebo group. Intention to treat analysis was performed to analyse data.

Which of the following is true?

A. Intention to treat analysis is the patient's intention to be treated
B. Per-protocol analysis analysed data according to the original treatment protocol
C. Intention to treat analysis ignores the integrity of the random allocation process
D. Intention to treat analysis is a pragmatic estimation of likely real-life treatment effect
E. Study results should be analysed with either the intention to treat or per-protocol analysis method

29. Authors conducted a randomised trial to compare the effectiveness of physiotherapy vs arthroscopic decompression in rotator cuff tendinopathy. The results were analysed using the intention to treat.

Which of the following is true?

A. Intention to treat analysis is based on the care-giver's intention to treat the patient once allocated to an intervention
B. Patients were included in the analysis only if they completed the treatment allocated initially
C. Patients who did not complete the treatment were excluded from the analysis
D. The analysis would be flawed for including patients who did not have the treatment
E. The results might be affected by confounding bias

30. Researchers performed power calculation for a trial to compare blood loss between tranexamic acid and usual care for knee arthroplasty. They commented: 89 patients would be required in each treatment group to detect a difference in mean blood loss of 100 ml between them.

Which of the following is true?

A. The calculated sample size is optimal for adequate power in the study
B. The stated blood loss is the minimal clinically important difference
C. If the power of the study is increased the required sample size would correspondingly decrease
D. The researchers eliminated type II error by performing a sample size analysis
E. The P-value does not affect power calculation

31. Researchers conducted a randomised trial to assess if exercise compared with usual care in patients with high cholesterol prevented coronary death. Patients were all recruited from the local postal service and randomised according to their date of birth. There was no blinding. More patients assigned to usual care were lost to follow up.

Which of the following is true?

A. The study was free of selection bias
B. The study was free of allocation bias
C. The study was free of observer bias
D. The study was affected by attritional bias
E. The results were adjusted for confounding

32. Authors analysed medium-term survivorship of total hip replacement implants in very young patients. No patient was lost to follow up. Five patients died.

Which of the following is true?

A. Patients lost to follow up would have been excluded from the analysis
B. The estimate of survival probability is accurate
C. The median survival time could be estimated by finding the half-way point of follow up
D. The survival curve was only affected by the revision of the implant
E. There were no censored data in this analysis

33. Researchers wished to identify threshold preoperative levels of haemoglobin that would predict the requirement for blood transfusion in patients who undergo total knee arthroplasty (TKA). The authors found that a preoperative threshold value for the level of haemoglobin of 13.75g/dl offers a sensitivity of 70% and specificity of 71% for predicting perioperative transfusion. Area under ROC curve = 0.79 (95% CI 0.73–0.84) (Figure 31.5).

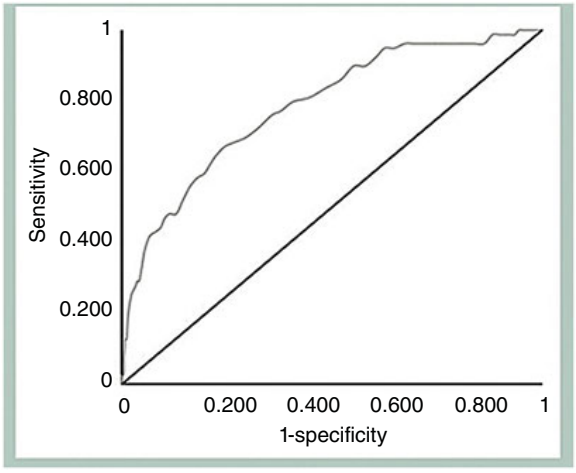


Figure 31.5 Pre-op Hb as predictor for transfusion. Figure courtesy of Maempel JF, Wickramasinghe NR, Clement ND, Brenkel IJ, Walmsley PJ. The preoperative levels of haemoglobin in the blood can be used to predict the risk of allogenic blood transfusion after total knee arthroplasty. *Bone Joint J.* 2016;**98-B**:490–497.

Which of the following is true?

A. 1-specificity denotes the patients without the disease correctly identified as negative
B. A screening test that lies on the diagonal line cannot distinguish between patients with and without the condition
C. A test with absolute accuracy would have a sensitivity and 1-specificity of 1
D. ROC curves are plotted by comparing the ability of a test to correctly identify patients with a disease vs correctly identifying as negative those without the disease
E. The ideal test threshold should have both high sensitivity and 1-specificity

34. Researchers conducted a systematic review and meta-analysis to investigate the effect of topical tranexamic acid (TXA) on transfusion rate after total knee replacement. Control group had placebo. The results of the meta-analysis were presented in a forest plot (Figure 31.6).

Which of the following is true?

A. A risk ratio of 1 suggests a 100% increased risk of transfusion
B. All the trial results favoured TXA compared with placebo for blood transfusion
C. Effect estimate was larger in larger trials
D. There was heterogeneity between the study population
E. TXA application resulted in statistically significant reduction in blood transfusion

35. Researchers undertook a systematic review to investigate the efficacy of rib fracture fixation vs non-operative treatment in management of flail chest. The chart in Figure 31.7 is the result of a meta-analysis comparing the incidence of pneumonia between the two groups.

Which of the following is true?

A. A fixed-effects model meta-analysis was appropriate
B. Because of the small number of included trials, the confidence interval of the summary estimate is wide
C. Effects of treatment might differ between subgroups within the included population
D. The wide summary estimate suggests that our confidence on the summary estimate is very high
E. There was no evidence to reject the null hypothesis of heterogeneity between the included trials

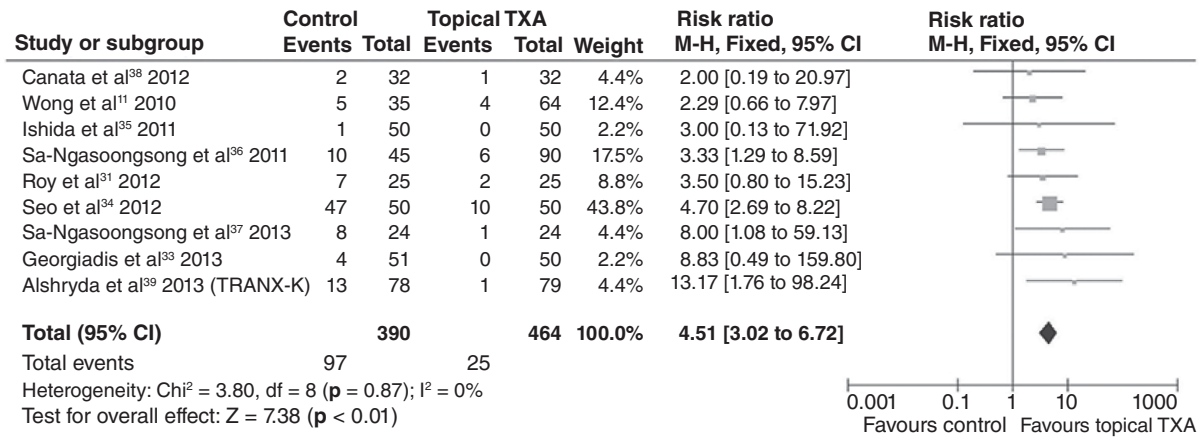


Figure 31.6 Trials of topical tranexamic acid (TXA) vs placebo: Forest plot of blood transfusion rate. CI, confidence intervals, M-H, Mantel–Haenszel. Figure courtesy of Alshryda S, Sukeik M, Sarda P, Blenkinsopp J, Haddad FS, Mason JM. A systematic review and meta-analysis of the topical administration of tranexamic acid in total hip and knee replacement. *Bone Joint J.* 2014;**96-B**:1005–1015.

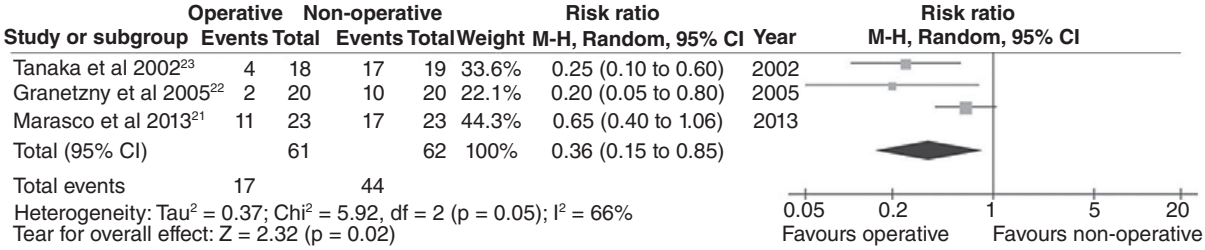


Figure 31.7 Forest plot comparing the incidence of pneumonia by operative versus non-operative management. A Mantel–Haenszel random effects model was used to perform the meta-analysis and risk ratios are quoted with 95% confidence intervals. Figure courtesy of Coughlin TA, Ng JW, Rollins KE, Forward DP, Ollivere BJ. Management of rib fractures in traumatic flail chest: a meta-analysis of randomised controlled trials. *Bone Joint J.* 2016;**98-B**:1119–1125.

36. Researchers investigated the outcome and long-term survival after high tibial osteotomy (HTO). Results were illustrated using the attached graph (Figure 31.8). The end point was conversion to total knee arthroplasty (TKA).

Which of the following is true?

A. 50% of participants survived 15 years or longer
B. It is safe to assume that censored patients may have been at higher risk of revision
C. Mean survival time is a useful parameter for this cohort
D. The accuracy of the survival estimation curve remains constant over time
E. The displayed Kaplan–Meier curve changes when HTO patients have a revision or are censored

37. The following chart was produced by the National Joint Registry (NJR) team as part of clinician feedback. The x-axis denotes the expected mortality and the y-axis the standardised mortality ratio (Figure 31.9).

Which of the following is true?

A. Data points A and B have the same case mortality
B. Data points C and D perform the same volume of surgery
C. The red line marks a control limit of 2 standard deviations from the mean value
D. This is a scatterplot
E. Values on the red line are outliers

38. Concerning Figure 31.9 which of the following is true?

A. 95% of data points lie within the red line

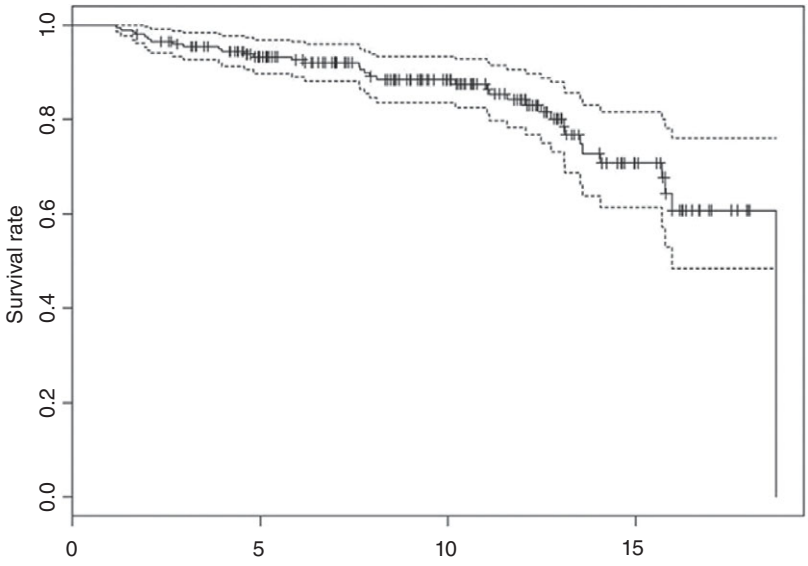


Figure 31.8 Survival outcome after HTO (image copyright BMC musculoskeletal disorders, available under Creative commons licence). Efe T, Ahmed G et al. Closing-wedge high tibial osteotomy: survival and risk factor analysis at long-term follow up. *BMC Musculoskelet Disord.* 2011;**12**:46.

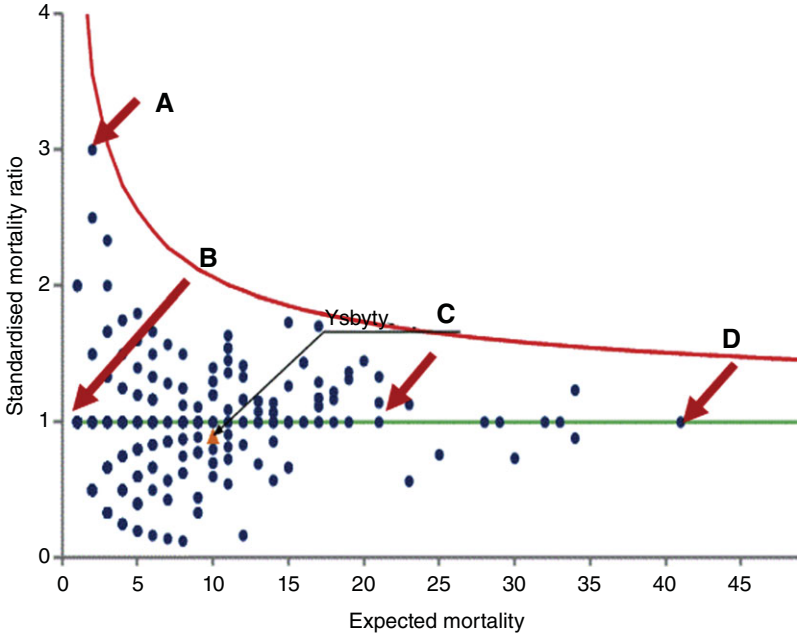


Figure 31.9 Funnel plot

B. Datapoint B has observed mortality that is 1 standard deviation above the expected mortality
C. The control limit is narrower due to the smaller volume of surgery
D. The x-axis represents the outcome of interest
E. The y-axis represents the outcome of interest

EVIDENCE MANAGEMENT: DATA ANALYSIS AND CLINICAL TRIALS STRUCTURED SBA ANSWERS

1. Answer A. **50% of samples in the dataset lie above the mean value**
   The normal distribution has a symmetric curve and therefore 50% of sample data lie above and 50% below the mean value. Mean, median and mode may have the same value in perfectly normally distributed data but not necessarily so. When there are minor variations, which is common in real life, there will be minor differences in mean, median and mode, but data may still be within the parameters of the normal distribution. Parametric data are conventionally relayed with the help of mean and standard deviation. Mean ±2 standard deviation would capture 95% of the data. The normal distribution is used to plot numerical variables.

2. Answer B. **Investigating pain relief on a visual analogue scale before and after hip arthroplasty**
   A concerns two groups of independent observations, the independent sample t-test is the appropriate test. B: the first observation can be paired with the second; the paired sample t-test is appropriate. C is a test of proportion; a Chi-square test or Fisher exact test is appropriate. D is to assess correlation – a correlation coefficient is appropriate. E is of two independent samples; an independent sample t-test is appropriate.

3. Answer E. **There was a <1% probability that the observed differences in pain relief were due to chance**
   The available results suggest that there was a statistically significant improvement in pain relief following resection arthroplasty of the shoulder. We do not know if the degree of pain relief was clinically significant. Pain relief may well have been statistically significant but not clinically significant and may not be noticeable. Resection arthroplasty cannot be recommended as a treatment option based on this single parameter. A low P-value is evidence against the null hypothesis of no difference. It does not give any indication of the level of bias in a study. The results confirm that there was $<1\%$ probability that the observed differences in pain relief could be due to chance.

4. Answer C. **The range of the confidence interval can be used to test the null hypothesis**
   Confidence interval is a measure of the uncertainty of the unknown but true population mean. The wider the confidence interval, the more uncertain the researcher is regarding the actual population mean. A small sample would result in a wider and less precise confidence interval. A larger sample would result in a more precise effect estimate and a narrower confidence interval. If the width of the confidence interval crosses 0, this confirms that the null hypothesis is likely true. When an intervention is compared with another intervention or control, if the confidence intervals of the two interventions do not overlap then this confirms that there is a statistically significant difference in the effect between the two interventions. However, this does not automatically mean the difference is clinically significant. The difference might be true or statistically significant but minimal in size and therefore may not be clinically meaningful. A 95% confidence interval is conventionally used, but a 99% confidence interval can also be used depending on the clinical circumstances.

5. Answer C. **The lower the P-value, the greater the strength of evidence against the null hypothesis**
   P-value is ascertained to test the null hypothesis. P is the probability of observing the noted difference in treatment effect if the null hypothesis was true. Therefore, P is the strength of evidence against the null hypothesis. It does not give any idea about the size of the treatment effect. A smaller P-value suggests that the observed differences are even less likely if the null hypothesis was true. P is conventionally set at 0.05, but not always. Although not common, sometimes researchers might wish to be more certain and choose a P-value of 0.01. Just because the P-value suggests that the null hypothesis is unlikely ($P < 0.05$) does not necessarily mean that the observed difference is clinically significant. If multiple statistical tests are performed, then for every 100 tests there could be up to 5 cases of false rejection of the null hypothesis. This is a type 1 error. One way to avoid this

error is to perform a Bonferroni correction that adjusts the P-value at a lower level to account for multiple testing (if the test is performed twice, for the original $P < 0.05$, the new P threshold becomes $0.05 \times 2 = 0.025$, new P-value is set at $P < 0.025$, etc.).

6. Answer E. **This was a retrospective study**
A case-control study is retrospective in design. The cases (infected THR) were identified and risk factors investigated retrospectively. Patients were identified based on the infection status of THR, and therefore there is no scope to randomly allocate patients to the infected and the non-infected groups. Case-control studies are usually at risk of selection bias because researchers usually employ convenience sampling to identify the population which may not be representative of the target population (infected THR). Patients were not randomly allocated to the two groups. Hence it is likely there will be demographic differences as well as the risk of confounding. Case-control studies can be at risk of conscious or unconscious assessor bias, especially if the outcome variables are not strictly objective.

7. Answer C. **Effect of confounding factors can be minimised if randomisation is adequately performed**
Computer-generated random number generation is the best method to conduct randomisation, but not the only appropriate method. Day of the week is not truly random, and therefore using it to conduct randomisation is not adequate. This method is also known as pseudorandomisation. Appropriate randomisation eliminates allocation bias but does not rule out selection bias. Selection bias occurs when patients are selected who are not representative of the population studied. Double-blind design blinds the participant and the care-giver but may be open to observer bias, as the observer is not blinded, especially if the outcomes studied are not objective. When randomisation is adequately performed, the known and unknown confounding factors are equally distributed between the two arms of the trial and the effects of confounding are minimised, although not completely eliminated.

8. Answer C. **Placebo effects also modulated the treatment response**
Placebo is a substance without any known therapeutic effect. The placebo effect is the patient's response to it. This effect is a combination of behavioural modification, expectation, regression to mean effect, natural variation in symptoms of the disease etc. Both the intervention group and the placebo group demonstrate the placebo effect. The treatment response would have been partly modulated by the placebo effect, not solely due to the intervention. The treatment response is the change in grip strength in the intervention arm pre- and post-intervention. The difference in grip strength between the intervention and the placebo is the treatment effect.

9. Answer E. **The MOXFQ score was normally distributed in this population**
The t-test is a suitable test for parametric data. Since before and after scores were assessed, a paired t-test would be the appropriate test for this dataset. Although the assumption of equal variance is an important condition for the independent t-test, this is not required in this case, as the same population was tested before and after. Since these are parametric data, the most useful parameters are the mean and the 95% confidence interval. A box plot is most appropriate to display non-parametric data. The Mann–Whitney test is used for non-parametric data. Since MOXFQ is the outcome of interest, the authors were satisfied that MOXFQ is normally distributed in the population and therefore undertook a parametric test.

10. Answer A. **A box plot is a suitable chart to describe the data**
This is a bell-shaped curve, but the curve is not symmetric, it is skewed to the left. This is known as a skewed distribution. This one is negatively skewed. The data displayed are non-parametric. Non-parametric data cannot be adequately described by sample mean and confidence interval; one would require the median value, which is suitably displayed via a box plot. Similarly, since these are non-parametric data, one would require median and interquartile range. Since data are skewed to the right, the mean would also shift to the same side as the outliers (towards the tail in

the graph) and therefore to the right of the median value. The Student's t-test is used to analyse parametric data.

11. Answer D. **There is a 2% probability that the difference in pain relief between physiotherapy compared with watchful waiting was due to chance**
Mean VAS score in the physiotherapy group was 4.2mm. This was the arithmetic average score of all reported scores and not the score reported by the majority. The trial results indicated that there was a significant difference in effect size between the two treatments. However, the effect size was smaller than MCID and not clinically significant. P = 0.02 means that there was a 2% probability that the difference in observed treatment effect might be due to chance. There is no proof that a larger sample would have resulted in larger effect size. There is a risk of type II error if the sample size is not adequate, but the sample size does not have any bearing on the effect size.

12. Answer D. **The observed difference in pain relief between the two groups was probably due to chance**
The calculated 95% confidence interval means that we can be reasonably certain that the mean difference in pain relief lies anywhere between –8.1mm to 31.1mm. The 95% confidence interval is an estimate of the degree of uncertainty around the mean difference in pain relief. If we wished to calculate the 99% confidence interval, this estimate would be even wider, since our uncertainty would increase. The calculated 95% confidence interval includes the point of no difference in treatment effect (0). Pain relief could be better or worse in the intervention group compared with the control. Therefore, the observed difference in treatment effect is not statistically significant and likely due to chance; there is no need to calculate a P-value.

13. Answer D. **The graph shows the median, inter-quartile range and extreme values**
The graph is a box and whisker plot. Box and whisker plots are used to display non-parametric data. The bold horizontal line denotes the median value, the box the inter-quartile range, the whiskers the range of data. The extreme values are plotted as outliers (open circle). The interquartile range was wider in the pre-augmentation control group, but outliers were present in the post-augmentation balloon bone tamp group. The graph does not allow us to conclude if there was any significant difference in bone strength between the groups.

14. Answer C. **There is at least a 7% probability that the difference in range of motion observed between patients with or without HO was due to chance or random variation**
Non-parametric data can be transformed via logarithmic transformation. This reduces extreme variability and may allow the analysis of data using a parametric test. However, a paired sample t-test would not be appropriate, as the groups are not related. The suitable parametric equivalent would be the independent sample t-test. The Mann–Whitney U-test is performed on non-parametric data. Therefore, the useful measure of central tendency is the median value. The mean value is appropriate for parametric data. There was no significant difference in range of motion between those with or without HO. This does not mean there was no difference. Rather, the observed difference did not cross the threshold of statistical significance. P = 0.07 means that there was a 7% probability that the difference in range of movement in patients with or without HO may be due to chance. Since the authors performed a non-parametric test, they did not have to make any assumptions regarding data distribution. It is conventional to state that researchers have made assumptions regarding data distribution when a parametric test is performed.

15. Answer B. **It is likely that the difference in vitamin D levels between those with and without loosening after hip arthroplasty was due to random variation**
The t-test was performed to test the null hypothesis. This test is only appropriate if the sample was normally distributed. The distribution of the variable would have to be assessed to help decide which test was the most appropriate. There was a 31% probability that the difference in vitamin D levels observed between the two groups was purely by chance. Since this is more than the

5% threshold, we accept the null hypothesis and conclude that the observed difference in vitamin D level was no more than by chance. The samples are not related, and therefore independent sample t-test would be the appropriate test. The P-value is essentially the evidence against the null hypothesis, i.e. what is the likelihood of observing the different rates of vitamin D levels between those with and without the loosening, assuming such a difference did not actually exist. It does not mean a 31% difference in vitamin D level. Similarly, P = 0.01 indicates the probability of observing the difference by chance. There was only a 1% probability that the observed differences in narrow femoral cortex between those with and without loose hip implant were due to chance.

16. Answer B. **Researchers compared a binary variable between the two groups**
A Chi-square test is performed to compare a categorical variable between the two groups. The categorical variable in this test was a binary one (smokers vs non-smokers between those with or without a loose THA). A Fisher exact test is a modified version of the Chi-square test and is relevant when the sample size is quite small. The P-value in a Chi-square test is a test of independence of the two variables (smoking status and stem loosening are independent). P-value is the probability against the null hypothesis that the variables are independent. Since the P-value is >0.05, we accept the null hypothesis that there is no relationship between the two variables, i.e. smoking status and stem loosening are independent. P=0.080 is not the difference in smoking status between the two groups.

17. Answer B. **Intention to treat analysis is the best analysis option to minimise the effect of confounding**
Following random allocation, if patients deviate from the original trial protocol, the deviation delegitimises the original randomisation and reintroduces allocation bias as the two groups may not be similar anymore. Such deviation may introduce confounding. Therefore, intention to treat is the best option to minimise the effect of confounding even if there is cross-over. If there is concern regarding cross-over one option is to perform additional per-protocol analysis as a sensitivity analysis to assess to what extent cross-over affected the trial but should not be the primary analysis. When randomisation is appropriately performed, it minimises the effects of confounding factors and eliminates allocation bias but does not eliminate all types of bias. Selection bias depends on the inclusion and exclusion criteria and what kind of participants are included in the trial. Blinding the assessor would minimise the chance of observer bias.

18. Answer A. **Patients treated with IGL may be up to 20 times more likely to have union than those with IGS**
The results indicate that participants having IGL treatment were more than 5 times more likely to achieve union than the participants treated with IGS. The 95% CI indicates that the actual rate might be between 2 and 20 times more. The given results only allow us to conclude the margin of treatment effect between IGL vs IGS. It does not allow us to make subgroup conclusions of whether impaction grafting, or the size of the stem independently had any effect on the bony union. The odds of an outcome in a group is the probability of the outcome occurring in a group divided by the probability of the outcome not occurring in the same group. The odds ratio is calculated by dividing the odds of the outcome in the intervention group vs the control group.

19. Answer B. **The short-term difference in pain relief was not sustained over the long term**
Although pessimist participants appear to have reported less pain relief initially, at the end of the trial period there was no appreciable difference in reporting of pain between the two groups.

This is evident by the 95% CI of pain at 5 years (0.51–2.83). Therefore, at 5 years the pessimist group could be almost half as likely to almost three times more likely to report pain compared with the non-pessimist group. The odds ratio is the probability of the pessimist group still complaining of pain compared with the non-pessimist group. This does not mean the severity of pain was over twice that of the non-pessimist group. Odds is the probability of an event taking place in a group vs the probability of the event not taking place. Therefore, the odds

are calculated by dividing the number of participants experiencing the event by the number not experiencing it. The odds ratio is calculated by dividing the odds of the outcome in the intervention group vs the control group. Odds ratios are adjusted for confounding factors.

20. Answer C. **Patients who had THR may be 241% more likely to develop symptomatic VTE compared with the control group after the first 90 days**
Absolute risk of symptomatic VTE was <1% and not large. Relative risk always gives the impression of a large treatment difference. Symptomatic VTE in the first 90 days was 13–19 times more likely in the THR group. This does not mean VTE was more severe. The adjusted relative risk of symptomatic VTE at a year after surgery is 2.41. This means that the risk of symptomatic VTE in the THR group is 241% more likely. Relative risk of symptomatic VTE in the THR group is 15.84. This means that compared with the control group the THR group may have 15.84 times higher probability of developing a symptomatic VTE in the first 90 days after surgery. Individual or absolute risk would be much smaller. Relative risk is an artificially inflated figure and does not give a true reflection of the absolute risks in the community. Absolute risk reduction or gain is a more appropriate figure to discuss with the patient. In this case, the rate of VTE in the THR group was 0.79%, or 80 in every 10,000 cases vs 5 in 10,000 in the control group. Therefore, this is 75 more for every 10,000 cases of THR. It is not possible to extrapolate results beyond the first year.

21. Answer D. **Gram stain would not be a reliable test to rule out a septic arthritis**
Gram stain has 65% sensitivity; therefore, the test would accurately identify 65 out of 100 patients with septic arthritis. 40% specificity means Gram stain would be negative in 40 out of 100 patients without septic arthritis. Gram stain would therefore be false-positive in 60% of cases. Since the test does not have high sensitivity, it would not be useful to rule out the disease. Since the sensitivity is 65%, 65 patients out of 100 would be positive with Gram stain and 35 would fail to test positive (false negative).

22. Answer D. **The given chart would demonstrate a correlation coefficient of >0**
Data are only available for 10–120mmHg pressure. There is no reliable way to predict pain score beyond the available data (<10 or >120mm). Although the chart shows a linear association between intra-articular pressure and pain scores, this does not mean increasing pressure caused the pain. Correlation is not causation. Since the chart demonstrates a positive linear correlation, the correlation coefficient would be >0.

23. Answer E. **As the study progressed, the uncertainty regarding the estimate of interest increased**
This is a survival analysis plot. Patients who are censored, lost to follow up or die before experiencing revision contribute to the data analysis up to the point of being censored and are not withdrawn from the analysis. Since the analysis is of time to event data, the calculation of mean survival time is not feasible. We calculate cumulative survival. As the study progresses, the study population (numbers at risk) becomes less and therefore the confidence interval becomes wider and our uncertainty also increases.

24. Answer E. **A study that is powered 100% would need to recruit the entire population**
The study was underpowered. The researchers performed a power analysis but did not take into account the likely loss to follow up. The actual sample size was smaller than required. The probability of unwittingly committing a type II error was more than the stated 20%. The 5-point difference is the proposed minimal clinically important difference. Although the difference in wrist function was not statistically significant, it cannot be accepted this was indeed the case in reality, since the study was underpowered. Further, a difference may be there even if not statistically significant. A study that is 80% powered means that if the study was repeated many times with exactly the same sample size and the 5-point difference in wrist function truly existed in the population, then 80% of samples would have a $P < 0.05$. To have 100% power would require sampling the entire population of interest, not a feasible option.

25. Answer C. **The aim of the study was to assess if symptomatic treatment was a viable alternative to cast immobilisation**
In traditional RCT design, the aim is to investigate if the experimental arm is superior to the control arm. However, from the statistical perspective, we start with a clinical equipoise of the null hypothesis that there is no difference in the treatment effect between the experimental and the control groups. In a non-inferiority trial, the aim is to investigate if the new treatment is no worse compared with the existing treatment up to a minimal clinically important difference of non-inferiority. Even if the efficacy is the same, the new treatment might have other attractions, i.e. convenience and cost in this case. The null hypothesis in this non-inferiority trial would start with the premise that: symptomatic treatment is worse than cast immobilisation (by a predefined clinically determined margin). Therefore, the analysis is based on a 95% confidence interval of the mean. The median value is a non-parametric measure. If non-inferiority is to be proved, one must be able to reject the null hypothesis and find that the difference in functional outcome after cast immobilisation compared with functional treatment is less than the specified non-inferiority margin.

26. Answer A. **For every 8 patients treated with the combined modality compared with mechanical prophylaxis, 1 patient might be prevented from developing DVT**
NNT is a measure of the treatment effect of the intervention as compared with the control. The NNT in the trial was 12 (95% CI 7.9–20.3). This means that it is likely that around 12 participants would require to be treated with the combined modality compared with mechanical modality to prevent a single incidence of DVT, but the actual number could vary between 8 and 20.

27. Answer E. **Minor departure from the bell-shaped curve is acceptable for assessing the normal distribution**
It is not the variables themselves but the paired difference that needs to be normally distributed for the paired samples t-test to be valid. Even if the variables are not normally distributed, as long the distribution of the paired differences is normal the test is still valid. There is no need for sample sizes to be equal for an independent samples t-test to be valid, although the difference must not be substantial. Although it is ideal to perform a non-parametric test when the assumption of normality is not met, this is not necessarily always the case. Parametric tests can accommodate a degree of departure from normality. For minor departures, a parametric test is entirely valid provided other assumptions are also met. Another option is to perform both parametric and non-parametric tests and accept the more conservative of the two estimates. Besides, one can also transform the data to allow a parametric test to be performed. When the distribution curve is skewed, a non-parametric test is best. However, when the departure is minor, as seen on visual inspection of the histogram of the data, a parametric test can still be performed.

28. Answer D. **Intention to treat analysis is a pragmatic estimation of likely real-life treatment effect**
The advantage of a randomised controlled trial is that if randomisation is conducted correctly, the known and unknown confounding factors are distributed reasonably equally between the different treatment arms. The observed treatment effect can therefore be attributed to the intervention. Often it may not be possible for trial participants to adhere to the allocated treatment. If this happens, the researchers have multiple options to analyse data. The first option is to undertake intention to treat analysis. Intention to treat analyses participants according to the original treatment allocation. This means that participants who violate the original allocation protocol and receive the alternative treatment are still considered and analysed as if they had received the original allocation. The advantage of this approach is that the integrity of randomisation is maintained, and unintentional confounding factor effect is minimised. Intention to treat (ITT) analysis also gives a 'pragmatic' real-life result, i.e. even if a treatment is offered to a patient, not all will be able or willing to comply with the treatment. Therefore, ITT may be thought of as a pragmatic reflection of what may happen in real life if a particular

intervention is offered to patients. ITT analyses are more conservative. The alternative approach is to perform a per-protocol analysis. This would entail excluding participants who did not adhere to the treatment protocol. Per-protocol analysis is at risk of being affected by the effects of confounding factors. Ideally, both should be performed. If the results of both are the same, then one can be reassured that cross-over of treatment has not affected the outcome.

29. Answer A. **The intention to treat analysis is based on the care-giver's intention to treat the patient once allocated to an intervention**
Intention to treat (ITT) is not based on the patient's intention to be treated but on the care-giver's intention to treat the patient once allocated to an intervention. Patients who violate the allocation are not excluded in ITT. They are treated as part of the original allocated group irrespective of the intervention received. ITT analysis is not flawed although the inclusion of patients who did not complete the treatment results in a more conservative estimate of the intervention. If randomisation had been appropriately performed, the trial is at low risk of confounding bias. ITT analysis is performed to try and avoid confounding bias. Instead, if the authors performed per-protocol analysis, the results might be affected by confounding bias.

30. Answer B. **The stated blood loss is the minimal clinically important difference**
Power calculation does not take into account likely loss to follow up. Therefore, one would need to add likely loss to follow up to the numbers generated from the power calculation to ensure the sample size was adequate. Otherwise, the study might be underpowered after loss to follow up. The power calculation is performed taking into account the minimal clinically important difference. To increase the power of a study one would need to increase the sample size. The traditional power of a study is 80%. If power increases to 90%, the required sample size would also increase. By performing power calculation researchers reduced the risk of type II error but not eliminated it. The standard threshold of type II error for a power calculation is 20%. Several variables are required to calculate study power. Both type I and type II errors are taken into account. The standard threshold for type I error for power calculation is 0.05. Hence, changing the chosen threshold for the P-value will also affect the power calculation. The smaller the P-value, the larger the required sample size.

31. Answer D. **The study was affected by attritional bias**
The study was not free of selection bias. Patients in the postal service are unlikely to represent the general population with high cholesterol. The study was not free of allocation bias. The allocation was based on the date of birth. The date of birth is not truly random. Since the outcome of interest was death assessor bias had no role in this study even though there was no blinding. Since higher numbers of patients were lost to follow up from the usual care group the study was not free of attritional bias. Since allocation was not strictly random we cannot be certain that the study was not free of confounders.

32. Answer D. **The survival curve was only affected by the revision of the implant**
The advantage of survival analysis is that it takes into account loss to follow up. If patients are lost to follow up, they are censored. Censored patients are analysed up to the point of loss to follow up. Although there was no loss to follow up, five patients died. We do not know the outcome of these five patients, and data are censored for these five patients. Since censoring took place, we have to make assumptions about the survival probability of the implants in these patients. Therefore, the calculated probability is only an estimated guess. We do not know the exact probability. The Kaplan–Meier survival curves only change in probability when the outcome of interest (revision) takes place, not when censoring happens. Median survival is not halfway to follow up, but the follow-up point when survival probability is 0.5.

33. Answer B. **A screening test that lies on the diagonal line cannot distinguish between patients with and without the condition**
A receiver operating characteristic (ROC) curve is a graphical plot that is obtained by plotting sensitivity against 1-specificity. Specificity is the

ability of a test to correctly identify as negative a person without the disease (negative in health). Therefore, 1-specificity denotes the number of cases without the disease incorrectly identified as positive (false positive). In simple terms, ROC is a plot of true positive vs false positive. Because these two are inter-related, there is a trade-off between the sensitivity and specificity of a test. If we increase the sensitivity of the test, the rate of false-positive will also increase. An ideal test will have a high sensitivity and low false-positive test. A 100% accurate test will have a sensitivity of 1 and false positive rate of 0. The diagonal line starts off with a sensitivity and 1-specificity of 0.0 to 1.1. Tests that fall on this line therefore do not have any ability to correctly diagnose the diseased population.

34. Answer E. **TXA application resulted in statistically significant reduction in blood transfusion**
A forest plot is a graphical illustration of meta-analysis. In this case, 9 studies were included. The column on the left shows the number of participants in each trial (total) and the number of blood transfusion (events). In this case, 9 studies were included. The column on the left shows the number of participants in each trial (total) and the number of blood transfusion (events). Because of the difference in sample sizes in the included trials, they do not contribute equally to the pooled result. The weight column shows the amount that each column contributes to the trial. Larger trials contribute more weight. Larger trials also mean a narrower confidence interval and more precise or narrower effect estimate. Since two different interventions are compared, a risk ratio of 1 means that there is no difference between the two groups concerning the particular risk. This line is the 'line of no effect'. If a confidence interval crosses the line of no effect, this suggests that there was no statistically significant difference in effect estimate between the intervention arm and the control arm (therefore, all the trial results did not favour TXA). The square is the effect estimate and the line the 95% confidence interval of the effect estimate for each trial (the effect estimate is smaller in larger trials, as our uncertainty is less). The summary estimate is represented by a diamond. The ends of the diamond represent the 95% CI. In this case, the diamond sits well away from the line of no effect. The diamond favours topical TXA with a risk ratio of 4.51 and 95% CI of 3.02–6.72. This means that participants having topical TXA as compared with placebo were on average 4.51 times less likely to require blood transfusion. Meta-analysis requires a test for heterogeneity to rule out undue variation in sample estimate. P-value for the test of heterogeneity was 0.87. Therefore, there was no evidence to reject the null hypothesis. We can therefore safely assume that the variation in sample estimate noted in the different trials is no more than what can be expected when different samples are taken from the same population.

35. Answer C. **Effects of treatment might differ between subgroups within the included population**
Following on from the previous question, when P-value for statistical heterogeneity is <0.05, we reject the null hypothesis that there is no statistical heterogeneity between the included studies. This is further proven by the results of an I^2 test. I^2 value was 66% for the above analysis.

Statistical heterogeneity is present when the I^2 value is $>50\%$. The standard meta-analysis is a fixed-effect model to account for the absence of heterogeneity. When there is statistical heterogeneity, one has to adopt a random effect model. When there is evidence of statistical heterogeneity in the included studies, treatment effect probably differs between subgroups of the population. A wide confidence interval is indicative of more uncertainty in our estimate of the actual treatment effect. Confidence interval is influenced by the number of participants involved in the trial and not by the number of trials.

36. Answer A. **50% of participants survived 15 years or longer**
Survival data are time to event data. From the graph, we can see that at least 50% of participants survived 15 years or longer. This is the median survival time. Both exact and censored data are used to calculate the survival graph. Censored patients contribute data until the point at which they are censored. This is based on the assumption that censored data are 'non-informative', i.e. censored patients are not at higher risk of

revision compared with the non-censored participants. As time progresses and patients get censored, the accuracy of the estimate becomes less. This is evident by the increasing widening of the confidence interval. The curve only changes when the outcome of interest, in this case revision, takes place. Survival rate marks the cumulative probability of survival. This was around 0.7 at 15 years. Censored patients are marked on the graph, but this does not change the graph.

37. Answer D. **This is a scatterplot**
This is a funnel plot. Funnel plots are essentially scatterplots. Observed values are plotted against the natural log of expected values to produce the plot. This plot compares mortality following arthroplasty. A point outside the red line, not on it, is an outlier. The control line represents 3 standard deviations from the mean value, not 2 standard deviations. A and B lie nearly at the same point at the x-axis. This means that their expected mortality is the same. However, A is higher at the y-axis. This means that mortality was comparatively higher for patients operated at A compared with B. C and D are at different points of the x-axis. Their expected mortality is different. Expected mortality is adjusted for the volume of surgery. D is a higher volume centre compared with C.

38. Answer E. **The y-axis represents the outcome of interest**
The y-axis in the funnel plot represents the outcome of interest, not the x-axis. The red line, which represents the upper control limit represents 3 standard deviations from the mean. Therefore, 99.8% of data points lie within the control limit. The control limit is wider to the left of the x-axis but narrower as we travel towards the right of the x-axis. The x-axis essentially is a surrogate for the volume of surgery. When the volume is low, there is greater uncertainty and the control limit is wide to the left. With an increase in volume, the uncertainty gets less and consequently, the control limit gets narrower as we travel to the right of the x-axis. Datapoint B has a standardised mortality ratio of 1. This means that the observed mortality was the same as the expected mortality.

Recommended Reading

Ernst E, Resch KL. Concept of true and perceived placebo effects. *Br Med J*. 1995;**311**:551–553.

Khan T. Survival analysis of time to event data in orthopaedic surgery: current concepts. *Bone and Joint 360*. 2017; **6**.

Parsons NR, Perry DC, Costa ML. All interventions differ, although some are more different than others. *Bone Joint J*. 2017;**99-B**:1123–1124.

Parsons N et al. Statistical significance and p-values: guidelines for use and reporting. *Bone Joint J*. 2019;**101-B**:1179–1183.

Perry DC, Parsons N, Costa ML. Surgeon level data: understanding the plot. *Bone Joint J*. 2013;**95-B**:1156–1157.

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Statistical power in testing a hypothesis. *J Bone Joint Surg Br*. 2010;**92**:1192–1194.

Chapter 32

Conditions Impacting on Orthopaedic Surgery Structured SBA

Sheba Basheer

CONDITIONS IMPACTING ON ORTHOPAEDIC SURGERY SBA QUESTIONS

1. A 50-year-old diabetic presents with a 3-month history of shoulder pain following trivial trauma. Movement is painfully restricted in all directions especially external rotation.
   What is the most likely diagnosis?
   A. Calcific tendinitis
   B. Adhesive capsulitis
   C. Septic arthritis of the glenohumeral joint
   D. Supraspinatus tear
   E. Unrecognised posterior dislocation of the glenohumeral joint

2. A 40-year-old man is listed for elective ankle arthrodesis for end-stage haemophiliac arthropathy.
   Which of the following should preoperative management NOT routinely include?
   A. Assessment of factor deficiency severity
   B. Factor VIII supplementation
   C. Perioperative tranexamic acid administration
   D. Prophylactic indomethacin
   E. Screening for presence of factor inhibitors

3. A patient who has no prior comorbidities has undergone surgery. Preoperative radiographs are in Figure 32.1. Thirty-six hours post-operatively their heart rate is 105 beats per minute, respiratory rate is 35 breaths per minute and pulse oximetry 90% on room air.
   What is the most appropriate initial investigation?
   A. Arterial oxygen tension
   B. Chest radiograph
   C. D-dimer levels
   D. Duplex ultrasound of the calf
   E. Full blood count and renal function tests

Figure 32.1
An anteroposterior radiograph of left knee

4. A patient is referred to your clinic for consideration for surgery. Radiographs reveal advanced tricompartmental osteoarthritis of the knee. Body mass index is 38kg/m^2.
   Which of the following statements is most accurate?
   A. Arthroplasty carries an acceptable revision rate
   B. It is unlikely that there will be improvement in knee function and pain following surgery
   C. Referral for knee surgery was inappropriate on the basis of the patient's body mass index
   D. There is an increased risk of mortality following knee arthroplasty
   E. Wound healing complications and surgical site infection incidence are no different in this patient group

5. A patient has been treated for *Pseudomonas aeruginosa* infection in a diabetic foot ulcer. They develop sudden onset atraumatic ankle pain and difficulty in weight bearing.
What is the most likely diagnosis?
A. Achilles tendon rupture
B. Charcot arthropathy
C. Osteomyelitis
D. Septic arthritis
E. Stress fracture

6. An 82-year-old woman has presented with this injury (Figure 32.2). She is not vaccinated against COVID-19 and is a smoker.

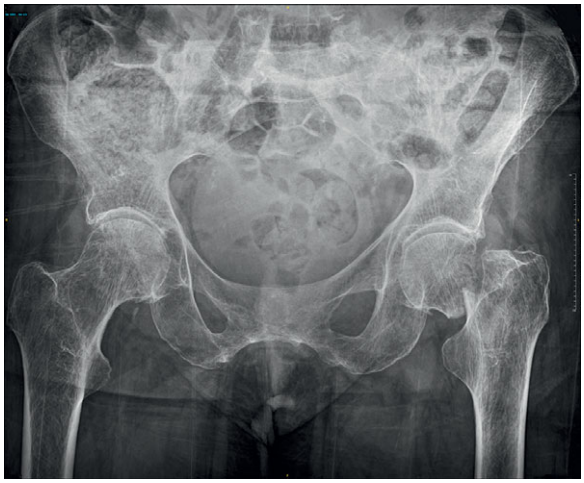

Figure 32.2 Anteroposterior radiograph of pelvis and hips

Contracting COVID-19 in the perioperative period could result in?
A. An increased risk of myocardial infarction
B. An increased risk of wound healing complications
C. Increased risk of mortality due to thromboembolic complications
D. Increased risk of mortality due to viral pneumonitis
E. Post-operative venous thromboembolism

7. A 68-year-old woman is referred with neck pain and occipital headache. An MRI reveals evidence of a soft tissue mass encircling the odontoid process.
Laboratory assessment is likely to reveal which of the following?
A. Calcium pyrophosphate crystals
B. COL1A1 gene mutation
C. Elevated anti-cyclic citrullinated protein
D. HLA-B27
E. M-protein peak on serum protein electrophoresis

8. A 70-year-old woman is 7 days post left primary total hip arthroplasty. She has a previous history of atrial fibrillation but her usual dose of apixaban has been omitted for 2 days due to persistent post-operative serous wound leak. She complains of pain and swelling of the entire left lower extremity.
What should the most important next action be?
A. Administration of oral flucloxacillin for superficial wound infection
B. Administration of intravenous heparin
C. Debridement and implant retention procedure left total hip arthroplasty
D. Duplex ultrasound of the left leg
E. Vena cava filter insertion

9. A 46-year-old woman is listed for a knee arthroscopy. She otherwise has no significant past medical history, but a younger sibling has recently been diagnosed with deficiency of von Willebrand factor.
What should the patient have?
A. Assessment of bleeding score and formulation of haemostasis management plan
B. Mechanical thromboprophylaxis
C. Perioperative antifibrinolytic therapy
D. Post-operative aspirin for thromboprophylaxis
E. Post-operative factor Xa inhibition

10. A child is listed for elective surgery. On enquiry, both parents reveal that they were found to have sickle cell trait.
What is the likelihood of the child being affected by sickle cell disease?
A. 25%
B. 33%
C. 50%
D. 75%
E. 100%

11. A patient with sickle cell disease undergoes elective foot reconstruction surgery. A few hours

post-operatively, they are found to have a mild pyrexia and complain of a cough, shortness of breath and severe back pain.

Which of the following factors may have increased their risk of developing these symptoms?

A. Avoidance of pneumatic tourniquet use
B. Metabolic alkalosis
C. Pain
D. Red cell transfusion
E. Use of antibiotics

12. A 35-year-old with sickle cell disease reports a 3-week history of progressive right groin pain and difficulty weight bearing. He is systemically well with no history of fevers or trauma. Movements of the right hip are painfully restricted in all directions. Radiographs of the hip and pelvis reveal no evidence of fracture.

What is the most sensitive diagnostic test for this patient?

A. C-reactive protein
B. Factor IX levels
C. Magnetic resonance imaging
D. Technetium-99 isotope bone scan
E. Ultrasound scan of the hip +/− aspiration

13. **An individual who is vaccinated against hepatitis B infection would be expected to have which of the following serology markers present?**

A. Anti-HBe
B. Anti-HBs
C. HBcAB IgG
D. HBsAg
E. HBV DNA

14. A 67-year-old is listed for total hip arthroplasty for end stage inflammatory arthritis. They take methotrexate 7.5mg once weekly and prednisolone 5mg daily as part of their disease management.

Which of the following medication adjustments is most appropriate in the perioperative period?

A. Commence anti-TNFα treatment
B. Intravenous hydrocortisone at induction of anaesthesia
C. Omit methotrexate for 14 days post-operatively until wound is healed
D. Omit methotrexate from 7 days prior to surgery until wound healed
E. Omit prednisolone for 14 days post-operatively until wound has healed

15. A patient with rheumatoid arthritis is listed for wrist arthrodesis.

Use of which of the following medications in the perioperative period would be associated with increased risk of post-operative infection?

A. Aspirin
B. Etanercept
C. Leflunomide
D. Naproxen
E. Sulfasalazine

16. A 17-year-old male with Factor IX deficiency presents with vague left hip and thigh pain, and inability to weight bear. There is no history of antecedent trauma. Clinical examination of the hip reveals a positive Thomas' test.

What is the most likely diagnosis?

A. Hip joint haemarthrosis
B. Iliopsoas haematoma
C. L4 disc protrusion
D. Septic arthritis
E. Stress fracture

17. A 45-year-old patient with a background of alcohol dependence presents with a painful swollen left index finger with erythema extending from the distal interphalangeal joint to the fingertip. There is reduced range of motion at the distal interphalangeal joint. There is no history of trauma.

What is the most likely cause?

A. Acute osteomyelitis
B. Avulsion of flexor digitorum profundus
C. Frostbite
D. Monosodium urate deposition
E. Seymour fracture

18. A 15-year-old female competitive sprinter presents with a 3-month history of pain in the left groin after activity. There is no history of injury. There is no significant past medical history and she takes the progesterone only oral contraceptive pill. Radiographs are unremarkable. Clinical examination reveals low body mass index, a

normal gait and discomfort in the left groin but no exacerbation with, or limitation of, hip motion.

What is the most likely cause of her symptoms?

A. Hip dysplasia
B. Hip osteoarthritis
C. Labral tear
D. Rectus femoris avulsion
E. Relative energy deficiency

19. A 54-year-old male sustains a closed, unstable trimalleolar ankle fracture. Past medical history reveals hypertension, angina and diabetes mellitus for which he takes metformin and gliclazide. Capillary blood glucose level is 13mmol/l. Clinical examination reveals strong pedal pulses and hypersensitivity to light touch over the toes. Surgical fixation is planned.

Which of the following statements is most accurate?

A. Blood glucose should be maintained below 6mmol/l
B. Bone healing will be rapid with a risk of heterotopic ossification
C. Risk of revision surgery is greater
D. Use of angiotensin converting enzyme inhibitors in the preoperative period will not lead to a risk of intraoperative hypotension
E. Variable rate insulin infusion should always be used while the patient is fasted

20. A 34-year-old male presents with a closed injury (Figure 32.3). He has a history of human immunodeficiency virus infection 8 years previously and is on antiretroviral therapy.

Figure 32.3 Lateral radiograph of tibia and fibula (distal)

Which of the following factors will most reliably reduce his risk of infection following surgery?

A. CD4 count of 45 cells/mm^3
B. Cephalosporin prophylaxis at induction of anaesthesia
C. HIV-1 RNA less than 200 copies per millilitre
D. Removal of implants following fracture union
E. Serum albumin level of 36g/l

21. **What is the most likely causative pathogen in a patient with a history of HIV infection with poor response to antiretroviral treatment and acute osteomyelitis?**

A. *Escherichia coli*
B. *Mycobacterium tuberculosis*
C. *Pneumocystis carinii*
D. *Staphylococcus aureus*
E. *Staphylococcus epidermidis*

22. A 58-year-old man presents with an 18-month history of groin pain and stiffness limiting activities of daily living. He is active and has a history of human immunodeficiency virus infection for which he is on combination antiretroviral treatment.

Figure 32.4 Anteroposterior radiograph of pelvis and hips

When considering his suitability for hip arthroplasty, which of the following statements is most appropriate?

A. A CD4 count of 200/μl is associated with a higher risk of 30-day mortality than CD4 counts of over 250/μl

B. Antiretroviral treatment should be withheld perioperatively to avoid anaesthetic drug conflict
C. Enhanced surgical precautions should be utilised intraoperatively
D. HIV infection results in an increased surgical risk in virally suppressed patients
E. There is a greater risk of venous thromboembolism in patients with HIV infection

23. A 65-year-old male presents with a 2-week history of a hot, red swollen foot. He is systemically well, able to weight bear and complains of no pain.
What is the most appropriate next investigation?
A. Ankle brachial pressure index
B. MRI scan of the foot
C. Biopsy for histological and microbiological analysis
D. Serum uric acid levels
E. Venous duplex ultrasound

24. A 59-year-old with diabetes mellitus is admitted with cellulitis of the hand to the acute orthopaedic ward. An hour after admission, her heart rate is 130 beats per minute, blood pressure is 100/60mmHg and respirations are 35 per minute. She is conscious and alert, and capillary blood glucose is 9mmol/l.
What is the next most appropriate step in management?
A. Central venous line insertion
B. Intravenous antibiotic administration
C. Surgical debridement with microbiological sampling
D. Variable rate insulin infusion
E. Vasopressor administration

25. A 12-year-old is referred to your general orthopaedic clinic with altered gait. She is autistic and weighs 76 kilograms. Plain radiographs are shown in Figure 32.5.
What is the most appropriate next step in management?
A. Cannulated screw fixation
B. Core decompression
C. Hip aspiration under ultrasound guidance
D. Lumbar spine MRI scan
E. Periacetabular osteotomy

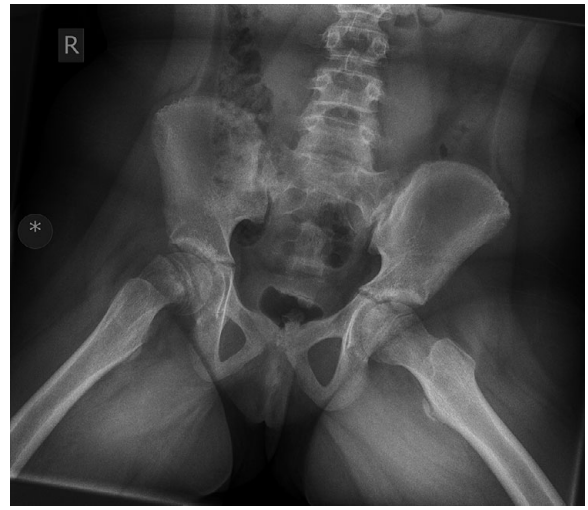

Figure 32.5 Anteroposterior (AP) radiograph of pelvis with frog leg lateral of both proximal femora

26. A 59-year-old man is referred with persistent atraumatic unilateral swelling and warmth of the foot. Radiographs are normal. The patient is systemically well and C-reactive protein is 6mg/l. Magnetic resonance imaging reveals soft tissue oedema not isolated to any individual joint. A standard technetium-99 isotope bone scan is performed and demonstrates increased uptake in all three phases.
Based on the information given, what is the most appropriate next step in management?
A. Biopsy for histological analysis
B. Debridement of septic arthritis
C. Therapeutic dose low molecular weight heparin
D. Non-weight bearing in total contact cast
E. Serial radiographs and protected weight bearing

27. A 20-year-old is referred with shoulder and hip asymmetry. There is a past medical history of a recent admission for spontaneous pneumothorax. On examination he is tall, of slim build and has bilateral flexible pes planus. Beighton score is 9. Adams' forward bend test reveals prominence of the ribs on the right-hand side.
Which of the following statements is most accurate?
A. There may be a reduced arm span to height ratio
B. Steinberg's sign is likely to be negative
C. Nephrology referral is required

D. The underlying condition is due to a defect in elastin production
E. Mitral valve prolapse should be suspected

28. A 3-year-old has been being monitored by their primary care physician for unilateral tibial bowing, they are referred for paediatric orthopaedic review due to parental concern regarding non-resolution. Radiographs reveal an apex lateral and anterior bow of the tibia.

With regards to this condition which of the following statements is most accurate?

A. Fractures should be treated non-surgically
B. Multiple 'coast of Maine' café au lait spots are classically seen
C. There is a risk of fracture and non-union
D. There is likely to be associated congenital knee ligament deficiency
E. This is likely physiological bowing and will resolve without intervention

29. A 27-year-old netball player with no underlying comorbidities has had arthroscopic surgery to her knee. Post-operative images are shown in Figure 32.6. Total anaesthesia time is 75 minutes.

Figure 32.6. Anteroposterior radiograph of right knee

Which is the most appropriate strategy for post-operative venous thromboprophylaxis?

A. Early mobilisation and adequate hydration
B. Factor Xa antagonist
C. Low dose oral aspirin
D. Low molecular weight heparin in prophylactic dose
E. Tranexamic acid at induction of anaesthesia

30. A patient presents with a 48-hour history of an increasingly painful hand. She reports that 5 days ago she was gardening wearing gloves but there was no history of trauma or skin puncture. A previous similar episode resolved with over-the-counter medication. On examination she is apyrexial with erythematous swelling of the index finger and thumb. Movement of the interphalangeal joints is extremely painful. Palpation of the palm does not elicit any tenderness. Plain radiographs demonstrate soft tissue swelling and ovoid erosions with sclerotic borders adjacent to the articular surfaces.

What is the most likely laboratory finding?

A. Anaemia
B. Elevated anti-cyclic citrullinated protein
C. Needle-shaped negatively birefringent crystals
D. Positive HLA-B27
E. Positive rheumatoid factor

CONDITIONS IMPACTING ON ORTHOPAEDIC SURGERY STRUCTURED SBA ANSWERS

1. Answer B. **Adhesive capsulitis**
Diabetes mellitus is a recognised risk factor for the development of adhesive capsulitis. Adhesive capsulitis, or frozen shoulder, is a painful and debilitating condition resulting in painful restriction of motion in the shoulder joint, with external rotation particularly affected. It commonly presents in patients who are in the sixth decade of life, and rarely in those under 40 years of age. Other causes of loss of shoulder external rotation include arthritis of the glenohumeral joint, or a chronic, locked posterior dislocation. The most common comorbidity associated with frozen shoulder is diabetes mellitus. The prevalence of frozen shoulder in the general population is around 0.75%, but this is much higher in those with diabetes mellitus.

Dyer BP, Rathod-Mistry T, Burton C, van der Windt D, Bucknall M. Diabetes as a risk factor for the onset of frozen shoulder: a systematic review and meta-analysis. *BMJ Open* 2023;**13**:e062377.

2. Answer D. **Prophylactic indomethacin**
Non-steroidal anti-inflammatory drugs, such as indomethacin, are not recommended for use in patients who have increased bleeding risk, such as haemophilia.

Poston JN, Kruse-Jarres R. Perioperative hemostasis for patients with hemophilia. *Hematology. American Society of Hematology Education Program* 2022;**1**:586–593.

3. Answer A. **Arterial oxygen tension**
The radiograph demonstrates medial compartment knee osteoarthritis. Following lower limb surgery there is an increased risk of venous thromboembolism. In the context of a post-operative patient with tachycardia, tachypnoea and low oxygen saturations the differential diagnosis includes pulmonary embolism and the most appropriate initial test would be an arterial blood gas to quantify arterial oxygen tension (PaO_2). Of the remaining possible options a chest radiograph and baseline bloods would also be appropriate, but the most appropriate *initial* bedside test would be an arterial blood gas.

4. Answer A. **Arthroplasty carries an acceptable revision rate**
A recently published registry cohort study demonstrated that there was no evidence of poorer outcomes in obese patients undergoing primary knee arthroplasty surgery. Patients with raised BMI were more likely to have undergone revision surgery but the cumulative revision rate was still below the benchmark of 5% generally considered to be acceptable. The same study also reported no increase in mortality following knee arthroplasty.

Evans JT et al. Obesity and revision surgery, mortality, and patient-reported outcomes after primary knee replacement surgery in the National Joint Registry: a UK cohort study. *PLoS Med.* 2021;**18**:e1003704.

5. Answer A. **Achilles tendon rupture**
Pseudomonas aeruginosa may be treated by fluoroquinolone antibiotics such as ciprofloxacin which are associated with tendinopathy or tendon rupture.

Baik S, Lau J, Huser V, McDonald CJ. Association between tendon ruptures and use of fluoroquinolone, and other oral antibiotics: a 10-year retrospective study of 1 million US senior Medicare beneficiaries. *BMJ Open* 2020;**10**:e034844.

6. Answer D. **Increased risk of mortality due to viral pneumonitis**
Since the coronavirus pandemic, there has been data emerging on the impact of COVID-19 infection on patients undergoing surgery. Evidence suggests that there is a 19% 30-day mortality in elective patients undergoing surgery, and for emergency surgical patients this risk increases to 26%. Around half of patients operated on when infected with COVID-19 experienced post-operative pulmonary complications. Patients who are currently symptomatic are at greater risk of 30-day mortality than patients whose symptoms have resolved or those who have asymptomatic infection.

Patients who sustain fragility hip fractures are often at an overall increased risk of morbidity

and mortality due to associated comorbidities and frailty, however perioperative COVID-19 infection can increase risk of mortality due to respiratory compromise and hypoxia due to viral pneumonitis.

Patients undergoing elective surgery will usually be expected to be free or fully recovered from COVID-19 infection prior to proceeding with surgery unless the risks of postponing surgery outweigh the risk of post-operative morbidity or mortality associated with COVID-19. However, patients may present in the trauma or emergency setting with concurrent infection and therefore it is important to understand the principles of perioperative management of such patients.

The urgency of surgery will need to be determined and, in some cases, surgery will be postponed until the patient no longer presents an infection risk to other patients or health professionals involved in their care.

In cases where there is no option but to proceed with surgery, considerations include:

(1) **Personal protective equipment**: COVID-19 is predominantly spread by respiratory droplets. These are relatively large particles (5–10μm) expelled when an infected individual talks, breathes heavily, coughs or sneezes. These tend to fall to nearby surfaces or the ground within about 1 metre from the infected person. Use of fluid-resistant surgical masks and standard personal protective equipment and hand hygiene practices is expected to provide sufficient protection from this form of transmission. Aerosol (airborne) transmission may be possible when procedures that generate aerosols are performed including endotracheal intubation, manual ventilation before intubation, non-invasive positive-pressure ventilation, tracheostomy, bronchoscopy and cardiopulmonary resuscitation. This involves much smaller particles (less than 5μm in diameter) which can remain in the air for long periods of time and be transmitted to others over distances greater than 1m. Enhanced personal protective equipment is used in these circumstances, including FFP3 face masks, long-sleeved gowns, gloves and visors.

(2) **Type of anaesthesia**: In patients with respiratory symptoms regional, neuraxial or local anaesthetic techniques may be preferred in order to reduce the risks of respiratory complications secondary to general anaesthesia and ventilation, as well as avoiding the risk of aerosol transmission.

(3) **Theatre protocols and ventilation**: Local protocols will define the exact requirements for taking a patient with COVID-19 to theatre. There will be specific instructions for how the case is booked, and the team who will be conducting the case. Staff present in theatre will be limited to essential personnel. There will commonly be a supporting team outside. The two teams will be able to communicate (for example through intercom or walkie-talkie) and the team outside functions to retrieve any additional equipment or medications that may be required during the case. The patient will usually be anaesthetised within the theatre itself and not in the anaesthetic room. Both laminar flow and plenum airflow systems are effective in reducing transmission risk. It is recommended that ventilation should remain fully on during surgical procedures where patients may have COVID-19 infection in both laminar flow and conventionally ventilated theatres. Following the case, the patient is usually recovered in theatre and then transferred back to the ward. There is a pause before any further theatre activity/cleaning to allow sufficient air changes for 99% airborne contaminant removal (may be between 10 and 20 minutes and will differ between hospitals).

El-Boghdadly K et al. SARS-CoV-2 infection, COVID-19 and timing of elective surgery. A multidisciplinary consensus statement on behalf of the Association of Anaesthetists, Centre for Perioperative Care, Federation of Surgical Specialty Associations, Royal College of Anaesthetists, Royal College of Surgeons of England; 2021. https://cpoc.org.uk/guidance-sars-cov-2-infection-covid-19-and-timing-elective-surgery

Fadulelmola A, Gregory R, Gordon G, Smith F, Jennings A. The impact of COVID-19

infection on hip fractures 30-day mortality. *Trauma (London, England)* 2021;**23**:295–300.

7. Answer C. **Elevated anti-cyclic citrullinated protein**
The clinical symptoms and imaging findings are suggestive of pannus formation at the atlantoaxial joint, which is consistent with rheumatoid arthritis with cervical involvement. Anti-cyclic citrullinated protein (anti CCP) is the most specific and sensitive biochemical marker for rheumatoid arthritis. M-protein on serum electrophoresis is associated with plasma cell disorders such as multiple myeloma. The COL1A1 gene is responsible for Type 1 collagen synthesis and is implicated in Ehlers Danlos syndrome and osteogenesis imperfecta. HLA B27 is associated with ankylosing spondylitis which is not associated with pannus formation, nor is calcium pyrophosphate disease.

8. Answer D. **Duplex ultrasound of the left leg**
In this scenario the diagnosis of deep venous thrombosis should be excluded as this will influence further management options. If there is a delay to scan there will be a local protocol of anticoagulation to follow to prevent clot propagation and embolism, however current alternative anticoagulant options mean that intravenous heparin is no longer commonly used.

9. Answer A. **Assessment of bleeding score and formulation of haemostasis management plan**
Von Willebrand's disease is an autosomal dominant inherited bleeding disorder characterised by an increased risk of post-surgical bleeding and bleeding from mucosal surfaces. With a family history of first degree relative with von Willebrand disease the patients would be best preoperatively managed by assessment of their bleeding risk (bleeding scores or bleeding assessment tools) and an individualised perioperative management plan for optimal haemostasis.

O'Donnell JS, Lavin M. Perioperative management of patients with von Willebrand disease. *Hematology. American Society of Hematology. Education Program* 2019;**1**:604–609.

10. Answer A. **25%**
Sickle cell disease is an autosomal recessive disorder. Individuals with sickle cell trait usually do not demonstrate any features of the disease but do carry the gene. As this is an autosomal recessive disorder, by drawing a genetic diagram (Table 32.1) we can demonstrate that there is a 1 in 4 chance of a child of two sickle trait carriers (Ss) being homozygous (ss) for the recessive allele. The dominant allele is represented by a capital letter and the recessive by a lowercase letter. Similar diagrams can be created to calculate likelihood of inheritance of other autosomal (Table 32.2) or sex-linked conditions (Table 32.3).

Table 32.1 Punnet square diagram demonstrating likelihood of two heterozygotes having a child who is homozygous for the recessive allele (1 in 4), in this case for sickle cell anaemia. There is a 1 in 2 chance of a child who is a carrier and a 1 in 4 chance of a child who does not carry the recessive allele.

	S	s
S	SS	Ss
s	Ss	**ss**

Table 32.2 Punnet diagram to demonstrate likelihood of an individual who is affected by an autosomal dominant condition (and is heterozygous for the allele in question) and an individual who is unaffected by the same condition having a child who is affected for the same condition (1 in 2). Examples include neurofibromatosis and Marfan syndrome.

	N	n
n	**Nn**	nn
n	**Nn**	nn

Table 32.3 Punnet diagram to demonstrate likelihood of an affected male child born of a carrier female (X'X) and unaffected male (XY). X'Y indicates affected male offspring (1 in 4 chance). Examples include Duchenne muscular dystrophy (X linked recessive).

	X	Y
X′	XX′	**X'Y**
X	XX	XY

11. Answer C. **Pain**
The symptoms are suggestive of possible postoperative sickle cell crisis. Pain is a recognised factor that may precipitate sickling. Patients with sickle cell disease should have careful preoperative assessment and involvement of the acute pain service if undergoing major surgery.

Sickle cell disease (SCD) is an autosomal recessive genetic disorder of abnormal haemoglobin synthesis. In a low oxygen environment, the abnormal Hb-S molecules polymerise, resulting in stiff and sickle-shaped erythrocytes that are less able to pass efficiently through the vasculature. This leads to an increased risk of microvascular occlusion and haemolysis. Sickling can be precipitated by hypoxia, dehydration, stress, pain, infections, cold environment and medications, including those that may be used in anaesthesia and surgery, such as sedatives and local anaesthetic drugs. As such perioperative management should include due consideration for and action towards minimising hypoxia, hypothermia, acidosis, intravascular volume depletion and management of postoperative pain.

Patients with SCD are susceptible to bone and joint infection due to localised areas of reduced blood flow resulting in relative ischaemic zones, and splenic dysfunction with resultant immune deficiency. Osteomyelitis often occurs in the diaphyseal region in SCD (as opposed to the metaphysis). Infection may be with *Salmonella* species, and it is important to cover for both *Staphylococcus* as well as *Salmonella* until microbiology results are available. Bone infarcts and osteonecrosis may also occur due to microvascular occlusion and may be challenging to diagnose and distinguish from infection. Other musculoskeletal manifestations include bone marrow hyperplasia with persistence of red marrow in both the appendicular as well as the axial skeleton which may increase the risk of fracture, and fish mouth vertebrae due to bone softening adjacent to the vertebral end plates.

Walker I et al. Guideline on the perioperative management of patients with sickle cell disease: guideline from the Association of Anaesthetists. *Anaesthesia* 2021;**76**:805–817.

12. Answer C. **Magnetic resonance imaging**
The history is suggestive of possible early avascular necrosis of the hip. Avascular necrosis is a frequent complication of sickle cell disease. In the absence of clinical features of sepsis, the most sensitive investigation would be magnetic resonance imaging of the hips, comparing the unaffected side with the symptomatic side. Technetium-99 isotope bone scan is initially 'cold' in early avascular necrosis.

13. Answer B. **Anti-HBs**
Hepatitis B surface antibody is present in individuals vaccinated against hepatitis B.

All healthcare workers and students who may be occupationally exposed due to contact with blood, tissue and bodily fluids are offered immunisation against hepatitis B to avoid inadvertent infection and subsequent risk of transmission to patients.

Following a primary course of immunisation (approximately 1–4 months) antibody titres are checked. The aim is to achieve anti-HBs levels above 100mIU/ml, although levels of 10mIU/ml or more are generally accepted to protect against infection. Individuals found to have anti-HBs levels of 10–100mIU/ml should receive one additional dose of vaccine. Non-responders and those that decline or are unable to have vaccination may be restricted from performance of exposure-prone procedures unless they can be proven to not be infective.

HBsAg, or hepatitis B surface antigen indicates current hepatitis B infection.

HBV DNA is a measure of hepatitis B viral load in an infected individual.

Anti-HBe indicates recovery following acute hepatitis B infection.

HBeAg, the hepatitis B e antigen correlates directly with infectivity.

HBcAB IgG, hepatitis B core antibody, indicates previous or current infection.

14. Answer B. **Intravenous hydrocortisone at induction of anaesthesia**
Methotrexate is usually considered safe to continue in the perioperative period and a number of studies have demonstrated no increased risk of wound healing complications or infection with continued use. However, patients taking prescribed glucocorticoid therapy are at risk of suppression of the hypothalamic-pituitary-adrenal axis. This places them at risk of adrenal insufficiency and subsequent adrenal crises during surgical stress or acute illness. Hydrocortisone should be given intravenously at induction of anaesthesia in adult patients and continued as an infusion until they are able to take their usual oral glucocorticoid dose.

Goodman SM et al. 2022 American College of Rheumatology/American Association of Hip and Knee Surgeons guideline for the perioperative management of antirheumatic medication in patients with rheumatic diseases undergoing elective total hip or total knee arthroplasty. *Arthritis Care Res.* 2022;**74**:1399–1408.

Krause ML, Matteson EL. Perioperative management of the patient with rheumatoid arthritis. *World J Orthop*. 2014;**5**:283–291.

Woodcock T et al. Guidelines for the management of glucocorticoids during the perioperative period for patients with adrenal insufficiency: guidelines from the Association of Anaesthetists, the Royal College of Physicians and the Society for Endocrinology UK. *Anaesthesia* 2020;**75**:654–663.

15. Answer B. **Etanercept**
Etanercept is a TNF-α antagonist. TNF-α use in the perioperative period has been shown to increase the risk of post-operative infection and it is usually recommended to withhold these in the perioperative period. None of the other medications has been demonstrated to increase risk of post-operative infection.

Giles JT et al. Tumor necrosis factor inhibitor therapy and risk of serious postoperative orthopedic infection in rheumatoid arthritis. *Arthritis and Rheumatism* 2006;**55**:333–337.

16. Answer B. **Iliopsoas haematoma**
Factor IX deficiency is also known as haemophilia B or Christmas disease. Factor VIII deficiency results in haemophilia A. Both are classically sex-linked recessive disorders characterised by prolonged and excessive bleeding which may be spontaneous or after minimal trauma. The musculoskeletal system is often involved with acute haemarthroses which may lead to arthropathy (usually affecting the knee, ankle and elbow); or bleeds into and around the musculature which may then develop into haemophilic pseudotumours. Intramuscular haematomas are common in haemophilia and occur in up to 25% of patients and are often in the extremities. Bleeding into the thigh musculature can lead to significant volume blood loss and haemorrhage into the forearm or calf compartments may lead to compartment syndrome. The iliopsoas muscles are also a common site for this, and large blood volumes can be lost in the retroperitoneal space. Bleeding into the fascial compartment containing the iliacus and psoas muscles can lead to femoral nerve compression with associated pain in the groin, hip and thigh regions, difficulty weight bearing and flexion contracture of the hip.

Ray A, Colville JG, Hartley R, Rowbotham E. The musculoskeletal manifestations of haemophilia: a review of the imaging findings. *Clinical Radiology* 2022;**77**:730-737.

17. Answer D. **Monosodium urate deposition**
Alcohol is a recognised risk factor for increased uric acid and excess and regular intake of alcohol increases risk of acute gout flares.

Acute osteomyelitis is mainly a condition affecting children and, in the absence of a history of trauma or a wound in this region, is unlikely. Avulsion of flexor digitorum profundus (jersey finger) would not be associated with erythema but is diagnosed by a finger that lies in an extension attitude at the distal interphalangeal joint. There would be a history of cold exposure in the case of frostbite. A Seymour fracture is a physeal fracture of the distal phalanx with an associated nailbed injury, and therefore is an injury sustained by the skeletally immature.

18. Answer E. **Relative energy deficiency**
Athletes have higher calorie intake requirements than individuals who are more sedentary and they are at risk of inadequate nutritional intake (which may be unintentional) and excessive energy expenditure. This combination can give rise to relative energy deficiency (RED-S) – female athletes are at greater risk of this than males and the constellation of interlinked problems used to be referred to as the female athlete triad; disordered eating, low bone density and disordered menstruation. Nutritional deficiency can lead to low body fat which is associated with low oestrogen levels. Oestrogen is extremely important for female bone health as it is a potent mediator of bone remodelling. Activities that lead to repetitive cyclical loading can give rise to microfractures. If the rate of damage accumulation exceeds the rate of remodelling stress fractures may occur. Use of oral contraceptives may

mask menstrual dysfunction associated with RED-S.

A rectus femoris avulsion would usually present with antalgic gait and weakness of hip flexion and the presence of an apophyseal avulsion in the region of the anterior inferior iliac spine.

Pain from an acetabular labral tear is classically provoked when the hip is brought to a position that reproduces the impingement e.g. an anterior labral tear will cause pain on hip internal rotation and adduction.

Statuta SM, Asif IM, Drezner JA. Relative energy deficiency in sport (RED-S). *Br J Sports Med.* 2017;**51**:1570–1571.

19. Answer C. **Risk of revision surgery is greater**
Diabetes mellitus with associated end organ damage such as peripheral neuropathy (hypersensitivity to touch can be a sign) carries an increased risk of infective and non-infective complications that may necessitate the need for revision surgery. This has been reported as a 5 times higher likelihood of revision surgery than patients with diabetes mellitus who do not have end organ damage.

Angiotensin converting enzyme inhibitors are usually omitted preoperatively due to a risk of intraoperative hypotension.

Variable rate insulin infusion is not always required. Capillary blood glucose should be maintained between 6–12mmol/l.

Diabetes mellitus is group of metabolic diseases characterised by hyperglycaemia due to the defective action or secretion of insulin. Chronic hyperglycaemia can lead to the damage and dysfunction of various organs as a consequence of microangiopathy and neuropathy. The number of patients with diabetes who simultaneously require orthopaedic treatment is expected to continue to increase in the coming years, and it is important to be aware of the number of ways that DM may impact a patient's recovery and rehabilitation following orthopaedic treatment:

(1) **Delayed healing**: Diabetes can impair the body's ability to heal wounds, surgical incisions, and fractures. Hyperglycaemia can affect the functioning of immune cells and reduce the production of growth factors necessary for tissue repair. As a result, patients with diabetes may experience delayed healing of surgical wounds and are more at risk of delayed fracture union or non-union.

(2) **Increased infection risk**: Diabetes mellitus causes dysfunction of the immune response resulting in a diminished ability of the body to combat infection. Surgical procedures, particularly those involving implants or prosthetics, carry a higher risk of infection in diabetic patients.

(3) **Peripheral neuropathy**: Chronic hyperglycaemia can lead to peripheral neuropathy which may lead to loss of protective sensation in the affected areas (usually the extremities, particularly the feet). This can lead to an increased risk of post-surgical problems as patients may not feel pain or discomfort associated with complications such as infection, pressure sores or fractures, delaying their diagnosis and treatment.

(4) **Charcot arthropathy**: As a result of peripheral neuropathy, patients may be at risk of accumulating recurrent microtrauma to the feet which, in combination with delayed healing and osteopenia can result in fractures, instability and progressive deformity of the foot.

(5) **Osteopenia and diminished bone quality**: Hyperglycaemia promotes osteoclast function while inhibiting osteoblast function and neovascularisation. It also results in increased glycation of collagen molecules which disrupts the structure and strength of collagen. This results in a net effect of diminished bone quality and strength which increases fracture risk.

(6) **Systemic comorbidities**: Diabetes is often associated with cardiovascular disease and renal disease, which can pose additional risks during orthopaedic surgery. It is therefore essential that a multidisciplinary approach is taken, with collaboration between orthopaedic surgeon, anaesthetist, and endocrinologist, to ensure safe and appropriate perioperative and post-operative management of the orthopaedic patient with diabetes mellitus.

Grant B, Chowdhury TA. New guidance on the perioperative management of diabetes. *Clin Med (London, England)* 2022;**22**:41–44.

Wukich DK. Diabetes and its negative impact on outcomes in orthopaedic surgery. *World J Orthop.* 2015;**6**:331–339.

Wukich DK, Joseph A, Ryan M, Ramirez C, Irrgang JJ. Outcomes of ankle fractures in patients with uncomplicated versus complicated diabetes. *Foot Ankle Int.* 2011;**32**:120–130.

20. Answer B. **Cephalosporin prophylaxis at induction of anaesthesia**

Fracture surgery in the presence of HIV infection has an infection risk comparable to HIV negative patients, but open fractures are at increased risk. The risk is higher in advanced HIV disease with CD4 counts lower than 200 cells/mm^3. There is no evidence that routine removal of hardware following fracture union reduces the risk of late infection. With modern combination antiretroviral treatment, the life expectancy and quality of life of patients with HIV infection that is promptly diagnosed and treated can be similar to that of age-matched, non-infected individuals. HIV infection is associated with low bone mineral density and bone mass which may be due to HIV associated increase in bone resorption and osteoclast presence.

Harrison WJ. HIV/AIDS in trauma and orthopaedic surgery. *J Bone Joint Surg Br Vol.* 2005;**87**:1178–1181.

Pretell-Mazzini J, Subhawong T, Hernandez VH, Campo R. HIV and orthopaedics. musculoskeletal manifestations and outcomes. *J Bone Joint Surg.* 2016;**98**:775–786.

21. Answer D. ***Staphylococcus aureus***

Although HIV infection (particularly with low CD4 counts) may increase susceptibility to opportunistic infection with more unusual pathogens, *Staphylococcus aureus* remains the most common infective organism.

Harrison WJ. HIV/AIDS in trauma and orthopaedic surgery. *J Bone Joint Surg Br Vol.* 2005;**87**:1178–1181.

22. Answer E. **There is a greater risk of venous thromboembolism in patients with HIV infection**

As the life expectancy for patients with HIV infection has increased, so too has demand for elective surgical procedures such as arthroplasty. Joint replacement surgery is considered safe in patients with HIV infection who are on appropriate antiretroviral treatment with adequate CD4 counts.

However, patients living with HIV infection have a greater risk of venous thromboembolism than uninfected individuals. Therefore, early mobilisation and use of pharmacological thromboprophylaxis is essential.

Patients with CD4 counts of over 200/μl and those who are virally suppressed are considered to have comparable risk to patients without HIV. Standard (universal) precautions should be taken intraoperatively and antiretroviral treatment should not be withheld wherever possible, but dose adjustments for medications may be required if there is drug conflict.

Yan L, Ellman T, McNairy M. Perioperative care in adults with HIV; 2021. https://www.ncbi.nlm.nih.gov/books/NBK576018/

23. Answer B. **MRI scan of the foot**

A painless hot swollen foot should raise suspicion of possible neuropathic arthrosis. Charcot neuropathic arthropathy is diagnosed based on the clinical history and examination findings, with additional information gained from radiological investigations. There may be a history of diabetes mellitus or known polyneuropathy resulting in diminished pain and proprioception. Magnetic resonance imaging is the most useful imaging modality to confirm the suspicion of early active neuropathic arthropathy as radiographs may appear normal in the prodromal stages (modified Eichenholtz stage 0).

Rosenbaum AJ, DiPreta JA. Classifications in brief: Eichenholtz classification of Charcot arthropathy. *Clin Orthop Rel Res.* 2015;**473**:1168–1171.

24. Answer B. **Intravenous antibiotic administration**

This patient is demonstrating signs of septic shock. The most important step in her immediate resuscitation would be establishing venous access and administering empirical intravenous antibiotics after taking blood cultures. Early administration of antimicrobials is one of the most effective interventions to reduce mortality in patients with sepsis.

Evans L et al. Surviving sepsis campaign: international guidelines for management of sepsis and septic shock 2021. *Crit Care Med.* 2021;**49**:e1063–e1143.

25. Answer A. **Cannulated screw fixation**
The history describes a child who is clinically challenging to assess and is obese. The radiograph reveals a mild slipped capital femoral epiphysis (SCFE). There is evidence of a metaphyseal blanch sign and uncovering of the proximal femoral metaphysis. On the AP view of a normal hip, a line down along the superior femoral neck (Klein line) intersects a small portion of the lateral capital femoral epiphysis. In the presence of a slipped epiphysis the line of Klein intersects less or none at all of the lateral epiphysis. On the frog lateral the displacement of the femoral epiphysis is often more apparent and can be quantified by the amount of metaphysis uncovered or by the head-shaft angle of Southwick. Obesity is one of the major risk factors for SCFE. Other risk factors include genetic predisposition or family history of SCFE, endocrine or metabolic disorders such as thyroid function disturbance, periods of rapid growth, femoral retroversion, systemic steroid usage, and prior local radiotherapy. The most appropriate management would be *in situ* pinning with a cannulated screw.

26. Answer E. **Serial radiographs and protected weight bearing**
The information given is suggestive of early neuropathic arthropathy. Based on the information given this is within the prodromal phase (Eichenholtz stage 0) with normal radiographs, swelling and increased warmth. Aside from determining the extent and cause for the neuropathic arthropathy (e.g. testing and treatment for diabetes mellitus), the foot should be protected and monitored for progression with protected weight bearing and serial radiographs.

Rosenbaum AJ, DiPreta JA. Classifications in brief: Eichenholtz classification of Charcot arthropathy. *Clin Orthop Rel Res* 2015;**473**:1168–1171.

27. Answer E. **Mitral valve prolapse should be suspected**
The patient demonstrates features of scoliosis and Marfan's syndrome which is an autosomal dominant condition cause by a gene defect in FBN1 which codes for fibrillin synthesis. Associated features include above average height and disproportionately long limbs (*increased* arm span to height ratio) and digits, presence of a high arched palate, dislocation of the lens, anterior chest wall deformity (e.g. *pectus excavatum* and *carinatum*), scoliosis, aortic root or mitral valve abnormalities, pulmonary bullae and spontaneous pneumothorax. Steinberg's thumb sign is elicited by asking a patient to fold their thumb into the palm and then close their fist. It is positive if the thumb tip extends beyond the ulnar border of the palm and is suggestive of arachnodactyly which is one of the diagnostic criteria for Marfan syndrome. Bracing for scoliosis in Marfan's syndrome is not usually effective and posterior arthrodesis is usually utilised for curves exceeding 45°.

28. Answer C. **There is a risk of fracture and non-union**
Anterolateral tibial bowing is associated with neurofibromatosis (NF) type 1 in over 50% of cases. There is a continuum between anterolateral bowing and progression to fracture and non-union (so-called congenital pseudarthrosis of the tibia – in fact not a congenital condition but one that develops after birth). Bowing without fracture can be managed with protective bracing, however if fracture occurs this is unlikely to unite without surgical intervention due to the presence of hamartomas. Even when treated with surgical stabilisation and vascularised bone grafting, the surgical management can be wrought with challenge and prone to failure of union.

Coast of Maine café au lait macules are associated with McCune Albright syndrome and are identified by their irregular border, as opposed to the smooth bordered coast of California café au lait spots seen in NF-1.

There are two major types of NF – type 1 and type 2. Musculoskeletal involvement occurs in NF-1, the more common type. This is an autosomal dominant condition with the affected allele present on chromosome 17. The diagnosis is made in the presence of three or more of the following features: axillary and/or groin freckling, five or more café au lait spots (>5mm diameter in child, >15mm in adult), presence of two or more neurofibromas or one plexiform

neurofibroma, optic nerve gliomas, iris hamartoma (Lisch nodules, 2 or more), family history, presence of bony lesions.

The bony lesions that are described include cortical bone defects, anterolateral bowing of tibia, congenital pseudoarthrosis (classically tibia, but ulna, humerus and other long bones have been described), rib pencilling, scoliosis which may be dystrophic with short sharp highly progressive curves or non-dystrophic with appearances more like adolescent idiopathic scoliosis.

29. Answer A. **Early mobilisation and adequate hydration**

The radiograph demonstrates post-operative appearances consistent with arthroscopic anterior cruciate ligament reconstruction. Venous thromboembolism (VTE) prophylaxis is generally not required in people with low individual risk for VTE undergoing arthroscopic knee surgery with total anaesthesia time of under 90 minutes. Patients are risk assessed on admission to identify their individualised risks of thrombosis and bleeding. Following anterior cruciate ligament reconstruction, the patient is usually allowed to weight bear to tolerance and is encouraged to regain range of motion in the knee at an early stage. If total anaesthetic time is greater than 90 minutes, lower limb immobilisation is to be used or if VTE risk is considered to be greater than the bleeding risk then pharmacological prophylaxis with low molecular weight heparin would be considered.

Tranexamic acid is an anti-fibrinolytic agent and not an anticoagulant, so would not be used as an agent for the prevention of VTE.

NICE. Overview: Venous thromboembolism in over 16s: reducing the risk of hospital-acquired deep vein thrombosis or pulmonary embolism: Guidance; 2019. https://www.nice.org.uk/guidance/ng89.

30. Answer C. **Needle-shaped negatively birefringent crystals**

The radiographic features are suggestive of changes associated with established gouty arthropathy. This is caused by deposition of monosodium urate crystals which are strongly negatively birefringent under polarised light microscopy.

Chapter 33

Ethics, Professional Behaviour and Leadership Structured SBA

Hussam Elamin-Ahmed and Hussein Noureddine

ETHICS, PROFESSIONAL BEHAVIOUR AND LEADERSHIP STRUCTURED SBA QUESTIONS

1. You have been assigned as the lead for a local audit meeting and have been asked to give an introductory talk regarding research principles specific to orthopaedic surgery.
   Which of the following statements is true regarding the ethical management of orthopaedic implants?
   A. A surgeon who receives monetary gain from a device he/she has developed may not use this device on his/her own patients
   B. Only studies with positive results should be considered when undertaking a literature review
   C. A surgeon need not disclose to a patient that they are one of the inventors of an implant and are receiving royalties from using that implant
   D. It is the responsibility of the surgeon to be aware of the implant's clinical track record
   E. Only implants with support from peer-reviewed clinical literature may be used in the operating room

2. A 72-year-old female attends your outpatient hip and knee arthroplasty clinic. You list the patient for THA for osteoarthritis. You undertake a shared decision-making process with the patient. You ascertain that she is able to understand, retain, analyse and communicate the necessary information. However, she seems very nervous and says she does not want to know the details of the operation, saying 'I'm in your safe hands Doctor'.
   What would be the most appropriate phrase for the patient?
   A. Document that the patient has declined any further information and sign the consent form
   B. Explain that to give no information may invalidate her consent
   C. Explain the procedure in brief but leave out any details which might worry her further
   D. Explain to her what the treatment aims to achieve, what it will involve and any serious risks
   E. Respect her wishes and sign the consent form

3. You are a recently appointed new consultant. A junior trainee working within the orthopaedic department has recently posted on twitter moaning about the state of the hospital you are working in.
   What would be the most appropriate way to proceed?
   A. Discuss with the trainee's training programme director indicating this should affect her progression in training
   B. Do nothing as they have the right to speak freely
   C. Inform your defence union as you feel that this is inappropriate behaviour
   D. Speak to his/her educational supervisor about the situation
   E. Talk to the trainee and explain they shouldn't do this

4. You are in the middle of a busy fracture clinic. One of the nursing staff asks if you would speak to a man seen earlier with a metacarpal fracture. He is becoming agitated demanding that you issue him one week's supply of methadone as he has 'family court next week'. He usually collects this daily from the pharmacy.
   What would be the single best way to proceed?

A. Give him the prescription he is requesting
B. Obtain advice from a colleague
C. Take him to a consultation room to discuss his concerns
D. Tell him that you cannot help him as this falls outside of your treatment plan
E. Tell him to contact his GP

5. On the morning ward round, you review a patient who underwent a left knee arthroscopy and debridement the previous day. There had been a mix up and the consultant in charge should have performed the surgery on the opposite right knee. Later that day you see the consultant altering the records of the patient.

What is the most appropriate way to proceed?

A. Arrange to meet with the clinical director as soon as possible
B. Complete an incident form for the incorrect procedure being performed
C. Discuss the case directly with the patient on the basis of your duty of candour
D. Discuss the case with another consultant colleague, but do not disclose the patient or consultant
E. Report directly to the GMC

6. You are on-call at a District General Hospital and you are referring a patient with a Gartland III supracondylar fracture for management at a Major Trauma Centre due to requirement of surgical Multi-Disciplinary Team input. The PACS transfer system is malfunctioning and the registrar at the MTC asks you to transfer imaging via WhatsApp. You are aware this is against hospital policy.

What single way is the best way to proceed?

A. Ask the registrar if you can send pictures via NHS email instead
B. Describe the radiograph image only as you are uncomfortable sending via WhatsApp
C. Send the pictures of the radiograph to the registrar via WhatsApp making sure you omit any patient identifiable information
D. Use Careflow – an EPR system
E. Use Siilo – secure medical messaging

7. You are the on-call trauma consultant for the week carrying out your post-take ward round. You receive a call from an upper limb consultant colleague who says he is going to perform a total elbow arthroplasty for an elderly patient admitted with a comminuted distal humerus fracture. They are running late and asked you if you would consent the patient on their behalf to prevent the list starting late, as they are only available for the morning. You are not familiar with the procedure.

What is most appropriate way to proceed?

A. Ask the registrar on call to read up about the procedure and then consent the patient
B. Contact a different upper limb colleague who is in clinic to come and consent the patient on your behalf as they are more familiar with the procedure
C. Contact your colleague due to operate and ask them to explain to you in detail all the associated risks of the operation so that you can relay this to the patient and consent
D. Contact your colleague due to operate and explain you do not feel it is appropriate for you to consent the patient as you are not up to date with all steps of the procedure and the associated risks
E. Leave the consent until the patient arrives in theatre for the operating team to complete

8. You are walking to your office and you come across a previous patient of yours who was recently seen in your OP clinic for back pain. This settled and she has been recently discharged. They thank you for referring them onto physiotherapy and during the conversation tells you that their sister finds you attractive and asks you if you would like to meet her out on a date.

What would the most appropriate option be?

A. Accept the offer on the basis that the patient has been discharged from your care
B. Accept the offer on the basis that this is not the patient but a family member
C. Ask the patient to advise their sister to contact you in 3 months from the date of their discharge from your care as it would be acceptable at that point
D. Politely decline and advise the patient that this would be inappropriate
E. Politely decline the offer and report the matter to your service line manager in writing

9. You review a 19-year-old female patient with a female chaperone in your afternoon fracture clinic. She is being reviewed 2 weeks following a radial shaft fracture. You note that she is particularly withdrawn during the consultation. In addition, you also note unexplained bruises on the other arm. The patient breaks down and explains that her partner has lost his temper and assaulted her. She explains that she has forgiven him and asks you not to disclose the information.

   What would be the single best way to proceed?

   A. Advise the patient that you cannot keep the information confidential and explain that you will notify the local safeguarding team
   B. Reassure the patient that the information will be kept confidential, however encourage her to seek further support
   C. Respect the patient's wishes and arrange and follow up the patient in 4 weeks' time as per your management of the fracture
   D. Respect the patient's wishes, however provide her with written information as to a point of contact should she change her mind
   E. Seek advice from your defence union and book the patient for a 1-week follow up to ensure that you do not miss further opportunities to help if they change their mind

10. You are the consultant on-call at a major trauma centre and receive a call overnight from the registrar updating you with a trauma call. An unconscious patient involved in a RTA was brought in by ambulance. The patient has been identified from cards in his wallet as a local 55-year-old man. He presents with a grossly contaminated open midshaft tibial fracture that needs urgent overnight surgery – however you note consent to be an issue.

    From the options below, what is the best way to proceed?

    A. Advise the Emergency team to resuscitate the patient to regain consciousness prior to consenting for potential limb-saving procedure
    B. Consult with hospital solicitors on an urgent basis prior to proceeding with necessary operative intervention
    C. Only undertake the necessary operative intervention with the express consent of the next of kin
    D. Prioritise the best interest of the patient and inform next of kin at the earliest opportunity
    E. Prioritise the best interest of the patient and maintain confidentiality by not informing the next of kin

11. A 36-year-old patient was admitted on your on-call take with non-specific hip pain. Inflammatory markers were raised and MRI imaging was consistent with pigmented villonodular synovitis. The suggested next investigation is for a nuclear medicine bone scan and you have been advised that this would be today at 14:00 and you inform the patient of this. However, you are later contacted by the department to explain that this will be delayed by several days. The patient subsequently becomes agitated and angry – and has now expressed a wish to make a formal complaint.

    How would you proceed?

    A. Approach or contact the patient to discuss the complaint in detail and attempt to come to a reasonable solution
    B. Contact the patient liaison service (PALS) and ask for advice
    C. Contact your defence union for impartial and specialist advice
    D. Discuss with your consultant colleagues at the next formal consultant meeting seeking advice at how best to proceed
    E. Discuss with your junior colleagues to review the situation and ascertain their individual accounts of the situation

12. You are at the annual orthopaedic department night out. You have had a glass of wine and are enjoying the social event but do not feel tipsy. Through a window, you can see that a male has collapsed in the street and people around are shouting for help. On arrival one of his friends describes him as 'unconscious' and 'not breathing'.

    From the options below, what would be the best way to proceed?

    A. Ask a bystander to call 999 and start to assess the patient yourself
    B. Attend the scene, but avoid direct patient contact, instructing bystanders to contact 999 and check for a pulse

C. Avoid any contact with the situation given recent alcohol intake
D. Call 999 yourself and instruct a bystander on how to check for a pulse
E. Phone your medical indemnity provider for advice before assessing the patient

13. You are on-call at a District General Hospital and at home overnight with the registrar on-site. You get a call from the ED consultant overnight explaining that they have not been able to locate your registrar for the past hour.

How would you best proceed?

A. Contact the on-call registrar immediately to check they are ok; offer your services and ensure they understand the importance of being available
B. Contact the SHO on call to track down the registrar and ask them to notify the registrar to attend the ED
C. Contact your registrar colleague and explain that this is unacceptable and you will be notifying their educational supervisor in the morning
D. Explain to the ED consultant that they should admit patients that they feel appropriate in order to prioritise patient safety
E. Offer to come in and step down to registrar level to ensure the calls are answered and actioned appropriately

14. You overhear a group of nurses at the hospital canteen discussing a patient you are aware of from the ward. This is being done so in voices loud enough to be heard by others. However, they do not mention the patient's name at any point.

The most appropriate next course of action would be?

A. Contact the matron in charge and inform them immediately that there is a group of nurses breaching patient confidentiality
B. Ignore the conversation as no names are being mentioned and thus confidentiality is not being breached
C. Immediately complete an incident form to ensure that the situation is appropriately escalated
D. Interrupt the nurses and explain that they can be heard and ask if they can change the topic of conversation
E. Politely suggest that they should leave the canteen to reduce the risk of any other individuals hearing the conversation

15. You attend your morning clinic and one of the outpatient clinic nurses enters your room to mention concerns with regards to a consultant colleague. He is about to start a clinic but she feels he may be intoxicated with alcohol and she is at a loss what to do.

The most appropriate course of action would be?

A. Contact the rota master and ask for the most experienced middle grade surgeon to be allocated to his clinic so that they can provide additional support
B. Immediately escalate to senior management without approaching your colleague as you are worried about them becoming aggressive
C. Speak to your colleague advising them to go home but that you will maintain confidentiality
D. Speak to your colleague advising them to go home explaining that you will need to inform their clinical lead
E. Speak to your colleague and if they are intoxicated ask if they need help and advise them to go home off sick

16. As a consultant on the on-call trauma rota, it is the first day of your agreed annual leave and you are driving to the airport. To obtain this leave, you have arranged a swap with a colleague. The department manager contacts you and asks where you are. Unfortunately, the colleague covering your shift has yet to arrive for duty and is not responding to phone calls.

How would you best proceed?

A. Explain that you would be willing to cancel your holiday and cover on the basis that you receive a locum pay incentive
B. Explain that there is an email chain clearly documenting the on-call swap and that it's not your problem to sort out
C. Return to the hospital and cover the shift
D. Ring a colleague to find out if anyone has an alternative number for the colleague who agreed the swap
E. Telephone a colleague and ask if they can cover the shift

17. You are at the end of a busy fracture clinic with a registrar colleague. He asks you to review a patient. The patient's breath smells heavily of alcohol and he was verbally abusive and uncooperative when he reviewed him. He is upset about the situation.

How would you best proceed?

A. Ask the registrar to review the patient again but in addition bring along a nursing colleague to act as a witness
B. Suggest that you will review the patient but they should also join you
C. Allow your registrar to tell you how he feels about what has happened
D. Inform the outpatient clinic sister to call security
E. Assess the patient instead yourself with additional nursing staff

18. You complete a routine elective arthroplasty list as normal. You get home later that day to discover that one of the patients has made a friend's request.

How would you best proceed?

A. Adjust your social media privacy settings to prevent any future friend requests
B. Decline the request
C. Delete your social media account
D. Ignore the request
E. Inform your clinical lead about this request

19. You are the consultant on trauma take this week. A patient admitted under your care with an ankle fracture says he is unhappy with several aspects of his treatment including the hospital food and lack of physiotherapy input.

What is the most appropriate next step?

A. Advise him to contact PALS (Patient Advisory Liaison Service)
B. Arrange an informal meeting involving the ward sister and service line manager so that they can address his concerns more fully
C. Ask him to make a formal complaint in writing
D. Go back and listen to his concerns after the ward round to see if you can resolve any issues
E. Remind him of how stretched NHS resources are

20. You are working in a busy fracture clinic. The waiting times for patients are getting longer and longer, however, you are getting through your workload as quickly as possible. You are taking a 5-minute break to go to the toilet when a patient stops you, expressing his 'frustration' at having been made to wait for so long.

What is the best way to proceed?

A. Apologise to him for the wait
B. Ask the nurses to announce to all patients waiting to be seen that the clinic is running late
C. Tell him he can rebook the appointment to a less busy day in the future
D. Refuse to speak to him until he has calmed down
E. Tell him that the department is busy and everyone must wait their turn

21. A 23-year-old man has a Glasgow Coma Scale score of 6 and an open book pelvic fracture. The patient's family reports that he is a Jehovah's Witness. In the operating room during external fixation, the patient's blood pressure becomes unstable.

What is the most appropriate action?

A. Ask the patient's family for consent to give blood
B. Consult the ethics board before giving blood
C. Give the patient blood
D. Use a cell saver
E. Use plasma expanders

22. As per the GMC guidance for consent, it is the responsibility of the doctor performing a procedure to discuss it with the patient and obtain consent.

When this is not practical which of the following should occur?

A. Discussion and consenting can be delegated but only to colleagues who are fully competent to perform the procedure independently
B. Discussion and consenting can be delegated to a colleague who has sufficient knowledge of the proposed investigation or treatment, and understands the risks involved even if they are not fully competent to perform it independently
C. If the consent process is delegated, then it becomes the responsibility of the doctor

obtaining consent to ensure that enough information and time is given to the patient to adequately consent to the procedure

D. If the consent process is delegated, then it becomes the responsibility of the doctor to whom it was delegated to ensure that consent was obtained prior to starting the investigation or treatment

E. The procedure must be delayed until the performing doctor is capable of having the conversation with the patient

23. You are conducting a clinical trial that involves taking blood samples from a patient using a newly invented needle tip that is currently under testing. This investigation is not related to the current treatment of the patient.

Which of the following should occur?

A. Either written or implied consent will suffice if the consent is documented in the clinical notes

B. Implied consent is sufficient as it is a minor and routine investigation

C. Written consent is needed by law for any investigation even if it were considered routine or minor

D. Written consent is needed, as the device is considered an innovative treatment; however, it would have not been indicated if blood samples were taken conventionally, in which case implied consent would have sufficed

E. Written consent is required, even for a minor procedure, if providing clinical care is not the primary purpose of the procedure

24. **Upon assessing the capacity of a young person to consent, which of the following is correct?**

A. A child who does not have the capacity to consent can be involved in research if parental consent is obtained even if the child is refusing in words or actions

B. A person younger than 16 who has been assessed and found to be competent to consent for a certain procedure does not need to be re-assessed if consent is sought for a separate procedure

C. At 16 a patient is presumed to have capacity

D. When assessing a young person's capacity to make decisions, that capacity is based more on age than on their ability to understand and weigh options

E. If a young person is not competent, then consent of one parent is sufficient even if the other parent does not concur

25. **In terms of sharing information with those close to a patient, which of the following options is the most appropriate?**

A. If family members want to discuss the condition of a patient without involving the patient, then you should refuse unless instructed to do so by the patient

B. If the patient lacks capacity, then assume that they would be happy for their information to be shared with those close to them and involved in their care

C. If you feel that disclosing information about a patient who lacks capacity is required or necessary, but they refuse the disclosure, then you can do so if it is in their best interest, without being obliged to inform them as they lack capacity to make that decision

D. When you feel the need to disclose information about a patient who lacks capacity, then you are not obliged to consult with family and close ones unless they have the legal right to make healthcare decisions

E. You must abide by the patient's wishes regarding disclosure of information to those close to them if they have capacity; if their capacity status changes during the treatment, then you could share information with the family as appropriate

26. **If a surgeon uses the wrong implant, thereby causing a degree of harm to the patient they should NOT do which of the following?**

A. Inform the patient promptly and openly of any significant harm, regardless of whether the information has been requested or whether a complaint has been made

B. Promptly apologise and, where appropriate, offer reassurance that similar incidents will not recur

C. Report all incidents where significant harm has occurred through the relevant governance mechanisms

D. Inform prospective patients who are awaiting their surgery of that specific incident in case they wish to reconsider their options

E. Reflect on adverse events and discuss them during their appraisal meeting

27. **In the case of a patient who has religious beliefs prohibiting blood transfusions, what should occur?**
   A. If the immediate family informs the doctor that an unconscious patient has the aforementioned religious beliefs, but no advance directive is presented then the doctor should still comply with the wishes expressed by the family
   B. In an elective setting the treating doctor has the right to choose not to treat the patient if they feel that possible risks are more than what they can accept
   C. In an emergency setting and where blood transfusion is needed, if the patient carries clear documentation stating that they refuse blood transfusion (such as the signed and witnessed advance decision cards), but now is unconscious, then the family should be consulted as the patient is unable to consent in their current status
   D. In cases of absolute emergency in a child, the blood products should be given, and no further authorisation is needed
   E. In cases of a child whose parents/legal guardians refuse blood transfusion, and where no immediate decision is required, advice from another doctor stating that a blood transfusion is needed would provide sufficient basis to proceed. Equally the parents will have to be informed of the decision

28. A child is brought into the ED after a RTA. The patient is 10 years old and is bleeding profusely from an open pelvis fracture. His parents arrive soon afterward and state that they are Jehovah's Witnesses and do not consent to giving blood to their child, even though to not do so threatens the life of their child. The child is awake and fully conscious and agrees with his parents, requesting that he receive no blood.
   What is the next step in treatment?
   A. Attempt to save the child's life, but respect the parent's wishes and give no blood
   B. Attempt to save the child's life, but respect the child's wishes and give no blood
   C. Contact the Jehovah's Witnesses local representative Hospital Liaison Committee Network
   D. Get a court order, then give the child blood
   E. Give the child blood immediately, as needed

29. A patient for whom you recently performed a total hip arthroplasty has left a very large expensive Christmas hamper as a gift for you as a token of appreciation.
   What would the most appropriate course of action be?
   A. Accept the gift and write a letter of thanks to the patient
   B. Accept the gift on behalf of your trust and not in a personal capacity
   C. Declare the gift to HMRC
   D. Give the gift to the nursing staff
   E. Refuse to accept the gift

30. An 80-year-old man is in a persistent vegetative state following a large CVA following hip fracture surgery. Two advance directives are in his case notes. One is a living will stating that the patient requests withdrawal of life-sustaining treatment if he were to ever be in a vegetative form. The other is a lasting power of attorney form stating that his brother is the legally designated surrogate healthcare decision maker. After reading these forms, the brother approaches you and requests that the orthopaedic team continue to treat, feed and rehydrate the patient.
   How will you proceed?
   A. The orthopaedic team should consult the hospital ethics committee
   B. The orthopaedic team should continue to treat, feed and hydrate the patient
   C. The orthopaedic team should let a court decide how you should proceed
   D. The orthopaedic team should seek out the opinion of the next closest family member to resolve the issue
   E. The orthopaedic team should withdraw all treatment

ETHICS, PROFESSIONAL BEHAVIOUR AND LEADERSHIP STRUCTURED SBA ANSWERS

1. Answer D. **It is the responsibility of the surgeon to be aware of the implant's clinical track record**
To answer this SBA, one should be aware of the GMC guidance on financial and commercial arrangements and conflicts of interest. Good medical practice dictates that:
   - You must be honest in financial and commercial dealings with patients, employers, insurers and other organisations or individuals.
   - You must not allow any interests you have affect the way you prescribe for, treat, refer or commission services for patients.
   - If you are faced with a conflict of interest, you must be open about the conflict, declaring your interest formally, and you should be prepared to exclude yourself from decision making.

   And specifically with medical devices:

   If you, or someone close to you, or your employer, has a financial or commercial interest in an organisation providing healthcare such as a pharmaceutical or medical devices company:

   - You must not allow that interest to affect the way you prescribe for, advise, treat, refer or commission services for patients. You must be open and honest with your patients about any such interests.
   - You must not try to influence patients' choice of healthcare services to benefit you, someone close to you, or your employer.
   - You must not ask for or accept any inducement, gift or hospitality that may affect or be seen to affect the way you prescribe for, advise, treat, refer or commission services for patients.

2. Answer B. **Explain that to give no information may invalidate her consent**
If a patient insists that they do not want even basic information about a proposed treatment, you must explain the potential consequences of them not having it, particularly if it might mean that their consent is not valid. You must record the fact that the patient has declined this information. You must also make it clear that they can change their mind and have more information at any time.

   Once you have warned them that you may not be able to obtain valid consent, you should go on to give the vital information. Documentation is very important in difficult situations such as this.

   To have effective discussions with patients about risk when obtaining consent for a procedure, you must identify the adverse outcomes that may result from the proposed options. This includes the potential outcome of taking no action. Risks will usually be side effects, complications and failure of an intervention to achieve the desired aim. Risks can vary from common but minor side effects to rare but serious adverse outcomes possibly resulting in permanent disability or death.

   If a patient does not want to know in detail about the treatment, you should respect their wishes, as far as possible. But you must still give them the information they need in order to give their consent to the proposed treatment. This is likely to include what the treatment aims to achieve and what it will involve, for example: whether the procedure is invasive; what level of pain or discomfort they might experience, and what can be done to minimise it; anything they should do to prepare for the treatment; and if it involves any serious risks.

   You should try to find out why they don't want to be involved in decision making and explore whether you can do anything to reassure and support them. They might be anxious about the decision or overwhelmed by the information and need time or support to process it.

   If, after trying to discuss options with them along the lines set out above, your patient insists that they don't want even this basic information, you will need to judge whether their consent is valid so that you can proceed. This is more likely to be the case if the proposed option is a well-established intervention commonly used for treating the condition they have, and there's reason to believe the patient wants to be treated or cared for rather than take no action. **You should consider seeking advice from your medical defence body or professional association in these circumstances.**

Guidance on professional standards and ethics for doctors. Decision making and consent. https://www.gmc-uk.org/-/media/documents/gmc-guidance-for-doctors—decision-making-and-consent-english_pdf-84191055.pdf.

3. Answer D. **Speak to his/her educational supervisor about the situation**
This is a difficult situation and to deal with it one must be aware of the GMC guidance on using social media and on whistle blowing.

The guidance on using social media in Good Medical Practice states that: "You must make sure that your conduct justifies your patients' trust in you and the public's trust in the profession" and that "that doctors must treat colleagues fairly and with respect".

As for whistle blowing the GMC guidance states that: "Doctors in particular have a duty to act when they believe patients' safety is at risk, or that patients' care or dignity are being compromised" and relevant to this question "Doctors in training may also raise concerns with the GMC about their place of training. However only those with a working relationship with the organisation about which they are raising concerns will be protected from detriment or dismissal under whistleblowing legislation." The Guidance then signposts whistleblowers regarding the means via which they can raise their concerns to the GMC.

In this case however the doctor in training, who as per the GMC guidance has the right to raise concerns about their place of training, is using social media instead of using the recognised channels to raise their concerns. Those concerns must be assessed primarily to ensure that no patient harm is caused and that the wellbeing of doctors in training is looked after and their training needs are met.

The educational supervisor's role here is to discuss those concerns with the trainee and ensure they are directed through the correct channels, locally to start with, and if this fails to address the issues then via the GMC, notwithstanding the importance of the annual GMC survey for training. If the concerns are about trainee well-being or training needs then the educational supervisor can both look into the departmental arrangements regarding supervision, rotas and availability of training opportunities, and also advise the trainee to engage with the TPD regarding these issues, engagement which could be individual or collective alongside other trainees. The educational supervisor could also advise the trainee to familiarise themselves with the relevant GMC guidance.

Posting responses to the tweets is a poor option and is likely to land you in trouble.

4. Answer E. **Tell him to contact his GP**
It is a busy fracture clinic and you will have had little or no involvement in his on-going addiction issues. You are not best placed to deal with them especially in not having an adequate amount of time to explore in detail his worries or concerns and be able to make a sound rational judgement of whether to give him the prescription he wants.

In general, when dealing with a difficult patient, remain calm, listen to what they are saying and provide them with an opportunity to explain what has angered them.

Taking the patient to a consultation room to discuss his concerns is a plausible alternative. The best way to deal with angry or distressed patients is to try to diffuse the situation by taking them to a quiet place and having a discussion in private. You should remain calm, listen to what they are saying and provide them with an opportunity to explain what has angered them. You can find out exactly what the issue is and try to come to a solution together with the patient.

The giveaway in the stem is a busy fracture clinic implying lots of patients still to see. Politely tell the patient you are not able to give him a prescription and the best person to contact for this would be his GP. This is not the best time to be dealing with this situation – perhaps you could discuss his concerns at the end of a clinic – but you are not given this option.

The request is complicated by the fact that the patient is demanding you give him a medication that is usually collected daily and has the potential to be abused. Giving him a week's supply could be dangerous particularly if he gives it to others and this must be considered. In difficult situations such as this it is reasonable to involve your colleagues early for support and guidance.

You should refuse to give him a week's supply but you may be able to come to a compromise, e.g. to collect it at a pharmacy closer to the court.

Although asking him to leave may seem severe it is better than giving him the medication.

Linked guidance. https://www.themdu.com/guidance-and-advice/guides/guide-to-dealing-with-challenging-patients.

5. **Answer A. Arrange to meet with the clinical director as soon as possible**

This is a situation where there is a never event, probity question, and then concerns about a colleague. And for the question to be answered one must understand the principles of probity and duty of candour, as well as the GMC guidance on raising concerns that we have touched on in question 3. The urgent meeting with the medical director or the clinical lead would be to ensure that the patient is made aware and that your colleague is formally made aware of his duties. Regarding the duty of candour, the GMC states that "When you realise that something has gone wrong, and after doing what you can to put matters right, you or someone from the healthcare team must speak to the patient. The most appropriate team member will usually be the lead or accountable clinician." And that "You should speak to the patient as soon as possible after you realise something has gone wrong with their care". This has not happened in this case, and you need to escalate and report, again as per the GMC good medical practice guidance which states that: "You must take prompt action if you think that patient safety, dignity or comfort is or may be seriously compromised", and "If you have concerns that a colleague may be putting patients at risk, you must ask for advice from a colleague, your defence body or the GMC. If you are still concerned you must report this, in line with the GMC guidance and your workplace policy and make a record of the steps you have taken." Urgently discussing the issue with the medical director meets the guidance in terms of seeking advice from a colleague and escalating the issue as per the workplace policies. However, this shouldn't preclude the need for making a record of the steps you've taken through emails or Datix forms after you've sought urgent advice from the medical leadership.

Incident forms (or Datix forms) allow an incident affecting patient safety to be formally recorded and brought to the attention of managerial staff to prevent it from happening again. The forms are sent to multiple members of managerial staff including the clinical director, charge nurse for the ward and hospital administrators. However, it can take days for this to be actioned and in this time the patient that has had the wrong procedure is at risk, as are other patients being treated by the same consultant.

Discussing the case anonymously with another consultant colleague is less helpful as without identifiable information, no immediate action can be taken.

6. Answer A. **Ask the registrar if you can send pictures via NHS email instead**

Currently there is no bespoke solution for this. NHS email is a secure means of communication, so you will be able to discuss patient-related matters and solve the situation efficiently.

Option C is a poor option, as it would go against the hospital's policies and risk breaking patient confidentiality.

Siilo is a secure medical messaging app designed to help healthcare professionals better collaborate on difficult cases, improve patient care and share knowledge in a compliant way. This is reasonable to use but you are assuming the receiving hospital and doctor has permission from their IT department and information governance to use it.

Likewise, CareFlow is a mobile, cloud-based, interoperable electronic patient record (EPR) platform used in some trusts. It could be used if both hospitals were users of this software.

The main guidance one must consider in this scenario is the GMC confidentiality guidance.

Sharing patient information is vital for safe and effective care. This is particularly vital when working within multidisciplinary teams, given that all members must have access to the information that they require for their role. Part of our duty as medical professionals is to ensure that information is only shared in a way that is both legal and ethical, whilst facilitating access to those who require it.

The consequences of inappropriate sharing of information can be significant, for both the clinician/patient relationship and the wider profession. There have been many media examples of inappropriate information sharing, and being aware of the relevant guidelines is crucial for avoiding this.

General GMC Confidentiality Principles

Most patients expect that some information will be shared with those who are directly involved in their care. Unless the patient specifically objects, this is considered implied consent.

If a patient objects to personal information being shared, you should not disclose the information. The exceptions are: if it is justified for the public interest or the patient lacks capacity.

You should explain to the patient the potential consequences of not allowing personal information to be shared and reach a compromise where possible.

In cases where a patient cannot be informed about information sharing, such as an emergency setting, you should pass relevant information to those providing the patient's care.

On entry to a hospital, patients may not be able to explicitly state their consent for information sharing. It is therefore easy to forget that they may wish to withhold some details. Wherever possible, it is good practice to discuss with the patient any concerns which they may have. In many cases, these concerns can be rectified without a need to breach confidentiality. This is the ideal scenario, as it helps to maintain transparency between the doctor and patient.

Conditions for Sharing Information

You must be accessing the information to support the patient's direct care or be satisfied that it is being shared for that purpose.

Patients should be kept informed regarding how their personal information will be used. It should be clear that they have the right to object.

You must have no reason to believe the patient has objected to the information being shared.

You must be satisfied that anyone you disclose the information to understands that you are giving it to them in confidence.

Houston J, Ashby L, Ogidi J, Lui DF, Trompeter AJ. A novel Caldicott-compliant hospital imaging protocol for open fracture photography. *Br J Hosp Med (Lond)* 2020;**81**:1–8.

7. Answer D. **Contact your colleague due to operate and explain you do not feel it is appropriate for you to consent the patient as you are not up to date with all steps of the procedure and the associated risks**

The consenting process is a significant aspect of a surgeon's practice. Often, this may be seen as a routine process, however, it is paramount to approach each consenting process individually. Each consenting episode presents unique challenges and one must be able to identify these and subsequently utilise known principles to ensure the right process is undertaken.

The British Orthopaedic Association (BOA) identifies negligence claims to fall under one of four broad categories:

1. Delayed diagnosis or treatment.
2. Failure to warn about potential complications of surgical or other treatment.
3. Adverse events during surgery.
4. Outcomes that fail to meet the patient's reasonable or unreasonable expectations.

When focusing on this scenario, there is a risk of failing to inform the patient of all the potential complications of surgical or non-surgical management as well as reasonable expectations of outcome due to a limitation in experience with TEA. It is important to identify this and the SBA tests what the best way to proceed would be.

Options A and C allow a surgeon to become more familiar with the procedure and give the opportunity to communicate this information more reliably to the patient. However, this is a less than ideal method to consent a patient.

Option B would address the issue of reliability of information. However, to further include a colleague who is not responsible for the patient, nor is likely to encounter the patient afterwards, greatly compromises continuity of care.

Although option E would allow the patient to have a formal informed consent process with the correct individual, this would not be an ideal situation as the patient may feel pressurised, in the theatre environment and not have been given adequate time to make an informed choice.

8. Answer D. **Politely decline and advise the patient that this would be inappropriate**

To answer this question, one should refer to the "Maintaining a professional boundary between you and your patient" sections of the Good Medical Practice. The guidance is categorical in prohibiting any intimate or emotional

relationships with current patients or using your professional relationship with a patient to pursue a relationship with someone close to them. However, this is a case of a former patient and here the guidance depends on several variables but the key word in the question is that they have been *recently* discharged. The variables in the GMC guidance are:

(1) The length of time since the professional relationship ended.
(2) The nature of the previous professional relationship.
(3) Whether the patient was particularly vulnerable at the time of the professional relationship, and whether they are still vulnerable.
(4) Whether you will be caring for other members of the patient's family.

Regarding the timing, whilst the guidance does not specify a time frame it clearly states that the more recently the professional relationship with the patient ended the less likely any personal relationship will be acceptable. Based on this options A and B are incorrect. Option C is also incorrect as accepting to explore an emotional relationship at this point but deferring it by a specific timeframe is no different in principle to accepting the offer at this point.

As for option E, reporting the issue is only needed if you feel harassed or pressurised by the patient in line with reporting incidents guidance for staff.

9. Answer E. **Seek advice from your defence union and book the patient for a 1-week follow up to ensure that you do not miss further opportunities to help if they change their mind**

Answer E is the most appropriate answer. This is a complex situation with a balance between the principles of maintaining confidentiality and protecting vulnerable adults who retain capacity.

As a principle where people have decision-making capacity under the Mental Capacity Act, doctors have no legal authority to make best interest decisions on their behalf. But where health professionals have serious concerns about whether a competent adult is at risk of being coerced into a decision, they should consider taking legal advice about approaching appropriate services and authorities.

The first step for the doctor to do in this case is to try to speak to the patient, understand their concerns about disclosing the information and try to obtain their consent regarding sharing the information with the adult protection service, or the police. If the patient does not consent then the question becomes whether there is a public interest in disclosing the information. If there is a third party in the same household such as child who is also at risk this will also need to be considered. Even without additional third parties health professionals may seek to disclose information on the basis of the public interest in order to protect competent adults **where they have a reasonable belief that the individual will be the victim of serious crime such as violent assault**. This is unlikely to be a decision that a clinician can make on their own and they should seek medical defence advice after understanding the patient's circumstances and in the interim make sure the patient is booked for frequent follow ups to ensure that no opportunities are missed to help if the circumstances or patient decision changes. The clinician should make clear contemporaneous notes of any decision they make and the reasons behind it and should also make a note of any discussion with colleagues or supporting organisations.

10. Answer D**. Prioritise the best interest of the patient and inform next of kin at the earliest opportunity**

It is essential that treatment is prioritised in terms of patient's best interest in the case of the unconscious patient. In this specific instance, there is a time pressure element to the decision-making process, and thus the fall-back principle of patient's best interest should drive any decision – no matter how difficult this may be.

The Mental Capacity Act 2005

The Mental Capacity Act of 2005 came into force in 2007. It applies to adults over the age of 16 and sets out who can take decisions if a patient becomes incapacitated (e.g. following a stroke). Mental capacity includes the ability to make decisions affecting daily life, healthcare and financial issues.

The Act contains five key principles:

A person must be assumed to have capacity unless it is established that he lacks capacity.

- A person is not to be treated as unable to make a decision unless all practicable steps to help him to do so have been taken without success.
- A person is not to be treated as unable to make a decision merely because he makes an unwise decision.
- An act done, or decision made, under this Act for or on behalf of a person who lacks capacity must be done, or made, in his best interests.
- Before the act is done, or the decision is made, regard must be had to whether the purpose for which it is needed can be as effectively achieved in a way that is less restrictive of the person's rights and freedom of action.

11. Answer B. **Contact the patient liaison service (PALS) and ask for advice**

It is essential to seek advice in a situation where you may be involved in a complaint, but even more paramount not to be seen to be interfering with the process. Trusted colleagues may provide a good initial source of advice as they may have been in a similar situation previously. Defence unions can also be valuable in providing confidential and reliable advice when faced with similar situations.

There is no need to talk with the GMC so early on in the proceedings – most cases will not result in a GMC referral. However, it would be ill advised to try and contact either witnesses or the patient themselves. This would be seen as interfering with the process and this could reflect badly on you if anything comes out of the complaint. Discussing the complaint in detail with the patient without some sort of support and witness could end up aggravating him and make the situation more difficult to resolve.

There is no absolutely correct answer but complaints are part and parcel of consultant practice as we all know. It is not essential to call your defence union for each and every complaint. The next step is generally liaising with the complaints manager or PALS who will receive the complaint or contact the patient if the complaint has not been formally placed yet to understand the issues that the patient is raising, and then they would escalate the complaint accordingly with the radiology superintendent, the divisional manager and the clinical lead as needed to resolve the issues.

12. Answer D. **Call 999 yourself and instruct a bystander on how to check for a pulse**

The GMC states you **must offer assistance** if you come across an emergency situation in the community.

In the UK a doctor has no legal obligation to offer assistance in a community situation, however the GMC states you must offer your assistance and give a reasonable level of care. Failing to help at all is unacceptable and **may risk your registration**.

Although you have alcohol in your system, from the stem you are not drunk and functionally impaired when the situation arises. This indicates that you should offer to help in any way you can. The first point of call would require one to ensure that appropriate help may be recruited as soon as possible. Thus calling 999 would be the most important response whilst instructing a close by individual to assess the emergency.

Maintaining Trust

Maintaining trust is one of the four domains in Good Medical Practice.

Key points include:

- Show respect for patients.
- Treat patients and colleagues fairly and without discrimination.
- Act with honesty and integrity.

13. Answer A. **Contact the on-call registrar immediately to check they are ok; offer your services and ensure they understand the importance of being available**

This question is focused on good communication and teamwork skills when working with a colleague who is underperforming. This is highlighted in the GMC Good Medical Practice's – Communication, Partnership and Teamwork domain, and the Maintaining Trust domain. This GMC guidance specifically advises: "When you are on duty you must be readily accessible to

patients and colleagues seeking information, advice or support."

Contacting the on-call registrar immediately to check they are ok; offer your services and ensure they understand the importance of being available is the most appropriate action since it is clear, direct, polite and professional. As well as this, you are ensuring that you are making it clear that you are available for appropriate escalation or cover should there be any issues.

It is also important that you make these responsibilities clear to any staff in a team that you are leading.

Ultimately you may need to notify the registrar's educational supervisor if there isn't a good valid reason for unbeing uncontactable during their on-call duties. This is particularly so if this behaviour is repeated and may need to be escalated to involve their TPD.

The most important duty of a doctor is to the dignity, safety and care of their patients. Again, it is important for doctors to ensure that it is clear exactly which staff members have which responsibilities, to ensure that these do not "fall between the cracks" and get missed.

When mistakes happen, it is often the result of system problems. For example, it could be that under-staffing puts decision making under higher strain resulting in errors. This happened in the Bawa-Garba case, the tragic death of a child from unrecognised sepsis on a day where a single doctor was trying to cover multiple wards.

Consequently, it is also the responsibility of doctors to engage in setting up and maintaining systems to make sure that risks are appropriately assessed and managed. Doctors are just as accountable for advice they give as a member of a decision-making body, as they are for any other medical advice they offer.

14. Answer D. **Interrupt the nurses and explain that they can be heard and ask if they can change the topic of conversation**

The most important factor to consider when dealing with this situation is that the name of the patient does not have to be mentioned for confidentiality to be breached. Factors related to the patient's diagnosis and treatment may be enough for another individual to identify the patient.

Even if you could not identify the patient from what is being said, the canteen is not an appropriate place to discuss patients. The best thing to do would be just to mention that they can be overheard. This should prompt them to stop.

The next best step is to politely ask the group to leave the canteen – as this would also protect patient confidentiality.

Although completing an incident form would escalate the situation appropriately, this would not contribute to the patient's confidentiality being protected in the immediate short term.

15. Answer E. **Speak to your colleague and if they are intoxicated ask if they need help and advise them to go home off sick**

This is difficult situation to manoeuvre for any clinician. Our team-based ethic often lends to sympathy with one's colleagues.

This case falls under the following GMC leadership and management guidance: "You should be aware that poorly performing colleagues may have health problems and respond constructively where this is the case. You should encourage such colleagues to seek and follow professional advice and offer them appropriate help and support. But, in all cases, you should remember your duty to raise concerns where you believe a colleague may not be fit to practice or may otherwise pose a risk of serious harm to patients." Hence in this case you first speak to your colleague, clarify if there is an issue, and if so speak to them, offer your support and direct them to the help avenues regarding alcohol dependence if needed, and advise them to leave work on sick leave.

It is essential to consider why a colleague may have presented in this way, particularly if it is out of character. As a result, part of your duty as a colleague is to ensure that the correct support is available to a colleague in such a situation.

If the colleague gets defensive and refuses to go home and is unfit to treat patients then you must escalate it and raise your concerns to the clinical lead. Make sure they take a taxi home or offer to get someone to take them home. Do not let them drive home.

The General Medical Council clearly states, "doctors must protect patients from risk of harm

posed by colleague's conduct, performance or health". In this instance, the patients attending clinic are at risk due to the impaired decision making of the intoxicated colleague. Therefore, the priority becomes avoiding such a situation, and ensuring that the clinic does not go ahead, or is covered by a different individual.

16. Answer D. **Ring a colleague to find out if anyone has an alternative number for the colleague who agreed the swap**
This scenario is about coping with pressure. This scenario highlights the need to balance patient needs with your own pre-arranged commitments. Your pre-arranged commitments are important for your wellbeing, but it is expected that patients' needs will be given priority in emergency situations.

The most appropriate response is Option D as it demonstrates being proactive, good medical practice and trying to find creative solutions to solve the dilemma when under pressure.

Option E is the next best option, as it is still directly trying to resolve the problem but does not involve the person that should be covering the shift.

Option C is not ideal as it is important to ensure adequate time off is taken to avoid burn out and it is your professional duty to keep well to maintain workforce stability.

Option A may be perceived as being opportunistic.

The least inappropriate is Option B as it demonstrates avoidance of responsibility and does not demonstrate any concern for patient safety.

17. Answer C. **Allow your registrar to tell you how he feels about what has happened**
This situation is about empathy and sensitivity. There is an expectation/professional responsibility as a doctor to flag up concerns in practice (caused by an abusive patient) that have the potential to adversely impact on a patient's or staff health and wellbeing.

Option C is demonstrating responsibility in listening to your registrar's concerns, whilst gathering more information about the incident to assess the risk to either staff or the patient.

Option B is a reasonable action but not the most appropriate SBA choice.

Option E is resolving the situation for the patient; however, it does not help your registrar address how he is feeling or gather any other information about the incident.

Option A is the least appropriate action as this shows no concern for your registrar, which could potentially put them or the patient at risk.

18. Answer D. **Ignore the request**
Social media can blur the lines between a professional and personal relationship. Your behaviour should be no different online than how you would behave towards a patient in person.

Ignoring the request rather than declining the request whilst not ideal is the preferred option. Lots of requests are sent but never acknowledged and then forgotten about.

Politely declining a request is a reasonable approach but risks offending the patient and altering a doctor–patient relationship. It is a more direct straightforward method but more media savvy users would find the easiest approach is to just ignore the request.

We could endlessly debate between option B and D as the correct choice and in real life; depending on how the SBA is scored by candidates it may end up being deleted from the test paper and need to be either rewritten or scrapped.

By telling your clinical lead early on you are better protecting yourself if anything escalates but it is probably unnecessary and overreacting.

You should not terminate your doctor–patient relationship over this episode. If you send them a message on social media asking them not to message you, this could be misinterpreted the wrong way by the patient and offend them.

19. Answer D. **Go back and listen to his concerns after the ward round to see if you can resolve any issues**
When patients or their relatives feel that they have received inadequate care the first step is to try and achieve local resolution. Speaking to the healthcare professionals involved can often resolve any misunderstandings. If this does not resolve the issue then PALS should be contacted to try and help. If this still fails then a written complaint should be made to allow a formal response from the hospital.

All complaints should be dealt with seriously and on an individual basis. Whilst limited NHS resources will undoubtedly contribute to failings in care they should not be cited in individual cases. Threatening the patient with removal to a different ward is the worst response.

Option B is a very reasonable plan of action but it is preferable if the complaint can be resolved more informally before this.

20. Answer A. **Apologise to him for the wait**
Difficult situations can usually be de-escalated by listening and good communication. In situations with a distressed or angry patient, the best way to deal with it is to calm the situation down. You can apologise for the wait, find out if there is anything you can do and try to resolve the situation.

Hopefully, apologising in the first instance will be enough to resolve the situation. Remember, apologising is not an admission of guilt and can open the channels of communication. If necessary, this can be done in a quiet room rather than the middle of the waiting room but may unnecessarily escalate the complaint.

Telling him to 'wait his turn' may sound patronising and is likely to aggravate the situation further.

There is no suggestion that the patient is being aggressive hence telling the patient to 'calm down' is not helpful.

Calling security at this stage is disproportionate to the issue. Verbal de-escalation and compromise will resolve this far more easily than involving security.

Asking the clinic nurses to announce to all patients waiting to be seen that the clinic is running late should have already been done. This will not deal with the individual patient who is unhappy.

Telling the patient he can rebook the appointment to a less busy day in the future is not ideal. In practice the odd patient may choose to do this but it should be their own choice as you may not be fully aware of the clinical importance of the OP visit and this may compromise treatment outcomes.

21. Answer E. **Use plasma expanders**
Certain medical procedures involving blood are specifically prohibited in the belief system of a Jehovah's Witness whereas others are not doctrinally prohibited. For procedures where there is no specific doctrinal prohibition, a Jehovah's Witness should obtain the details from medical personnel and make his or her own decision.

Transfusions of allogeneic whole blood or its constituents or preoperative donated autologous blood are prohibited. Other procedures, while not doctrinally prohibited, are not promoted such as haemodilution, intraoperative cell salvage, use of a heart-lung machine, dialysis, epidural blood patch, plasmapheresis, white blood cell scans (labelling or tagging of removed blood returned to the patient), platelet gel, erythropoietin or blood substitutes.

The patient should not be given blood. Plasma expanders should be used first to restore haemodynamic stability.

Cell saver blood from an open wound is not usually recommended. Some Jehovah's Witness patients will agree to the use of a cell saver but this requires careful discussions beforehand and is most applicable to a planned elective procedure rather than emergency life-threatening injuries.

The patient's family may be expressing their own beliefs rather than the patient's beliefs and it would be better to ask the patient when he or she is more alert to determine what procedures they would allow.

Consultation with the ethics committee will unnecessarily delay an intervention that should restore haemodynamic stability.

22. Answer B. **Discussion and consenting can be delegated to a colleague who has sufficient knowledge of the proposed investigation or treatment, and understands the risks involved even if they are not fully competent to perform it independently**
The GMC guidance states that the consenting should be undertaken by the doctor performing the procedure; however, if that is not practical, then it could be delegated to a colleague who:

- Is suitably trained and qualified;
- Has sufficient knowledge of the proposed investigation or treatment, and understands the risks involved;
- Understands and agrees to act in accordance with the GMC guidance.

Being able to independently perform the procedure is not needed to be able to consent. With that said, it continues to be the responsibility of the doctor performing the procedure to ensure that the consent process has been undertaken adequately, including that enough information and time have been given to the patient and that the consent has been performed prior to initiating the procedure, rather than being the responsibility of the doctor to whom it was delegated.

http://www.gmc-uk.org/ethical-guidance/ethical-guidance-for-doctors/consent.

23. Answer E. **Written consent is required, even for a minor procedure, if providing clinical care is not the primary purpose of the procedure**

The case here is that of an investigation that is part of a research programme and uses an innovative treatment as part of this research, and the provision of clinical care is not the main purpose of this intervention.

The GMC guidelines state that written consent is needed if an intervention is part of a research programme or if it is an innovative treatment used as part of a research programme. Written consent is also needed if provision of clinical care is not the prime purpose of that intervention. Written consent is needed if the intervention is complex or involves significant risks, or if it might have significant consequences for the patient's employment, or social or personal life. Minor or routine interventions could be done with implied consent if the provider is happy that the patient understands the intervention and why it is done.

http://www.gmc-uk.org/ethical-guidance/ethical-guidance-for-doctors/consent.

24. Answer C. **At 16, a patient is presumed to have capacity**

The GMC guidelines suggest that at 16 a patient could be presumed competent. Option B is incorrect, as the GMC guidelines advise that capacity is assessed on an individual basis and is dependent on the complexity of the intervention, where a child might be able to fully understand a simple intervention but not necessarily have the capacity to consent to complex treatment involving high risks or serious consequences. Their capacity can also be affected by their physical and emotional development and by changes in their health and treatment.

Option E is a challenging situation, and while the consent of one parent is usually enough, if there is disagreement between both parents then legal advice should be sought.

With option A, children or young people should be involved in research only when research on adults cannot provide the same benefits and the risks are minimal, but they should not be involved if they show signs of objection, even with the parents' consent.

With option D, the opposite is true. A young person's ability to make decisions depends more on their ability to understand and weigh options than on their age.

http://www.gmc-uk.org/ethical-guidance/ethical-guidance-for-doctors/0-18-years.

25. Answer B. **If the patient lacks capacity, then assume that they would be happy for their information to be shared with those close to them and involved in their care**

The GMC guidance about disclosure states that in the case of a patient lacking capacity "it is reasonable to assume the patient would want those closest to them to be kept informed of their general condition and prognosis, unless they indicate otherwise".

Option A is wrong, as you are allowed to meet the relatives and listen to their assessment of the situation as it might provide information that could help with clinical decision making. However, you should consider informing the patient and avoid disclosing any information about the patient that they don't want disclosed.

Option C is wrong. In the case of the patient lacking capacity, if you need to disclose information which they refuse to, then you should persuade them of the necessity of the disclosure. If it were obligatory to disclose information without their consent, then you need to make them aware of this before doing so, and, if appropriate, seek and consider the views of an advocate or carer.

Option D is incorrect. In the case of a patient lacking capacity where disclosure is needed, you must consider the views of those close to them about what the patient's likely preferences would be even if they don't have legal guardianship.

Finally, option E is wrong, as you should abide by the patient's wishes that were expressed when they had capacity, and this does not change when they lack it.

www.gmc-uk.org/ethical-guidance/ethical-guidance-for-doctors/confidentiality/using-and-disclosing-patient-information-for-direct-care#paragraph-34.

26. Answer D. **Inform prospective patients who are awaiting their surgery of that specific incident in case they wish to reconsider their options**
Regarding duty of candour for surgeons, it would be beneficial to consult the guidance by the RCS of England. It outlines that in the case of adverse events leading to harm to a patient, the surgeon should inform the patient openly and promptly regardless of whether this information has been requested by them and apologise and assure them that this will not recur. Also report the incident through the appropriate clinical governance processes and reflect on those events and discuss them in the annual appraisal. Informing the prospective patients is not a duty of the involved surgeon.

http://www.rcseng.ac.uk/standards-and-research/gsp/domain-3/3-5-4-responding-to-harm-and-duty-of-candour/.

27. Answer B. **In an elective setting, the treating doctor has the right to choose not to treat the patient if they feel that possible risks are more than what they can accept**
The RCS of England has provided a guide to treating patients who refuse blood transfusion and consulting this guide is useful here. The correct answer is B; the doctor has the right to choose not to treat a patient who refuses blood transfusion in an elective setting if they feel that the impact of not being able to treat a possibly treatable problem through blood transfusion is more than what they can accept. In this situation, however, the doctor must refer the patient onwards to a colleague who would be willing to proceed, knowing the restrictions. The doctor also must detail the reasons for the onward referral in the notes.

Option C is incorrect, as the patient has a clear advance directive, and while the family should always be listened to, they don't have the right to overrule a legally signed advance directive unless adequate evidence could be provided to suggest that the patient had changed their mind after signing the directive.

Option A is wrong, although it represents a very challenging situation; in the absence of a clear advance directive, the judgement of the clinician must take priority over verbal information given by the family.

In option E, what should be sought is not another doctor's opinion but a court order while keeping the parents informed. If the case is that of an emergency where there is no time to obtain such an order (Option D), then the doctor is allowed to proceed with a lifesaving transfusion. However, a court order should be sought as soon as possible.

http://www.rcseng.ac.uk/standards-and-research/standards-and-guidance/good-practice-guides/patients-who-refuse-blood.

28. Answer E. **Give the child blood immediately, as needed**
In the UK, when it comes to the treatment of children under the age of 16 (not just under 12), the law has made provisions to ensure their safety.

Best interests of the child: The paramount concern for doctors is the best interests of the child. This can sometimes override parental wishes. If a doctor believes that a blood transfusion is the only way to save a child's life or prevent serious harm, and the parents object on religious grounds, the doctor can seek legal intervention.

Court orders: If there's an immediate risk to the child's life or long-term health, doctors may provide treatment (including transfusions) while simultaneously applying to the courts for an emergency order. This order can authorise the hospital to proceed with the treatment against the parents' wishes. The court's primary objective is to decide what is in the best interests of the child.

Age and competence: While the focus is on children under 12 in the question, it is important to note that in the UK, if a child is believed to be "Gillick competent" (meaning they have the maturity to understand and make decisions about their own medical treatment), their views

should be considered. However, even if a Gillick competent child refuses treatment, a court may still overrule that decision if it believes the treatment is in the child's best interests.

Respect for beliefs: While the medical community and the courts in the UK prioritise the well-being and safety of the child, there is also an understanding and respect for the deeply held beliefs of Jehovah's Witnesses. Doctors will often make every effort to provide alternative treatments and will usually only resort to legal action when they believe there is no other viable option.

Alternative treatments and strategies available to avoid the need for transfusions include:

Erythropoiesis-stimulating agents (ESAs): These stimulate red blood cell production, potentially reducing the need for transfusions. This is more useful in patients with chronic kidney disease or certain types of anaemia.

Cell salvage: During surgery, blood lost from the surgical site can be collected, cleaned, and then returned to the patient.

Antifibrinolytic drugs: Tranexamic acid can reduce bleeding by stabilising blood clots.

It is worth being aware of the various alternatives that could be used to avoid the need for blood transfusion as this topic often gets asked in a viva examination.

29. Answer B. **Accept the gift on behalf of your trust and not in a personal capacity**

Accepting gifts from patients can be a complex ethical issue for doctors.

Conflicts of interest: Accepting expensive gifts could potentially create conflicts of interest that might compromise the doctor's ability to make unbiased medical decisions. Patients might feel that their gift obligates the doctor to provide preferential treatment.

Professional boundaries: Maintaining appropriate professional boundaries is crucial in healthcare. Accepting expensive gifts might blur these boundaries and impact the doctor–patient relationship.

Ethical considerations: Many medical associations and ethical codes advise against accepting gifts that could potentially influence medical decisions or undermine the trust between doctors and patients.

Value limits: Some institutions or professional associations may establish guidelines regarding the value of gifts that doctors can accept. Smaller, token gifts might be acceptable, but larger or more extravagant gifts could be seen as problematic.

Transparency: If a doctor does receive a gift from a patient, it is generally considered ethical to disclose it to the appropriate parties, such as supervisors or colleagues, to maintain transparency and accountability.

Cultural sensitivity: In some cultures, giving gifts as a sign of gratitude or respect is a common practice.

It is important for doctors to carefully consider their own ethical obligations, the policies of their institution, and any relevant legal or professional guidelines before accepting gifts from patients.

Guidance from Gateshead Health NHS Foundation Trust includes:

- Gifts of cash and vouchers to individuals should always be declined.
- Staff should not ask for any gifts.
- Gifts valued at over £50 should be treated with caution and only be accepted on behalf of Gateshead Health NHS Foundation Trust, not in a personal capacity. These should be declared by staff.
- Modest gifts accepted under a value of £50 do not need to be declared.
- A commonsense approach should be applied to the valuing of gifts (using an actual amount, if known, or an estimate that a reasonable person would make as to its value).
- Multiple gifts from the same source over a 12-month period should be treated in the same way as single gifts over £50 where the cumulative value exceeds £50.

What Should be Declared?

- Staff name and their role with the organisation.
- A description of the nature and value of the gift, including its source.
- Date of receipt.

If a patient is insistent on offering money as a gift suggest they donate this to one of the hospital charities and make sure it is not a personal

financial gift. Sharing out the gift with multiple nursing staff is a good option provided the trust has been informed of the gift to avoid any potential for a conflict of interest and transparency.

30. Answer E. **The orthopaedic team should withdraw all treatment**

An "advance directive" or "living will" is a legal document that outlines a person's decisions about end-of-life care ahead of time. It provides a way for individuals to communicate their wishes to family, friends, and healthcare professionals, to avoid confusion later on.

A lasting power of attorney is another type of advance directive that allows a patient to name someone else (a proxy or agent) to make health decisions for them if they are unable to do so. This person will have the authority to make decisions about a patient's medical care based on the patient's living will guidelines and any other wishes the patient has communicated to them.

In many cases, patients choose to have both a lasting power of attorney and a living will. This approach ensures that they have a designated person to make decisions for unforeseen circumstances and that their specific wishes about particular treatments are documented.

In this case, the patient meets criteria for persistent vegetative state and therefore the orthopaedic team should follow the patient's written request and withdraw life-sustaining treatment. If the living will had not been done, the surrogate healthcare decision maker would have had authority to dictate how to proceed with treatment. Although surrogates should typically make decisions consistent with the stated wishes of the patient, this case highlights the importance of patients making their wishes known in a format such as the living will.

The hospital ethics committee does not need to be consulted because the living will clearly states the appropriate course of action for the given clinical situation.

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