PLEASE CLICK ON THE FOLLOWING LINK TO WATCH THE LECTURE ONLINE:-

https://www.youtube.com/watch?v=A8qp5WU0NKk&list=PLuBRb5B7fa_d_ITkxtB-KQYUusx0C1s_x&index=10

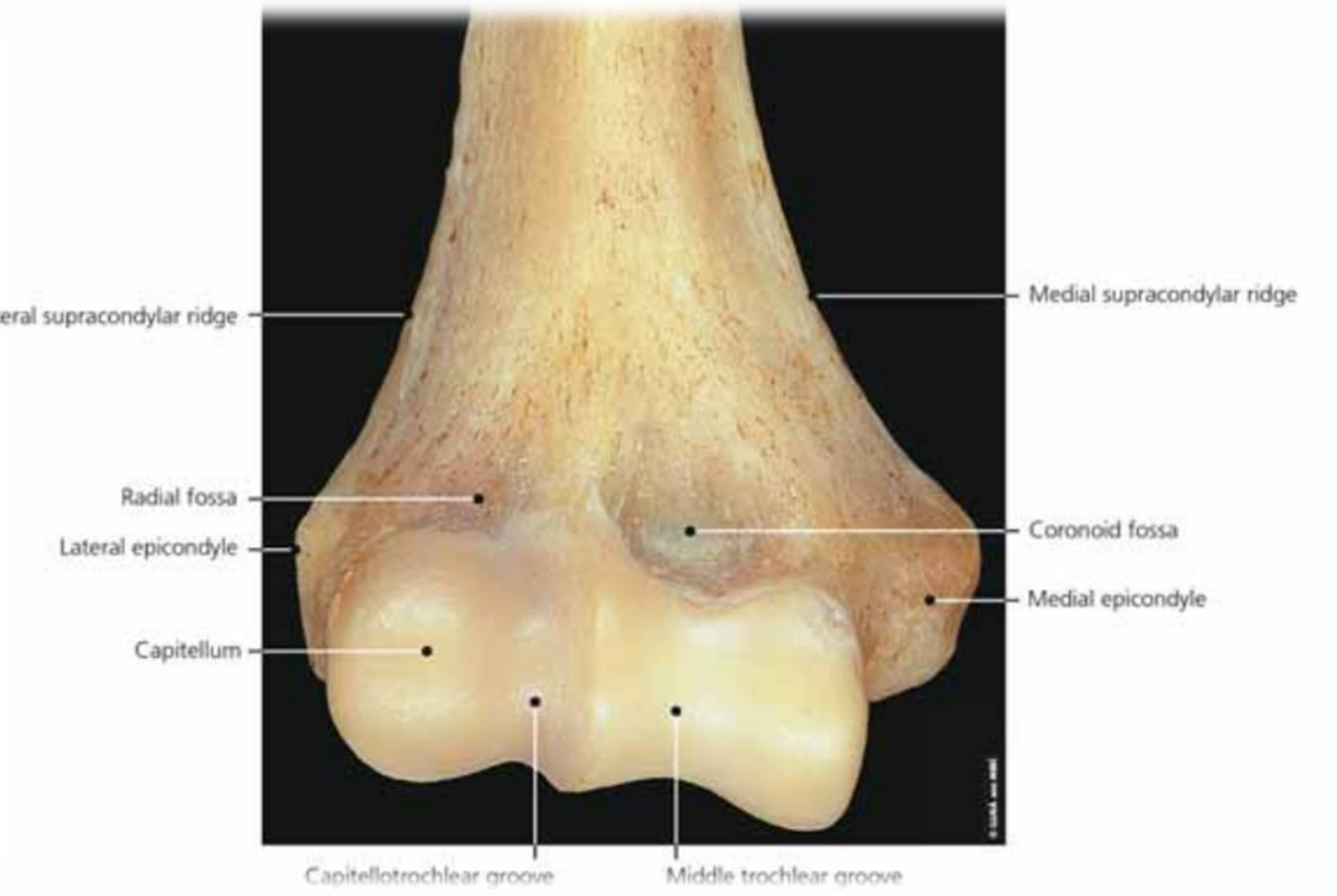
Approach to Distal Humeral Fractures

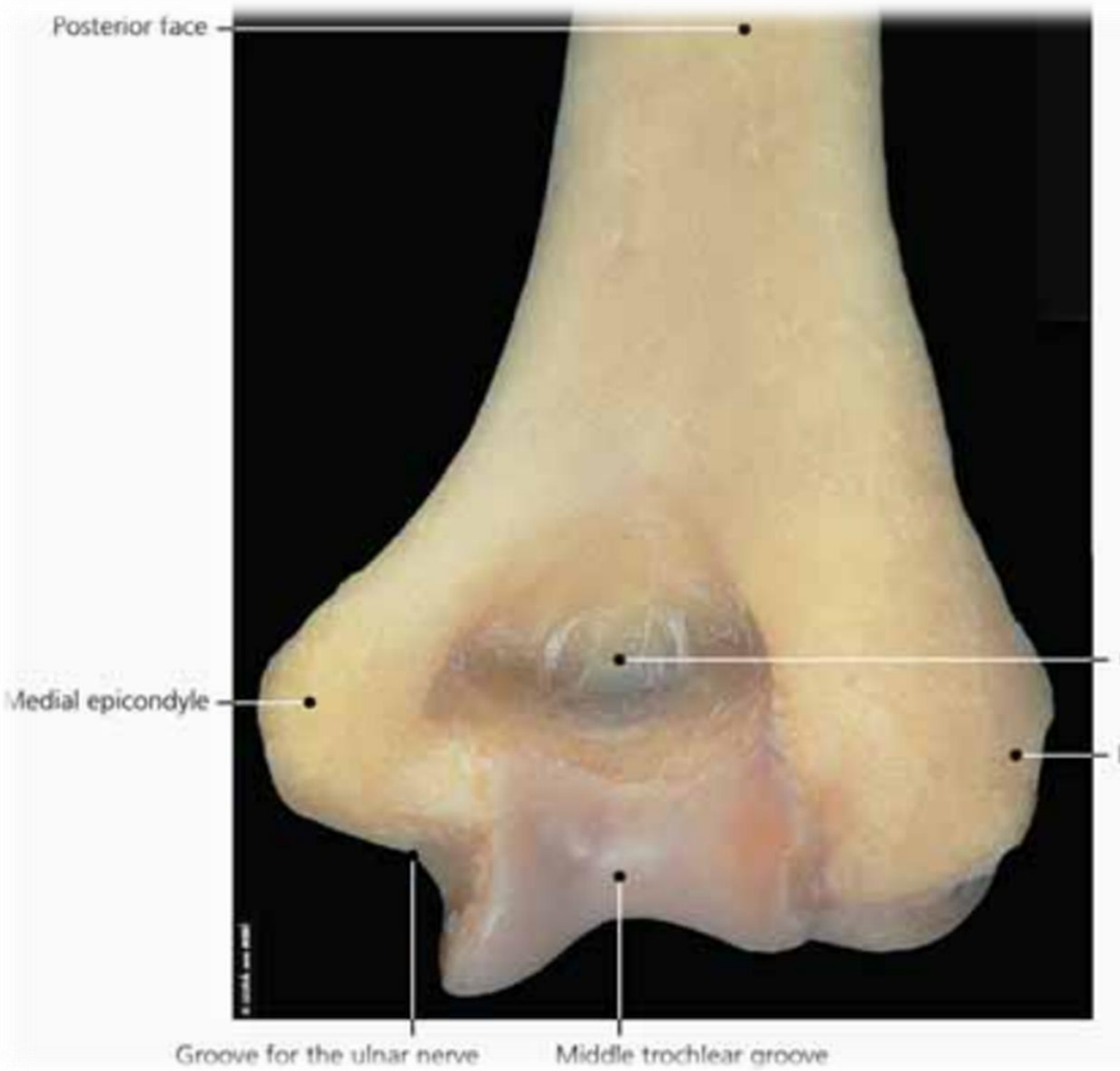
Headlines

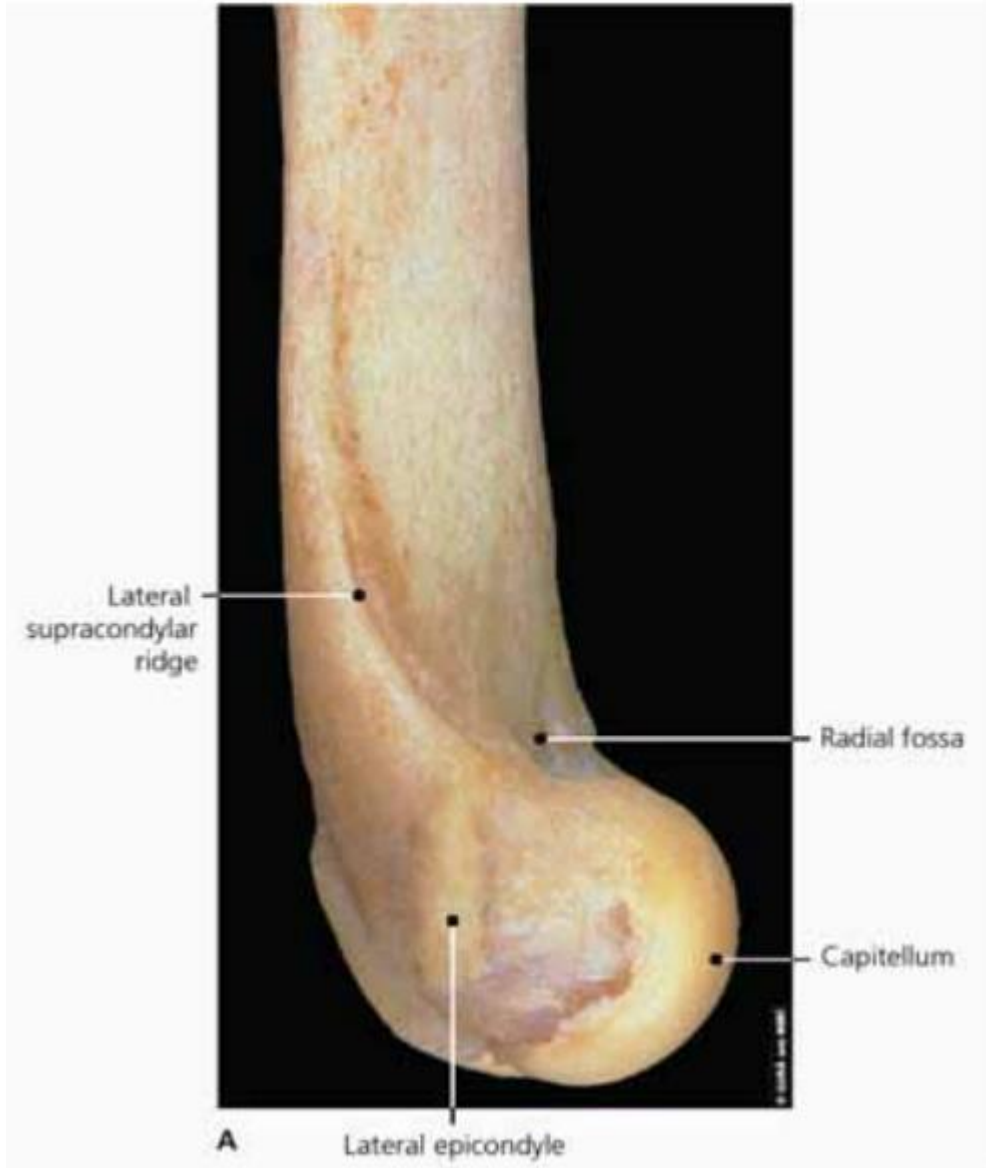
- Anatomy.
- Epidemiology.
- Imaging.
- Fractures Classification.
- Management.
- Approaches.
- Techniques.

Anatomy

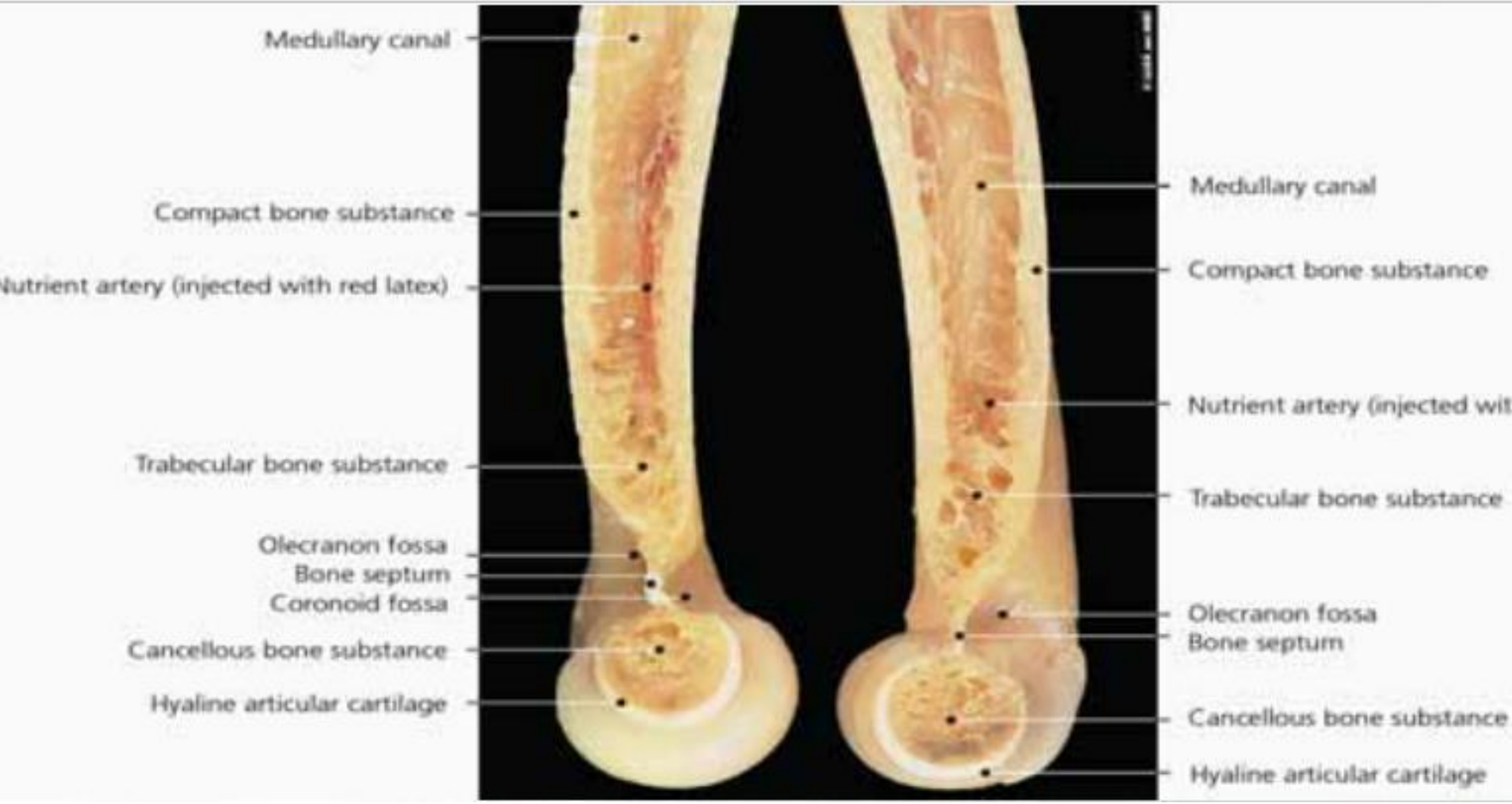
Trocho-ginglymoid joint

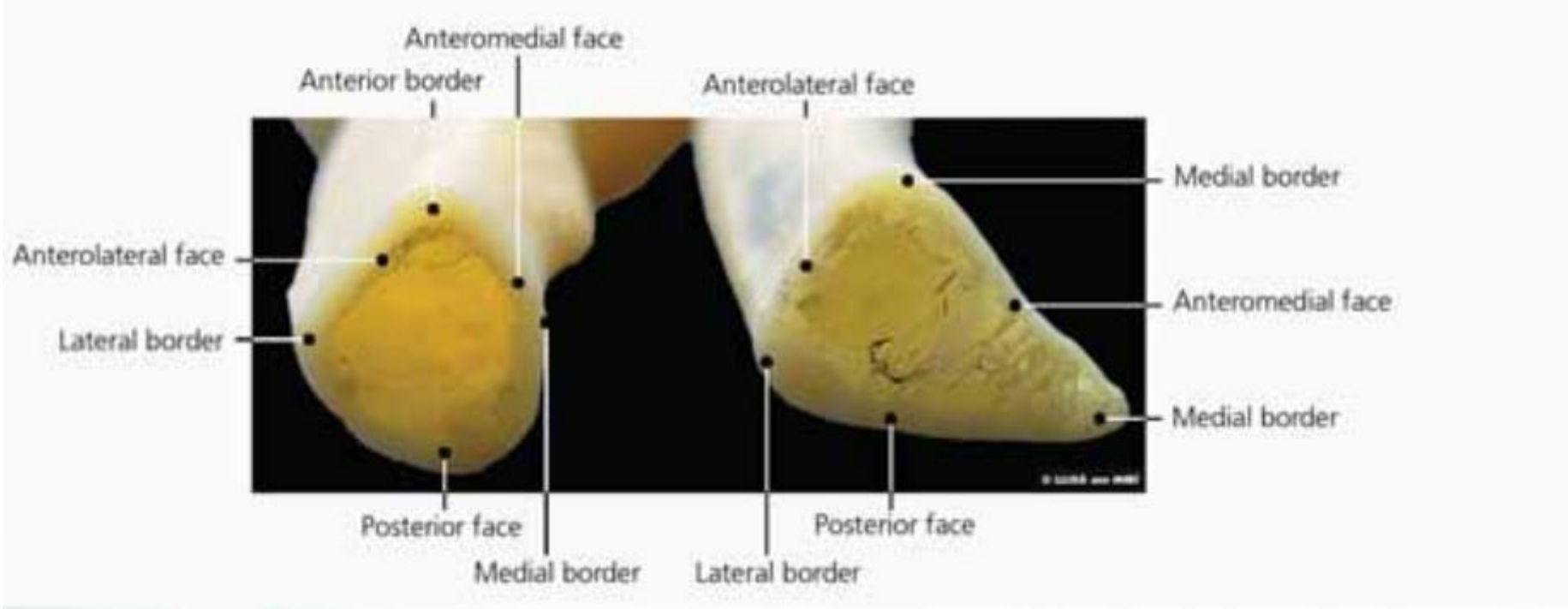


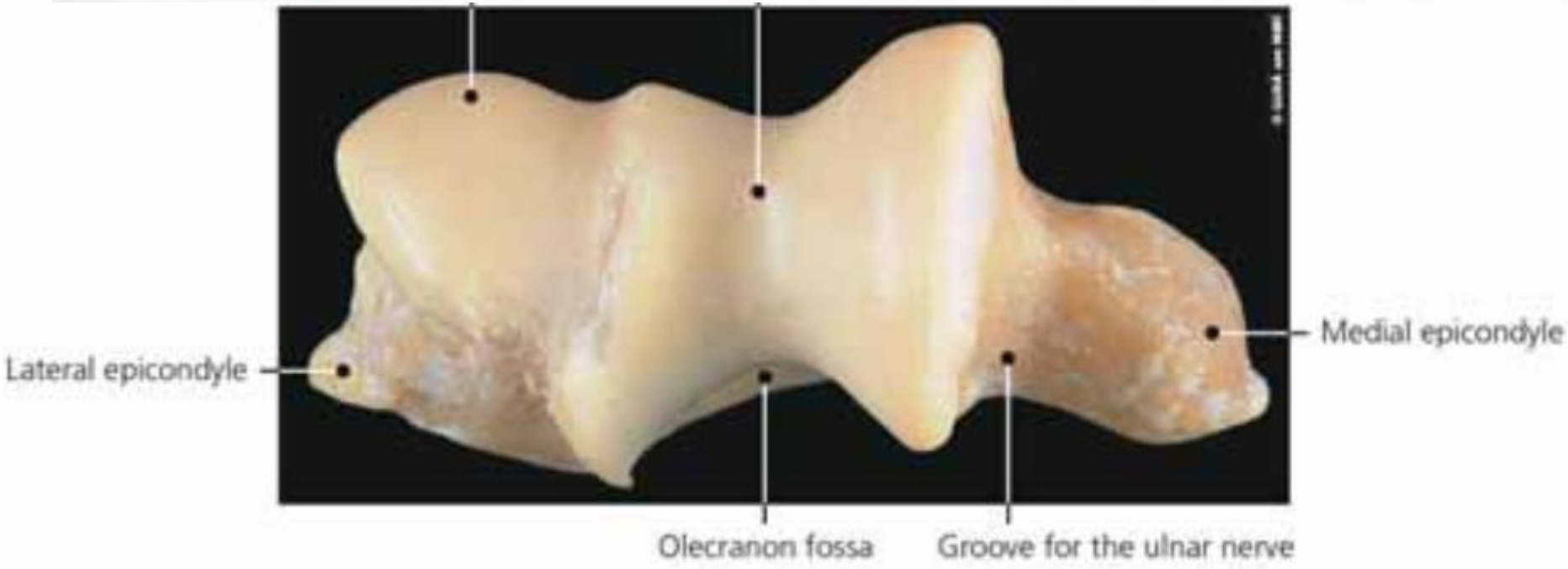


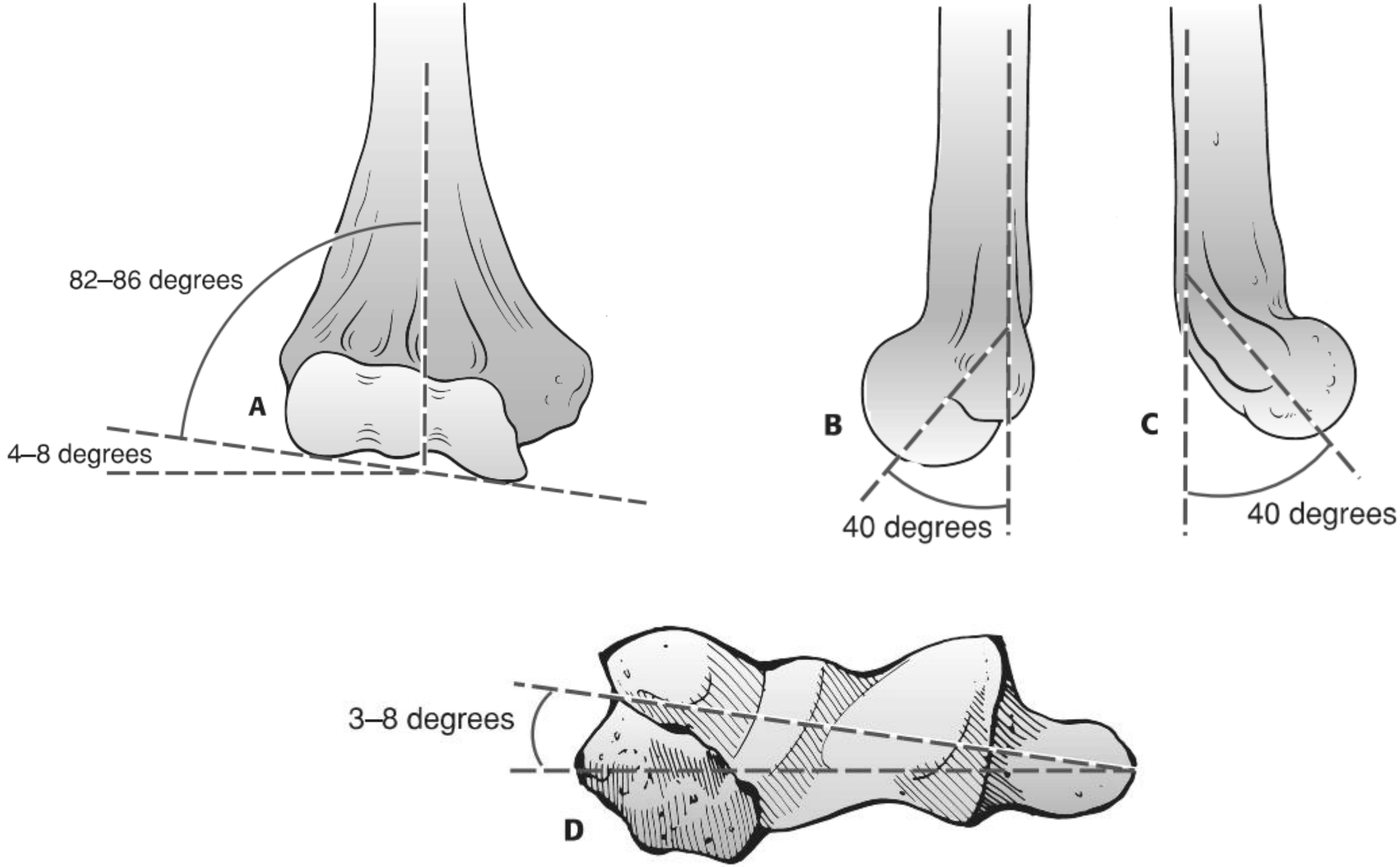

Lateral supracondylar ridge
Radial fossa
Capitellum
A
Lateral epicondyle

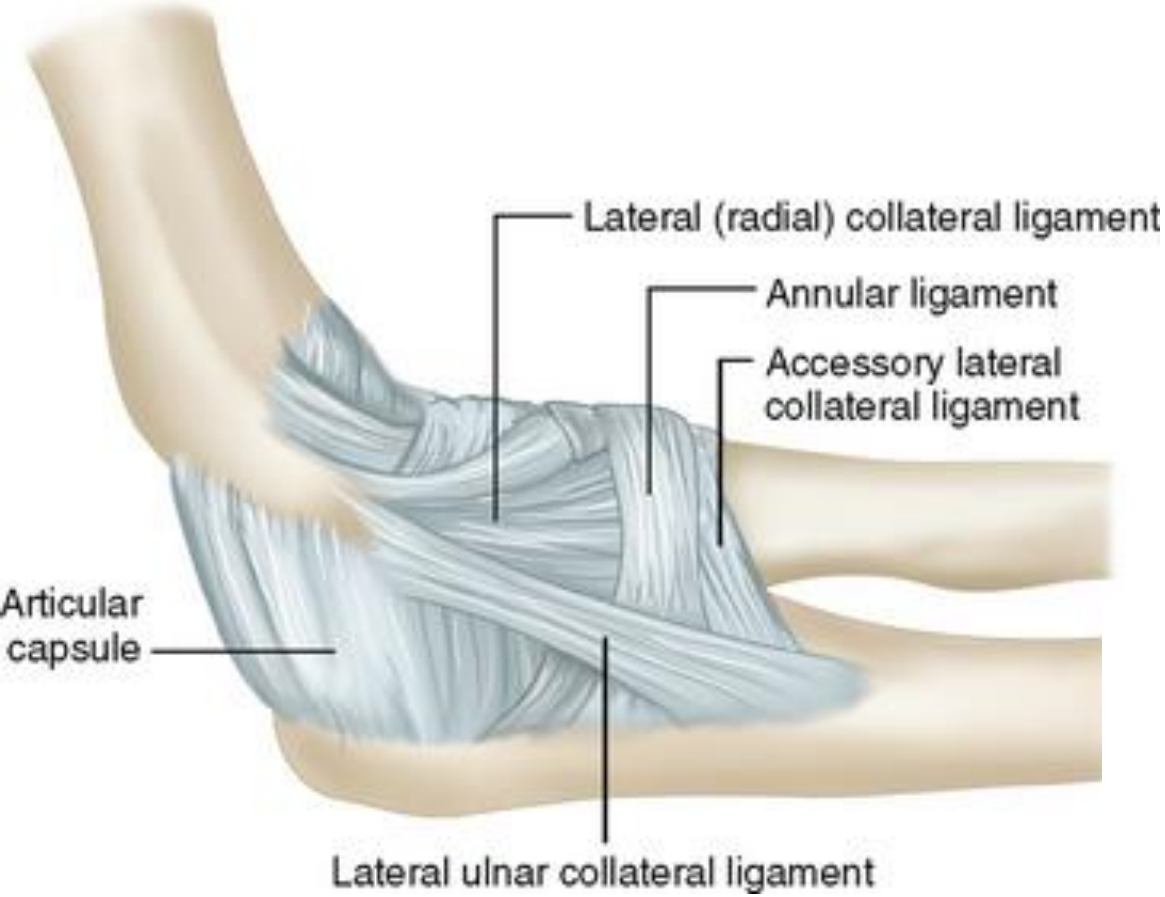

Medial supracondylar ridge
Medial epicondyle
B
Trochlea
Groove for the ulnar nerve

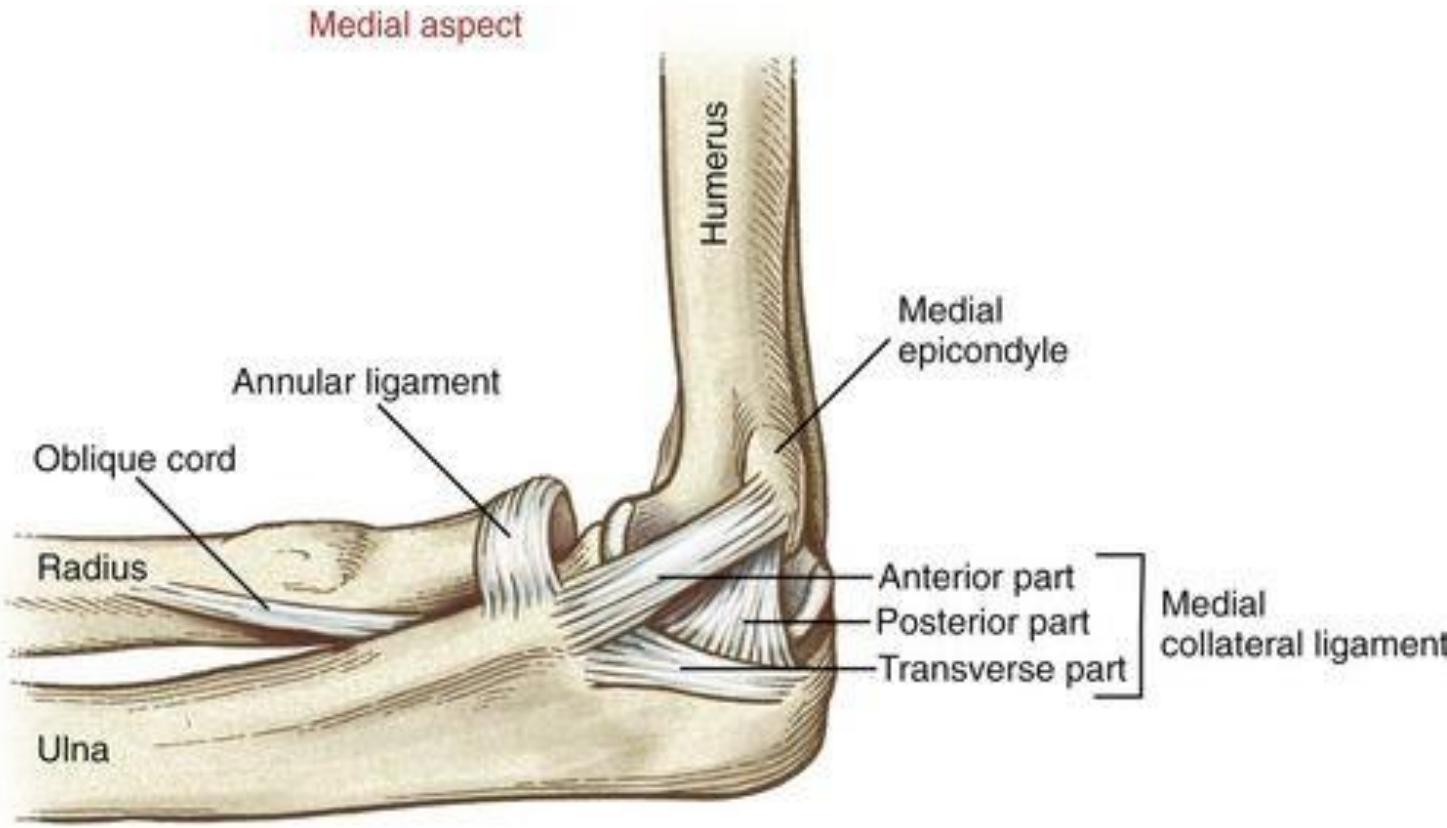

Medullary canal
Compact bone substance
Nutrient artery (injected with red latex)
Trabecular bone substance
Olecranon fossa
Bone septum
Coronoid fossa
Cancellous bone substance
Hyaline articular cartilage
Medullary canal
Compact bone substance
Nutrient artery (injected wit
Trabecular bone substance
Olecranon fossa
Bone septum
Cancellous bone substance
Hyaline articular cartilage


Anteromedial face
Anterior border
Anterolateral face
Anterolateral face
Lateral border
Medial border
Anteromedial face
Medial border
Posterior face
Posterior face
Medial border
Lateral border

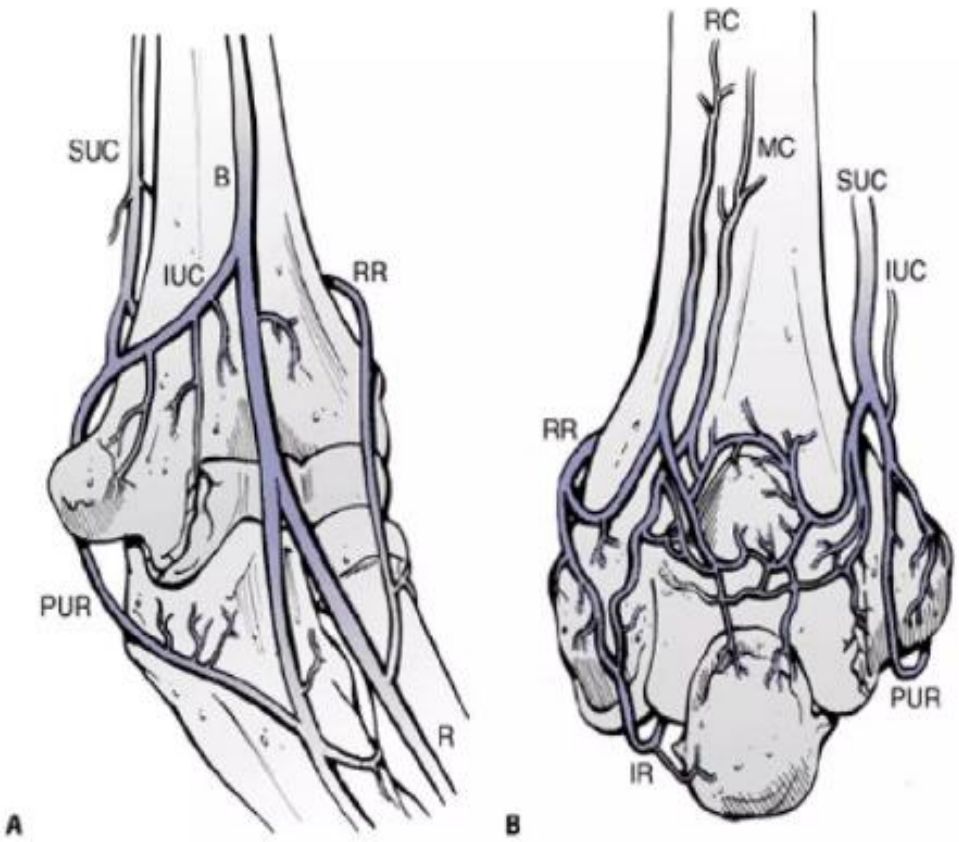

Lateral epicondyle
Medial epicondyle
Olecranon fossa
Groove for the ulnar nerve


82–86 degrees
A
4–8 degrees
B
40 degrees
C
40 degrees
3–8 degrees
D


Lateral (radial) collateral ligament
Annular ligament
Accessory lateral collateral ligament
Articular capsule
Lateral ulnar collateral ligament


Medial aspect
Humerus
Medial epicondyle
Annular ligament
Oblique cord
Radius
Anterior part
Posterior part
Transverse part
Medial collateral ligament
Ulna

- Ulnar Nerve
  - Peireces Medial Septum at Middle Third of arm
  - Under ligament of struthers 70%
  - To cubital tunnel under Osborn’s ligament
  - Between 2 FCU heads
- Radial nerve:
  - In spiral groove:
    - In : 20 cm above medial epicondyle 74% of Humerus length.
    - Out: 14 cm above the lateral epicondyle 51 % of Humerus length
  - Pierces the lateral septum 10 cm above lateral epicondyle 36% of length


SUC
B
IUC
RR
PUR
R
A
RC
MC
SUC
IUC
RR
PUR
IR
B

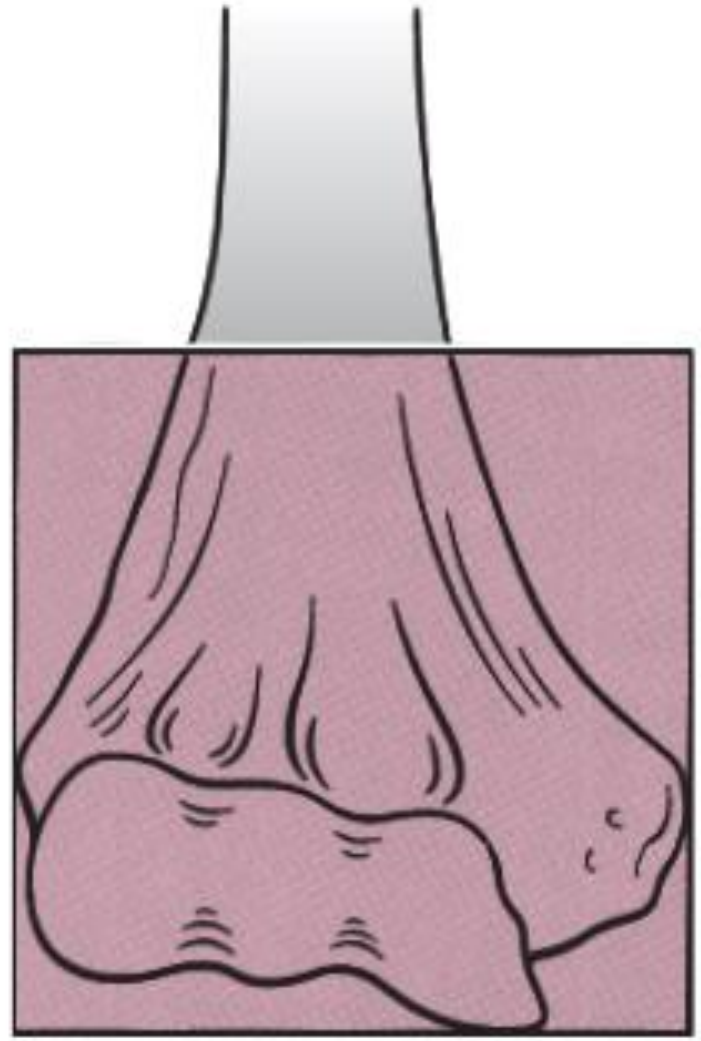


FIGURE 35-2 A distal humerus fracture is defined as a fracture with an epicenter that is located within a square whose base is the distance between the epicondyles on an anteroposterior radiograph.

Epidemiology

- Elbow Fractures 7% of Adults Fractures.
- 1/3 Of elbow fractures.
- Bimodal Age:
  - Males : 12-19
  - Females : 80 and older
- High and low energy
- Simple Falling Down the most common.
- Extrarticular 40% > Bicolumnar 37% .
- 2 Folds increased incidence (3 By 2030 !!)
- Mainstay of management is prevention
  - Bone Density screening
  - Falling Risk
    - (age, weight, morbidities, smoking, previous fractures and mother's hip fracture)
- Partial Articular fracture:
  - Capitellum COR , Bimodal , elderly Female (Carrying angle & osteoporosis)

History and Exam

- Systemic injury in polytrauma.
  - Intoxication and drugs
  - Pain From polytrauma
  - Counseling of possible occult fractures
- Elderly
  - Precipitating Event
    - Cardiac, Cerebrovascular , polypharmacy and Alcohol.
    - Mental status: Rehabilitation
    - Ambulation and preinjury functionality
    - Handedness
- Circumferential exam: Open injury and skin condition.
- Neurologic exam: Gofton et al 26% incidence incomplete neuropathy.
- Vascular exam: Brachial-Brachial index.
- Forearm Compartment
- Active Infection and Soft tissue in elderly with possible TEA

Early classification:

- Appearance
- Location
- Jupitar >> Mehne and Matta.
  - Complexity
  - Inter and intra-observer reliability

Late classification:

- AO-OTA
  - Location
  - Degree of articular involvement
  - Subclass based on fracture line orientation, direction and comminution degree
  - Weakness points
    - Doesn't count for fragment height and amount of displacement.
    - ORIF Vs TEA
    - Complexity

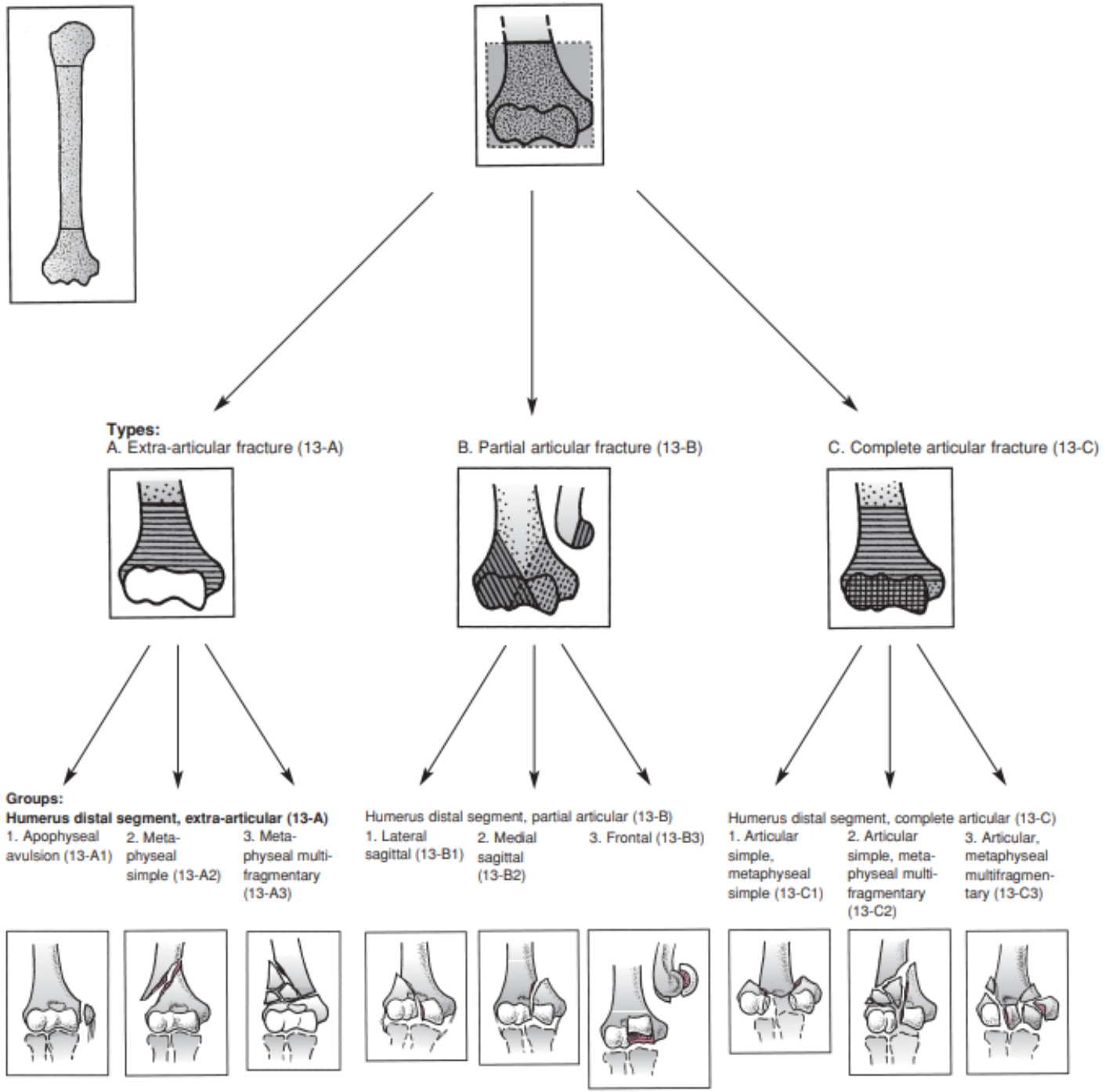


FIGURE 35-3 The AO/OTA classification of distal humerus fractures.[56,150]

Subgroups and qualifications:

Humerus, distal, extra-articular apophyseal avulsion (13-A1)

1. Lateral epicondyle (13-A1.1)
2. Medial epicondyle, nonincarcerated (13-A1.2)
   (1) nondisplaced
   (2) displaced
   (3) fragmented
3. Medial epicondyle, incarcerated (13-A1.3)

A1

Humerus, distal, extra-articular metaphyseal simple (13-A2)

1. Oblique downward and inward (13-A2.1)
2. Oblique downward and outward (13-A2.2)
3. Transverse (13-A2.3)
   (1) transmetaphyseal
   (2) juxtaepiphyseal with posterior displacement (Kocher I)
   (3) juxtaepiphyseal with anterior displacement (Kocher II)

A2

Humerus, distal, extra-articular metaphyseal multifragmentary (13-A3)

1. With intact wedge (13-A3.1)
   (1) lateral
   (2) medial
2. With fragmented wedge (13-A3.2)
   (1) lateral
   (2) medial
3. Complex (13-A3.3)

A3

FIGURE 35-3 *(continued)*

Humerus, distal, partial articular, lateral sagittal (13-B1)

1. Capitellum (13-B1.1)
(1) through the capitellum (Milch I)
(2) between capitellum and trochlea

2. Transtrochlear simple (13-B1.2)
(1) medial collateral ligament intact
(2) medial collateral ligament ruptured
(3) metaphyseal simple (classic Milch II) lateral condyle
(4) metaphyseal wedge
(5) metaphysio-diaphyseal

3. Transtrochlear multifragmentary (13-B1.3)
(1) epiphysio-metaphyseal
(2) epiphysio-metaphysio-diaphyseal

B1

Humerus, distal, partial articular, medial sagittal (13-B2)

1. Transtrochlear simple, through medial side (Milch I) (13-B2.1)

2. Transtrochlear simple, through the groove (13-B2.2)

3. Transtrochlear multifragmentary (13-B2.3)
(1) epiphysio-metaphyseal
(2) epiphysio-metaphysio-diaphyseal

B2

Humerus, distal, partial articular, frontal (13-B3)

1. Capitellum (13-B3.1)
(1) incomplete (Kocher-Lorenz)
(2) complete (Hahn-Steinthal 1)
(3) with trochlear component (Hahn-Steinthal 2)
(4) fragmented

2. Trochlea (13-B3.2)
(1) simple
(2) fragmented

3. Capitellum and trochlea (13-B3.3)

B3

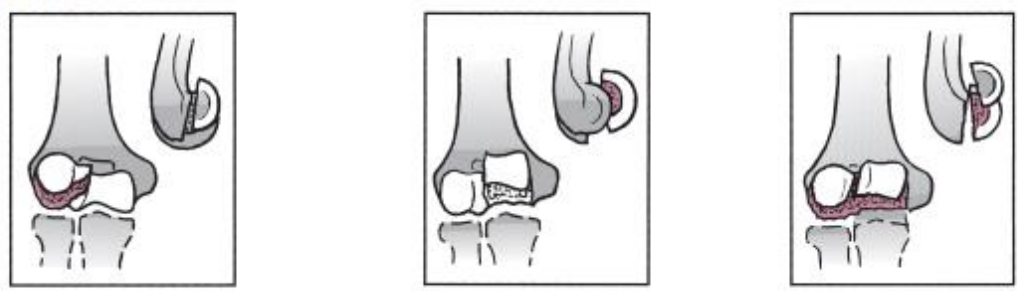


FIGURE 35-3 *(continued)*

Partial Articular shear fractures

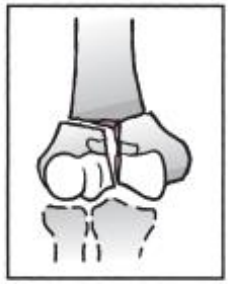
Humerus, distal complete, articular simple, metaphyseal simple (13-C1)

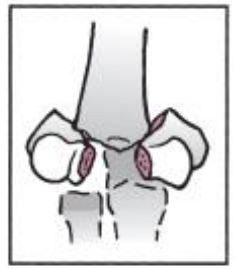
1. With slight displacement (13-C1.1)
(1) Y-shaped
(2) T-shaped
(3) V-shaped

2. With marked displacement (13-C1.2)
(1) Y-shaped
(2) T-shaped
(3) V-shaped

3. T-shaped epiphyseal (13-C1.3)

C1





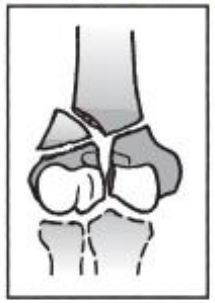
Humerus, distal, complete articular simple metaphyseal multifragmentary (13-C2)

1. With intact wedge (13-C2.1)
(1) metaphyseal lateral
(2) metaphyseal medial
(3) metaphysio-diaphyseal lateral
(4) metaphysio-diaphyseal medial

2. With a fragmented wedge (13-C2.2)
(1) metaphyseal lateral
(2) metaphyseal medial
(3) metaphysio-diaphyseal lateral
(4) metaphysio-diaphyseal medial

3. Complex (13-C2.3)

C2



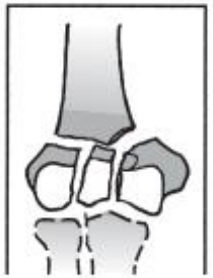
Humerus, distal, complete multifragmentary (13-C3)

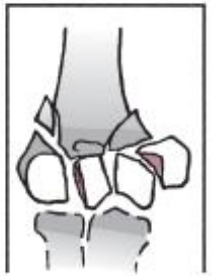
1. Metaphyseal simple (13-C3.1)

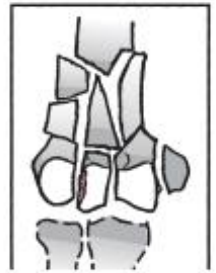
2. Metaphyseal wedge (13-C3.2)
(1) intact
(2) fragmented

3. Metaphyseal complex (13-C3.3)
(1) localized
(2) extending into diaphysis

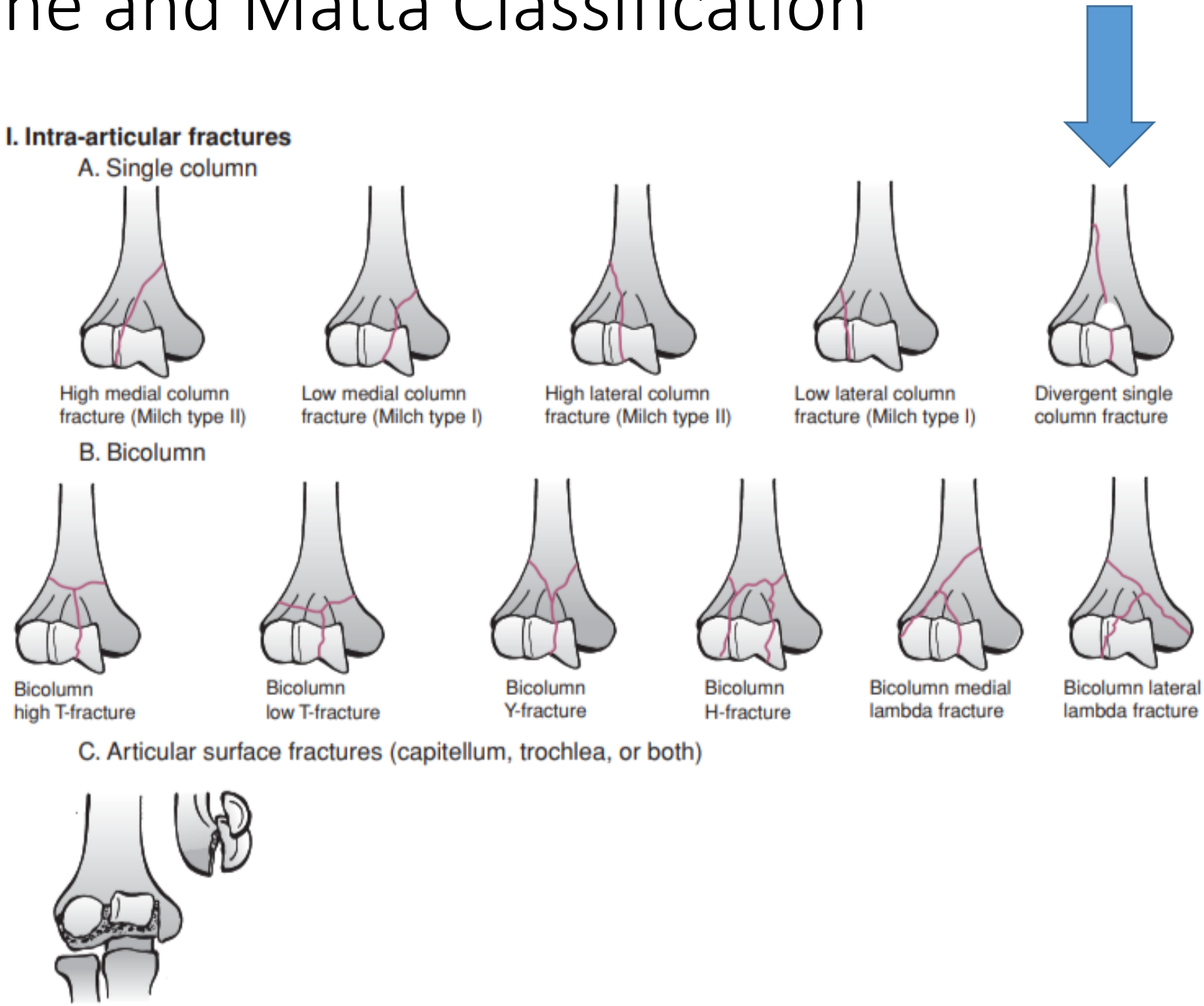
C3



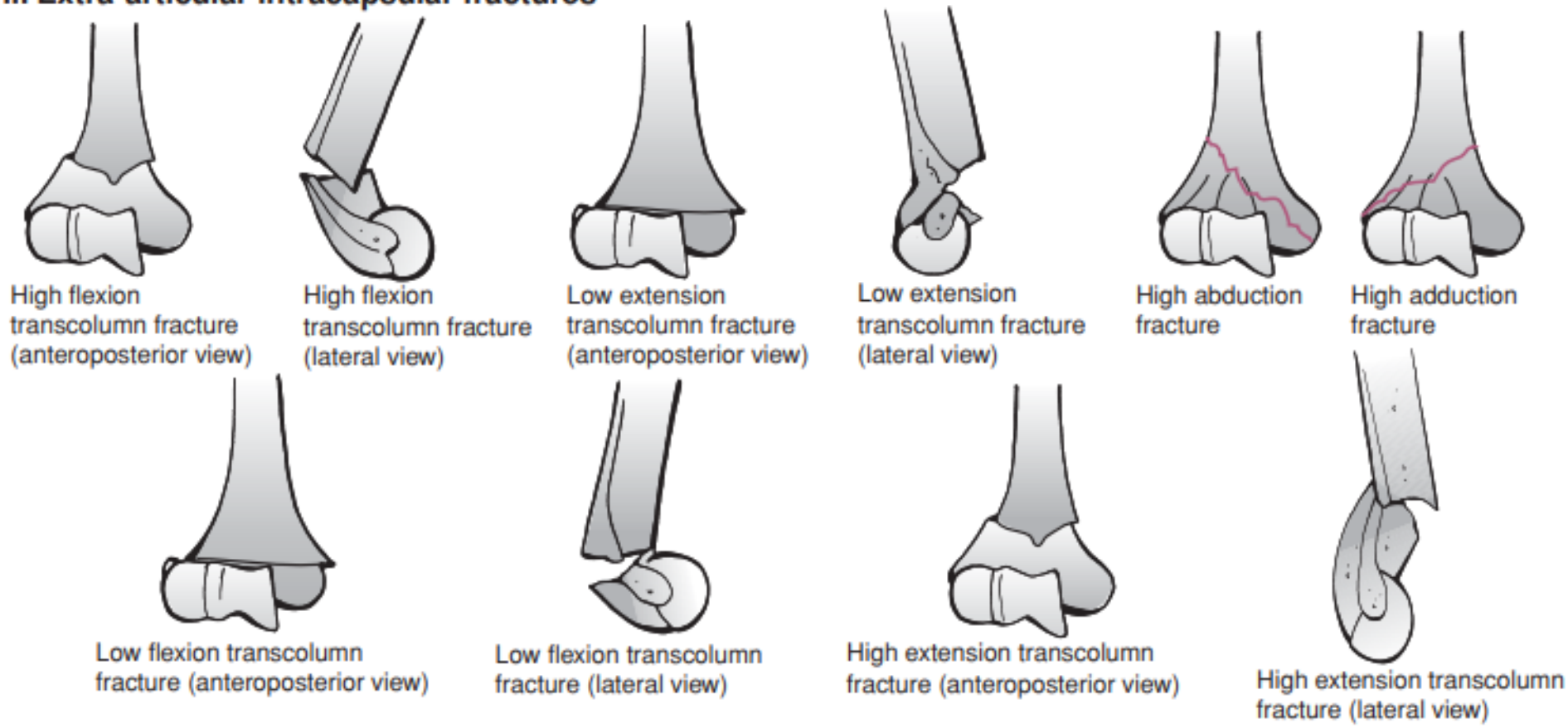




Mehne and Matta Classification



II. Extra-articular intracapsular fractures



III. Extracapsular fractures

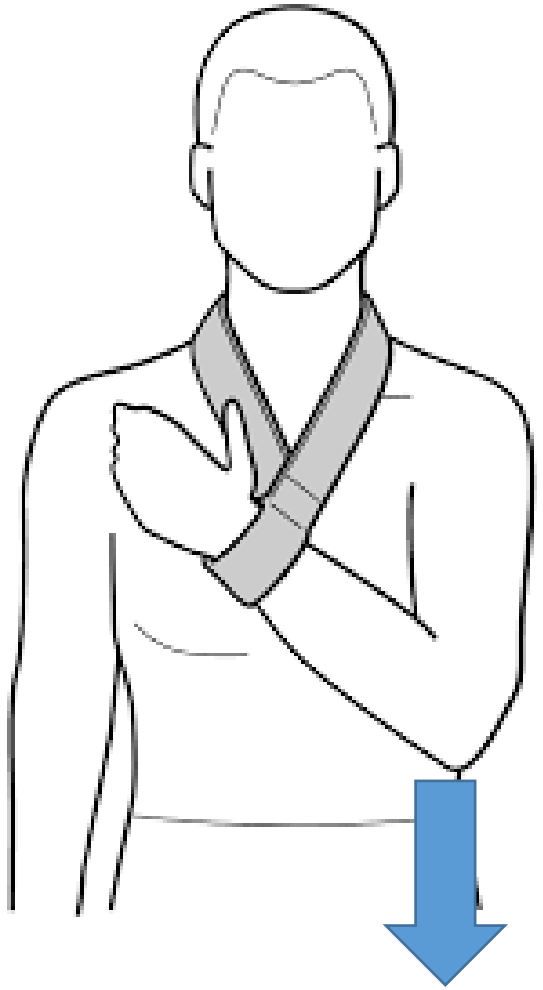
FIGURE 35-5 The Mehne and Matta classification of distal humerus fractures.[93]

Management goals

- Anatomic Articular surface
- Alignment restoration
- Early Rehabilitation

Nonoperative Managment

- Medically unfit for surgery.
- Elderly who need TEA with contraindications.
- Non displaced Fractures (Weekly Follow up).
- Abandoned in young active.
- **<u>Techniques:</u>**
  - Cast
  - Olecranon traction
  - Collar and cuff (Bag of bones)
    - Elbow 90-120 flexion
    - Ligamentotaxis effect
    - Shoulder and elbow active motion started at 2 weeks



- B3 Fracture
  - Full extension, Supination and varus along with Digital manipulation >> Flexion

Operative Managment

- Complex injury with fragmentation
- Bony instability
- Soft tissue injury
- Osteopenia

➔ORIF is gold standard: Anatomical healing, Early ROM and Max functional recovery.

➔Better outcome and less complications.

- Timing :
  - Early surgery 48-72 hours if stable and Soft tissue permits
    - Easier
    - Less HO and Stiffness
  - Delayed surgery (not more than 2-3 weeks)
    - Splint checked daily and removed for assessment every 2-3 days
    - Consider Ex-fix if surgery to be further delayed
    - Difficult reduction , Increased blood loss , Increased surgical time and Increased HO risk.
- Rehabilitation vs Displacement ??

Operative Managment

- Surgical management in TYPE A fractures
  - CRPP
    - Semi-rigid
    - Supplementary casting
    - Poor outcome in Elderly
  - Cannulated screws
  - Gold standard is ORIF
  - Approached via Paratricipital approach or limited Splitting.
  - Bicolumnar Fixation is recommended (Parallel or orthogonal)
  - Low Transcolumnar Fracture:
    - Fixation
    - In Elderly

- Type B and C
  - ORIF is the Gold standard

Operative Managment

- Preoperative planning:
  - Goals:
    - Anatomical reduction of the articular surface.
    - Anatomical alignment of the Joint.
    - Rigid fixation
    - Stable for Early ROM
  - Imaging
    - Radiographs
    - CT Determine Difficult patterns:
      - Coronal fractures of the Capitellum or Trochlea.
      - Low types.
      - Segmental articular Fractures.
      - TEA planning
  - Preoperative assessment at day of surgery:
    - Soft tissue
    - Neurological Conditions
    - Prophylactic ABx

Operative Management-Positioning

Operative Management- Surgical Approach

- Approach should Accommodate intraoperative finings
  - e.g.:
    - Paratricipital Approach in simple intrarticular fracture C1,2.
    - Olecranon Osteotomy in comminuted Articular fracture of Elderly .

- Different Approaches:
  - Posterior
    - Straight or curved (medially or laterally)
    - Large medial and lateral Fasciocutaneous flap
  - Lateral and Medial Approaches
    - Direct lateral/Medial or posterior incision:
      - Risk of skin complications with posterior incision (Seroma, necrosis).
      - Decrease risk of cutaneous nerve injuries with posterior incision.
      - Medial access.
  - Anterior

Posterior Approach to the Humerus

- Olecranon osteotomy
- Triceps On :
  - Paratricipital
- Triceps OFF:
  - Splitting
  - Reflecting
  - Tongue approach

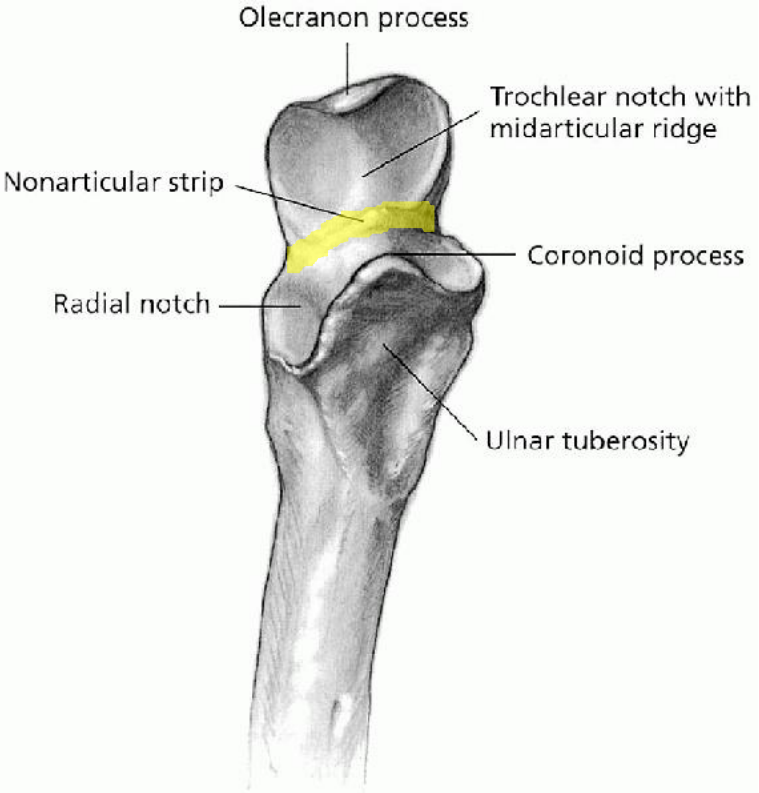
➔Factors that determine which type:

- Articular visualization required
- Associated Injury
- Patient factors (Age, Demand)
- Fracture charachterestics

Olecranon osteotomy

- Main advantage Best visualization of the articular surface .
- Disadvantage: Osteotomy Complications
  - Malunion
  - Nonunion
  - Metal irritation
- Most commonly For Type C fractures
- Can be used for Type B Fractures especially comminuted one.
- Contraindications:
  - Very anterior B3 #
  - TEA

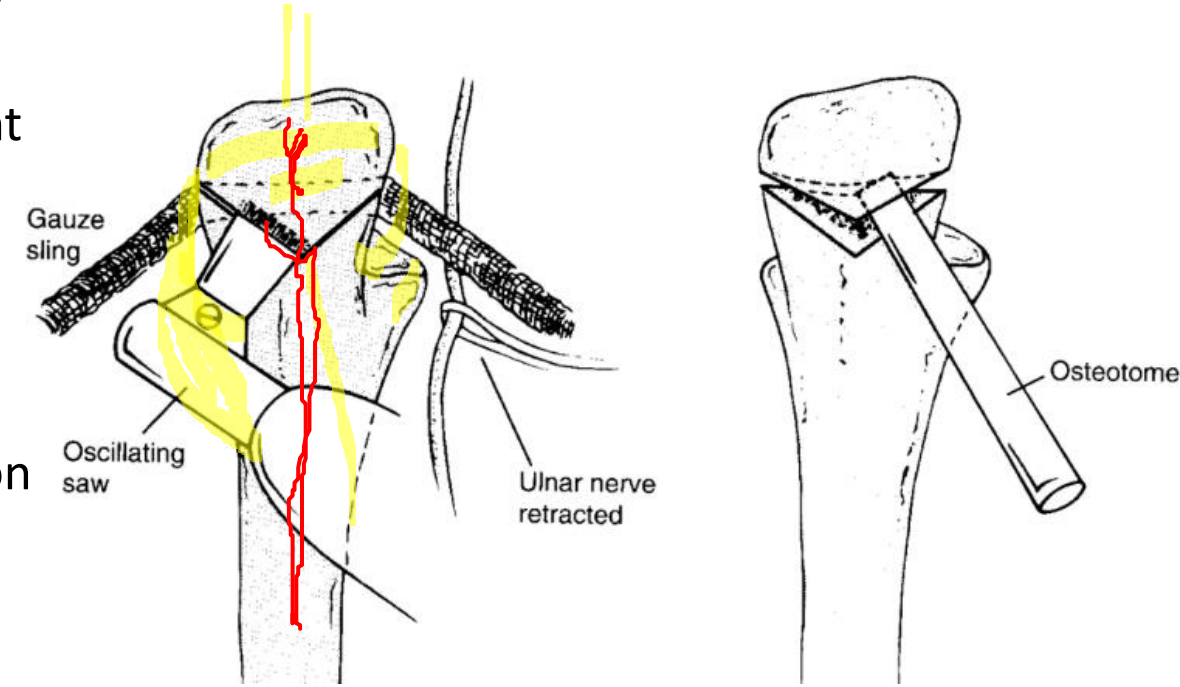
Olecranon osteotomy

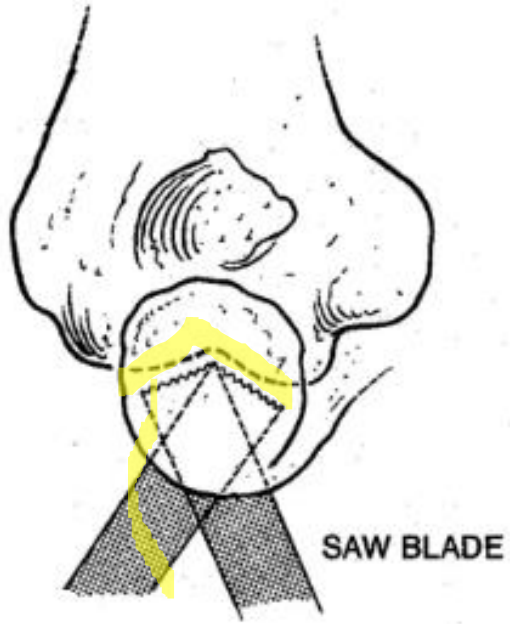


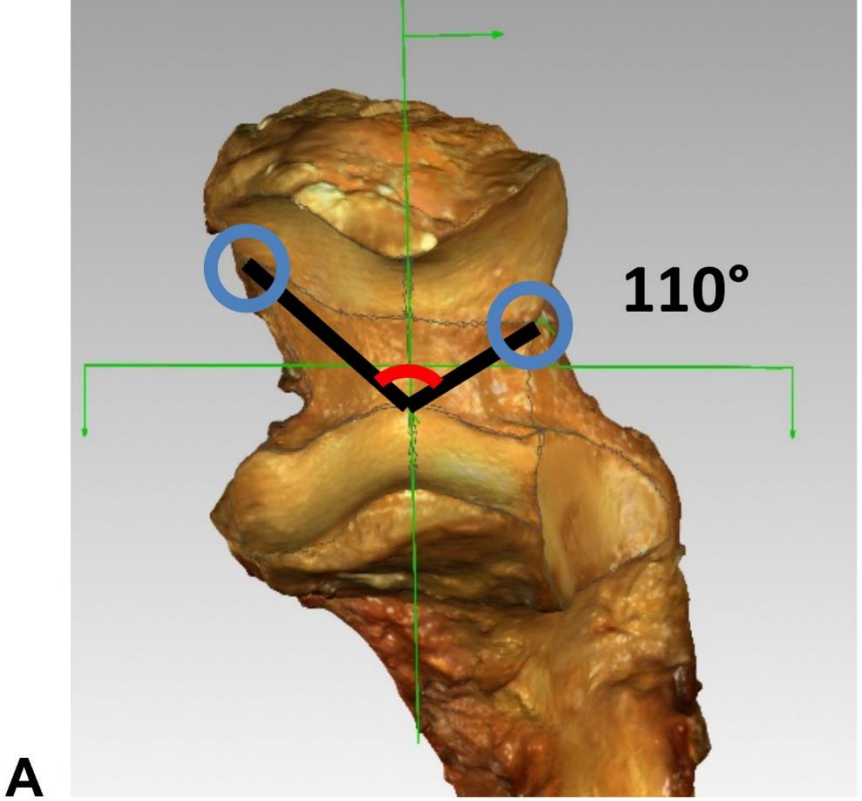
- Ulnar nerve isolation.
- Ulnar nerve transposition??
  - Related Ulnar neuropathy…
    - Wigger's et al vs chen et al
- Osteotomy through the bare area
  - Morphology of Proximal Ulna Bare Area: A Guide for Olecranon Osteotomy Francis et al Sep 2022
  - "The central bare area was consistent in its location, **4.9 ± 1.5 mm distal to the deepest portion of the trochlear notch and 23.2 ± 2.3 mm distal to the olecranon tip**.
  - The maximum chevron osteotomy apical angle to stay within the bare area averaged **110° ± 11.8**°. However, there was little tolerance for error without the risk of violating the articular cartilage. With **transverse osteotomy, averaging 18° ± 10.6°** in the coronal plane, there is less risk of damaging the articular cartilage.

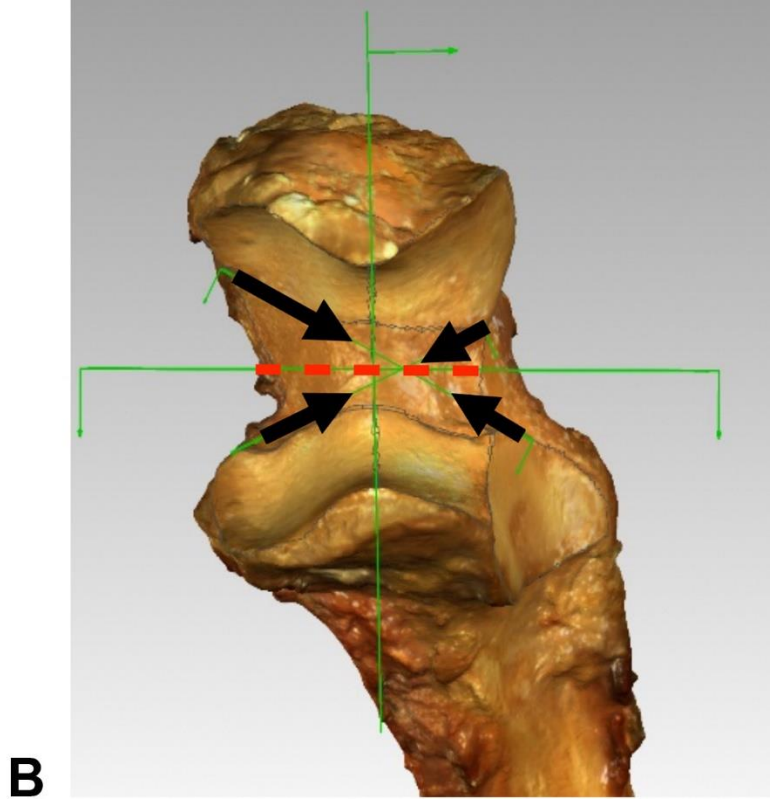
Olecranon osteotomy

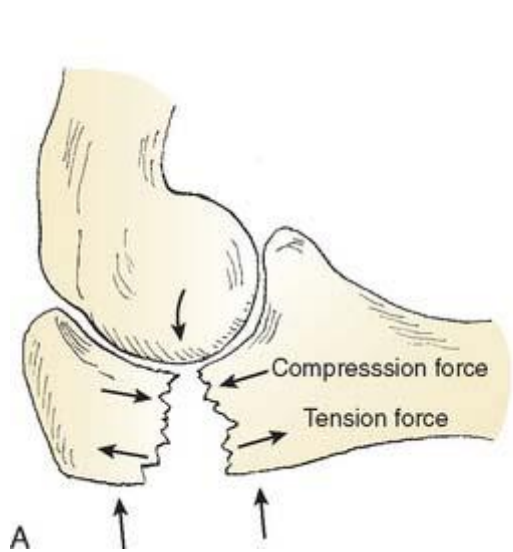
- Sub periosteal Dissection on both sides of ulnohumeral joint
  - Avoid distal dissection
- Protect the articular surface
- Mark the osteotomy
- 2/3 with Micro saw
- Multiple K wire Perforations to avoid unplanned Propagation
- 1/3 with osteotome (2 used for final Separation)
- Chevron osteotomy vs Transverse osteotomy :
  - Articular violation
  - Technical easiness
  - Interdigitating
  - Healing surface
  - Stability
  - Collateral ligaments insertion
- Anconeus denervation.
- Osteotomy fixation:
  - Plate , Tension band and Cannulated screw .
    - Predrilling of the plate
    - Malreduction with cannulated screw ??

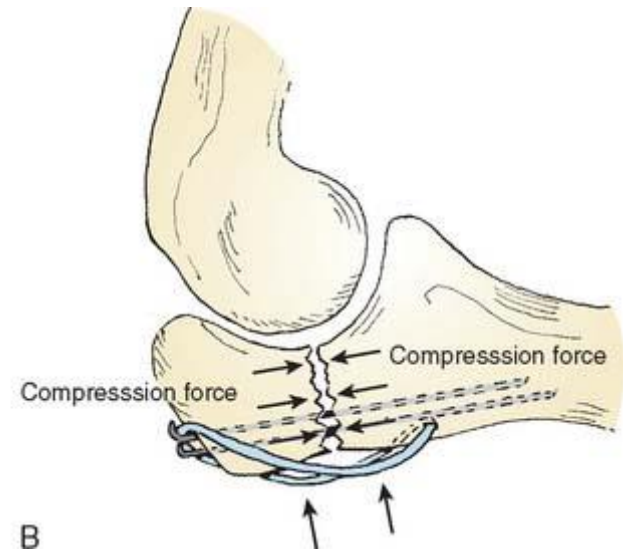





110°
A


B

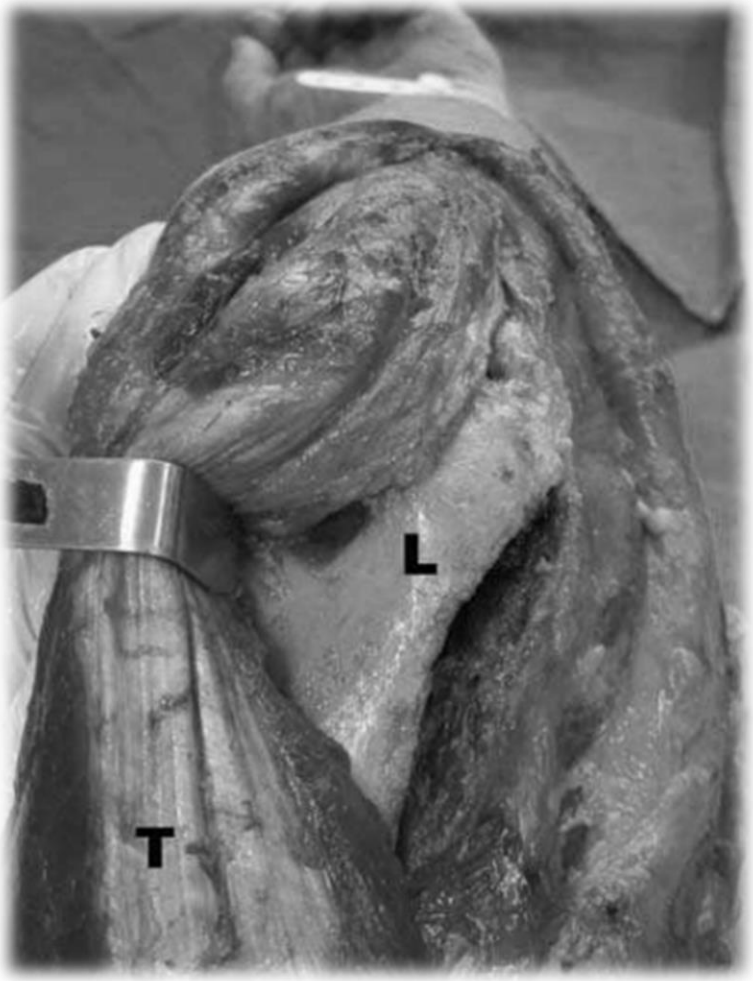

Compresssion force
Tension force
A


Compresssion force
Compresssion force
B

Paratricipital approach

- Ulnar nerve identification
- Medial and lateral elevation
- Exposure for:
  - Columns
  - Olecranon fossa
  - Limited articular exposure
    - **Boyd window**
- **Advantages:**
  - **Intact triceps**
  - **Early ROM**
  - **Preserved anconeus**
  - **Avoiding osteotomy complications**
  - **Can be converted into olecranon osteotomy**
  - **Extensile as Gerwin approach**

- **Disadvantages:**
  - **Limited articular exposure**
  - **Inadequate For C3 Fractures**

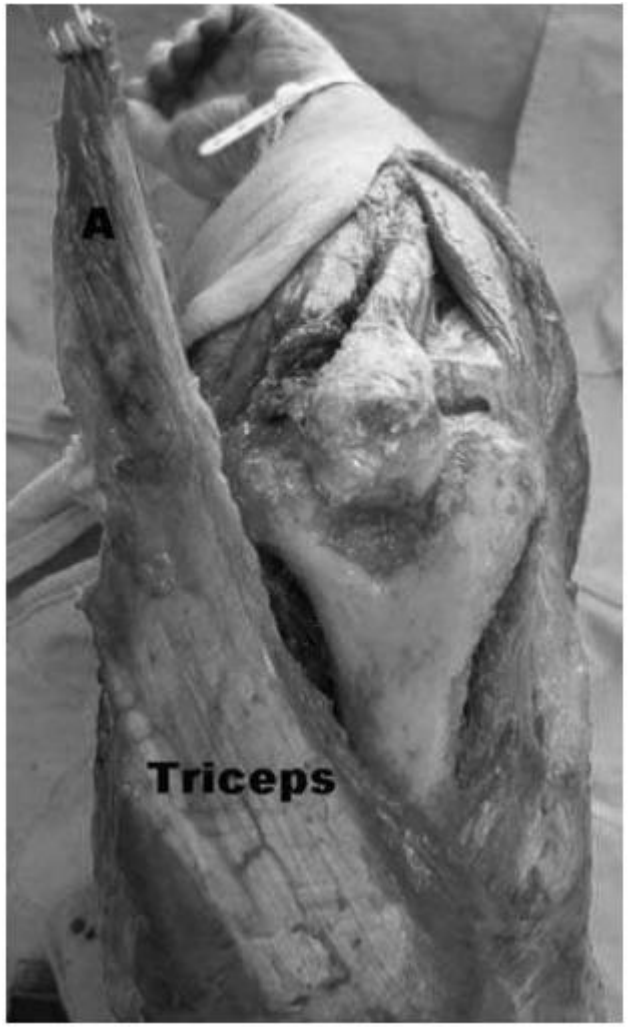


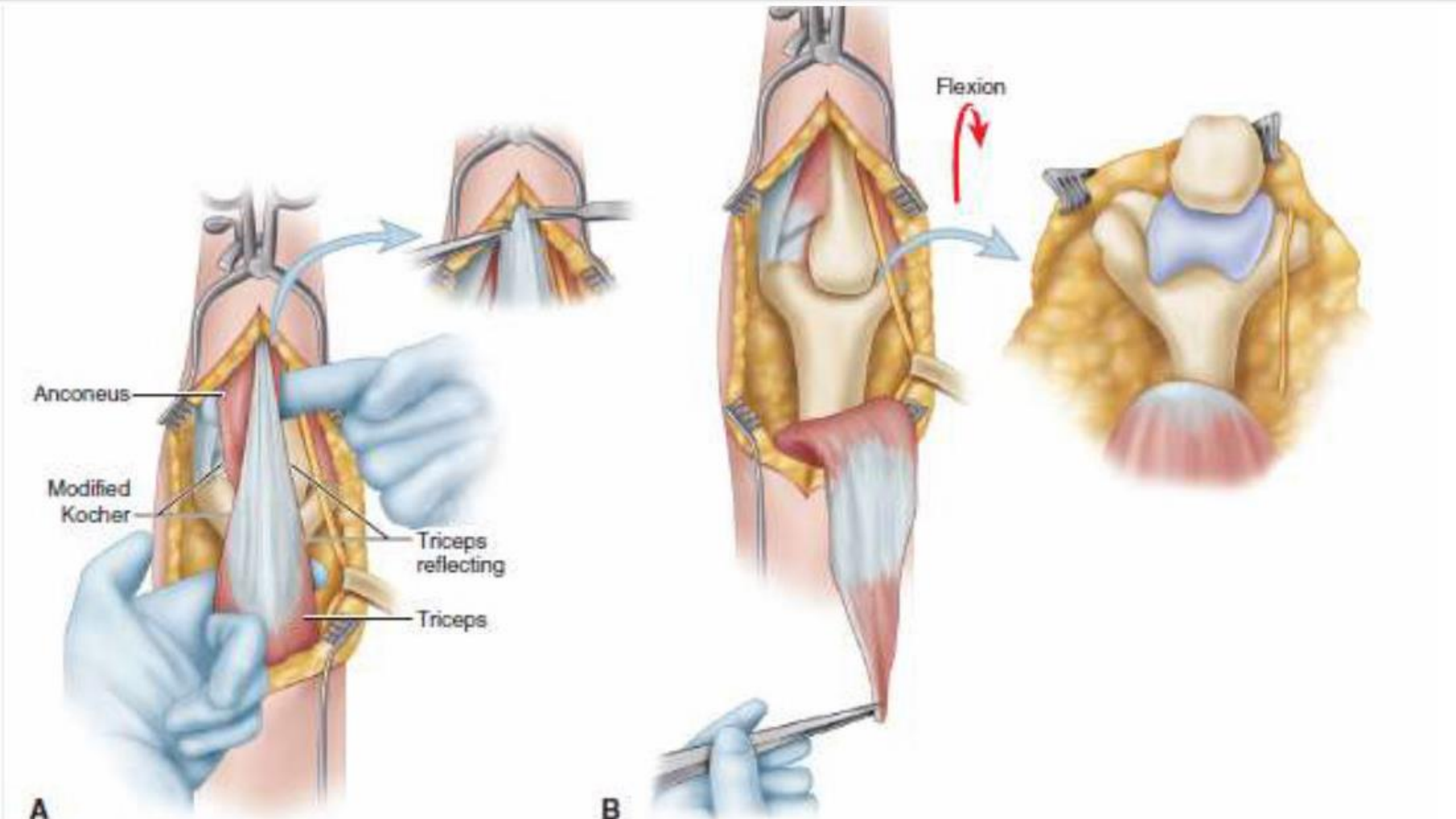
Triceps splitting approach

- Midline split through the triceps tendon
- No Articular surface exposure except with partial olecranon tip excision
- Elevated part of Triceps repaired to the olecranon process
- Proximal and distal Extension
- **Advantages:**
  - Technically easy
  - Can Convert ORIF To TEA
- **Disadvantage:**
  - Postoperative protection of the repair is needed
  - Limited articular exposure
- Gschwend modification of flake elevation to improve healing.
- Strength of extensor mechanism vs Olecranon osteotomy ??

Triceps reflecting Anconeus pedicle (TRAP) approach

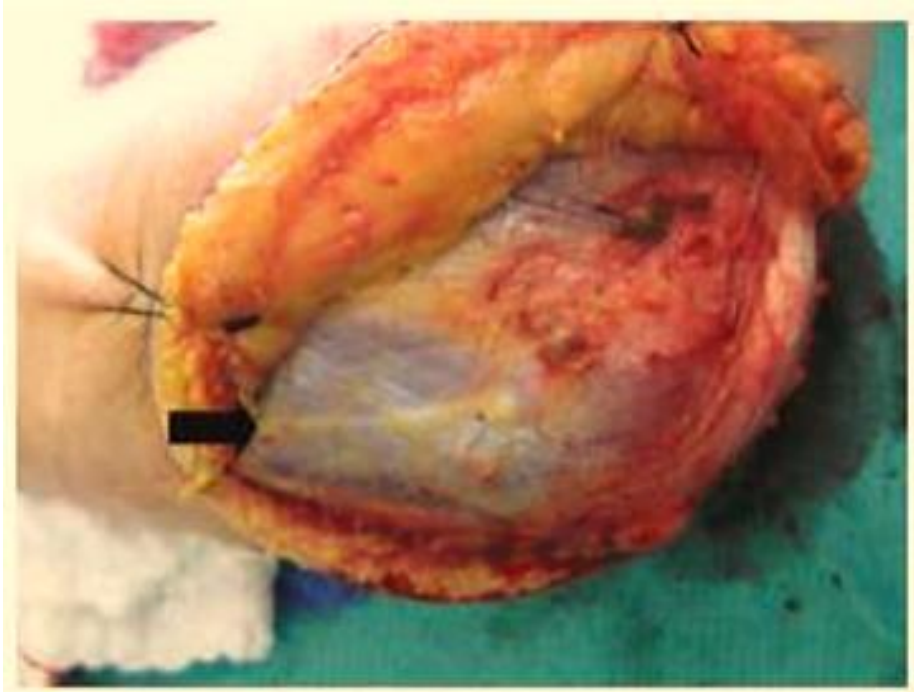
- Completely detaching the triceps from the proximal ulna along with anconeus.
- Kocher interval used to develop the distal lateral flap.
- the medial is created by sharp subperiosteal dissection.
- **Advatages:**
  - **Good exposure of elbow joint**
  - **Protection of the Anconeus Neurovascular supply**
  - **Avoid complications of osteotomy healing.**
  - **Trochlear sulcus used as template for reduction**
- **Disadvantage:**
  - **Triceps violated**
  - **Risk of extensor weakness and dehiscence**
- Van Gorder Approach (Triceps Tongue approach):
  - Most commonly for TEA
  - Indicated for ORIF if there is High grade or complete Triceps injury

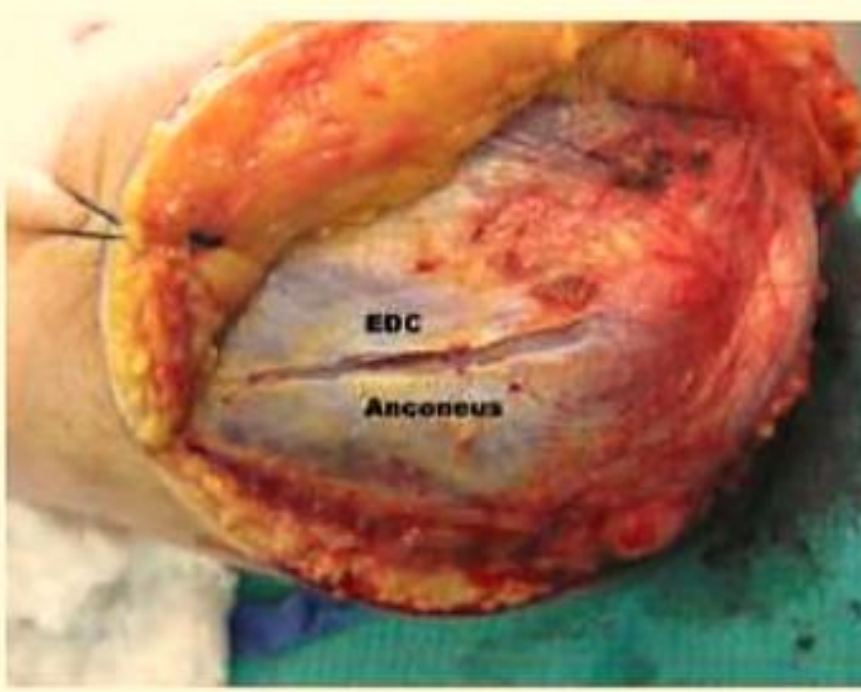


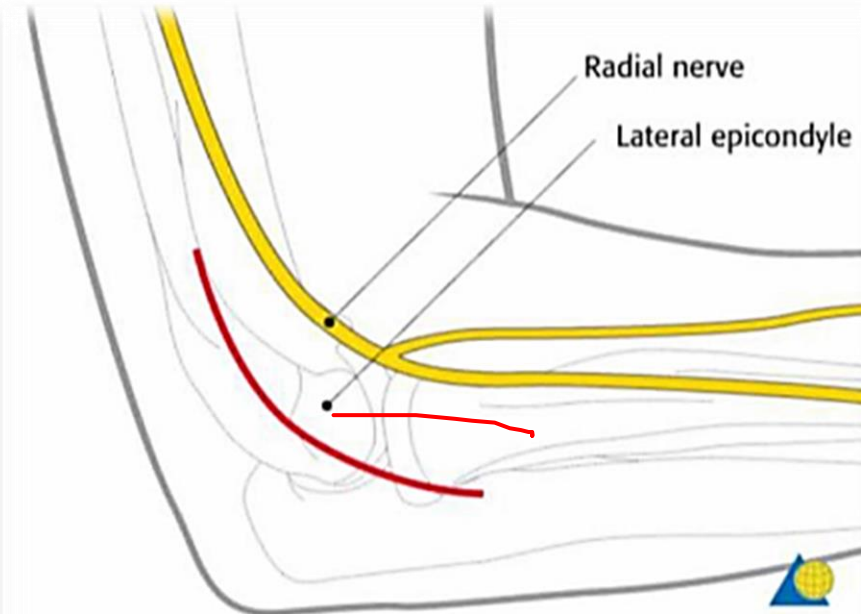

Anconeus
Modified Kocher
Triceps reflecting
Triceps
A
Flexion
B

Kocher's Lateral Approach

- Direct lateral incision
- Between ECU and anconeus.
- Identified by thin fat stripe / perforating branches of posterior interosseous artery.
- Keep forearm pronated.
- EDC split may be safer?
- Arthrotomy at the equator of the Capitellum in line with radiocapitellar joint.







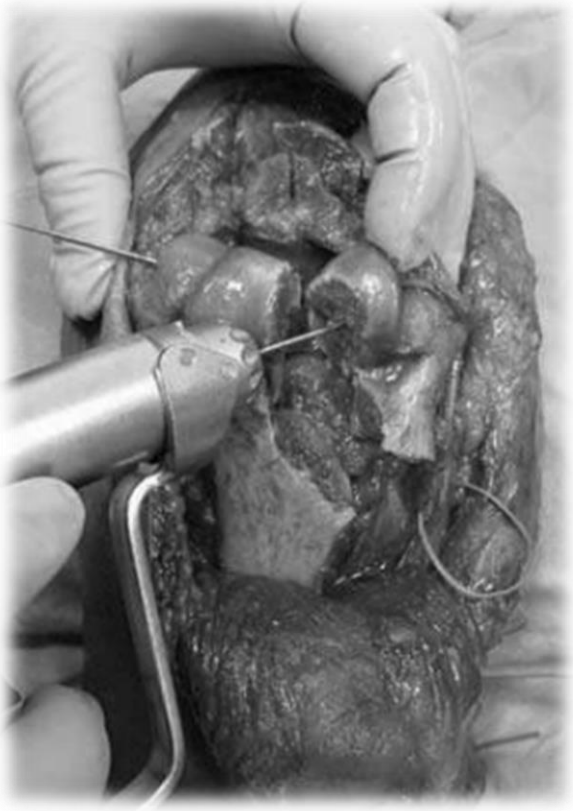
Medial approach

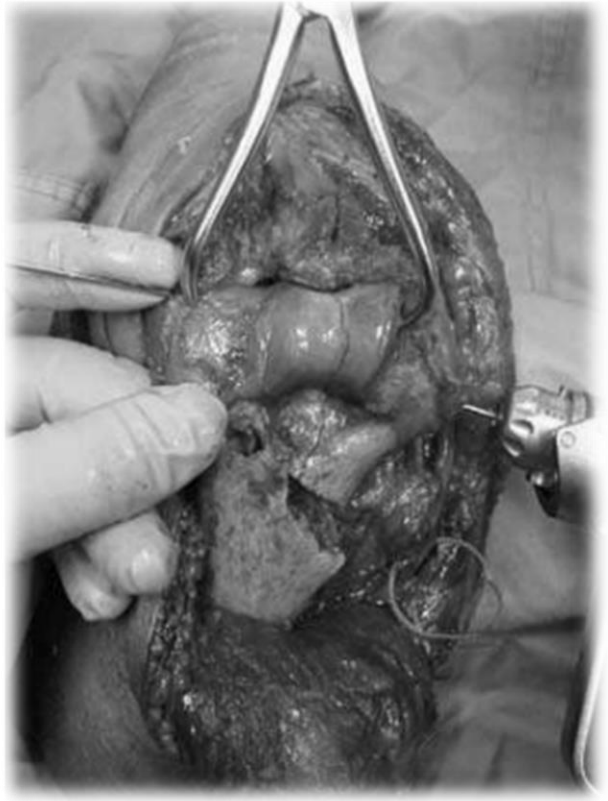
- Direct medial or posterior skin incision
- Careful with medial antebrachial cutaneous branches
- **Indications:**
  - **Medial column fracture**
  - **Trochlear fractures**
  - **Coronoid fractures**
  - **Medial epicondyle fractures.**
- Ulnar nerve identified
- Flexor pronator mass released to the level of medial epicondyle
- Split distally
- Elevate of MCL that is at the floor of the approach
- Arthrotomy anterior to ant bundle of MCL

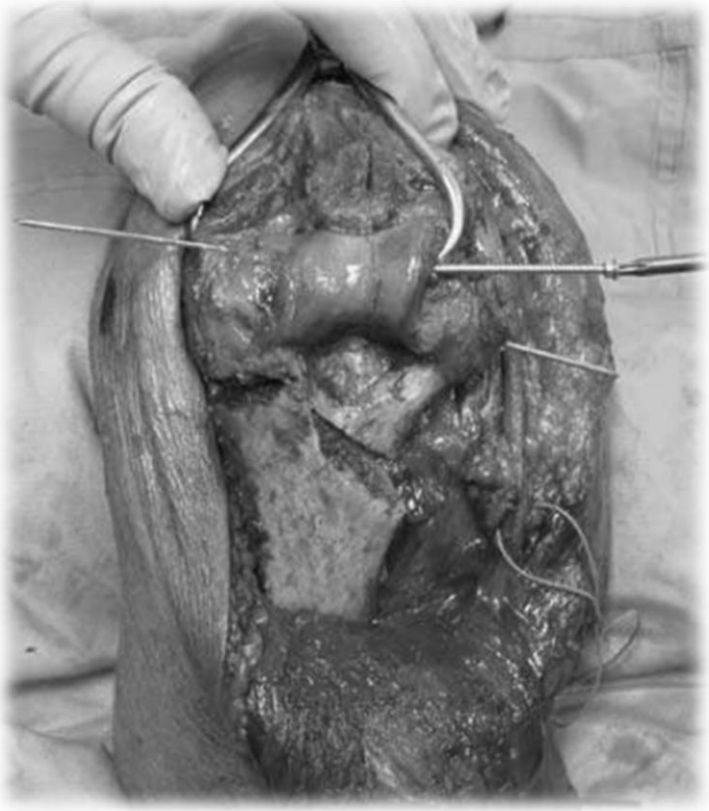
Technicals

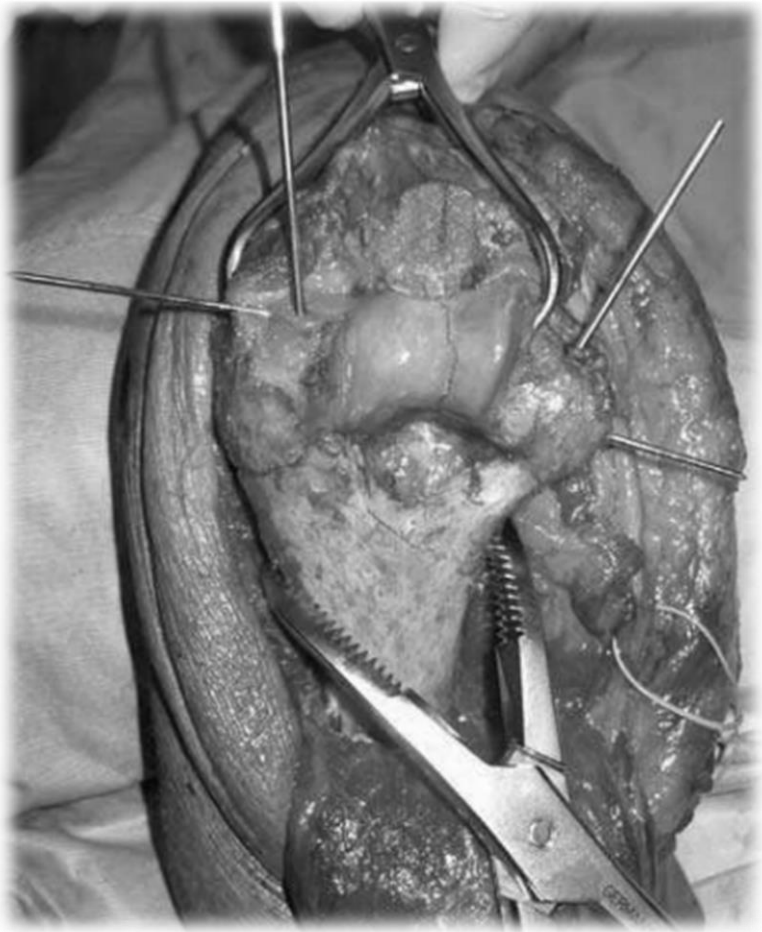
- for union and full elbow mobility after a severely fractured distal humerus, 2 principles must be satisfied:
  - (1) fixation in the distal fragment must be maximized
  - (2) all fixation in distal fragments should contribute to stability between the distal fragments and the shaft.
- There are 8 technical objectives by which these principles are met:
  - (1) every screw in the distal fragments should pass through a plate
  - (2) engage a fragment on the opposite side that is also fixed to a plate;
  - (3) as many screws as possible should be placed 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 structure;
  - (7) plates should be applied such that compression is achieved at the supracondylar level for both columns;
  - (8) the plates must be strong enough and stiff enough to resist breaking or bending before union occurs at the supracondylar level.

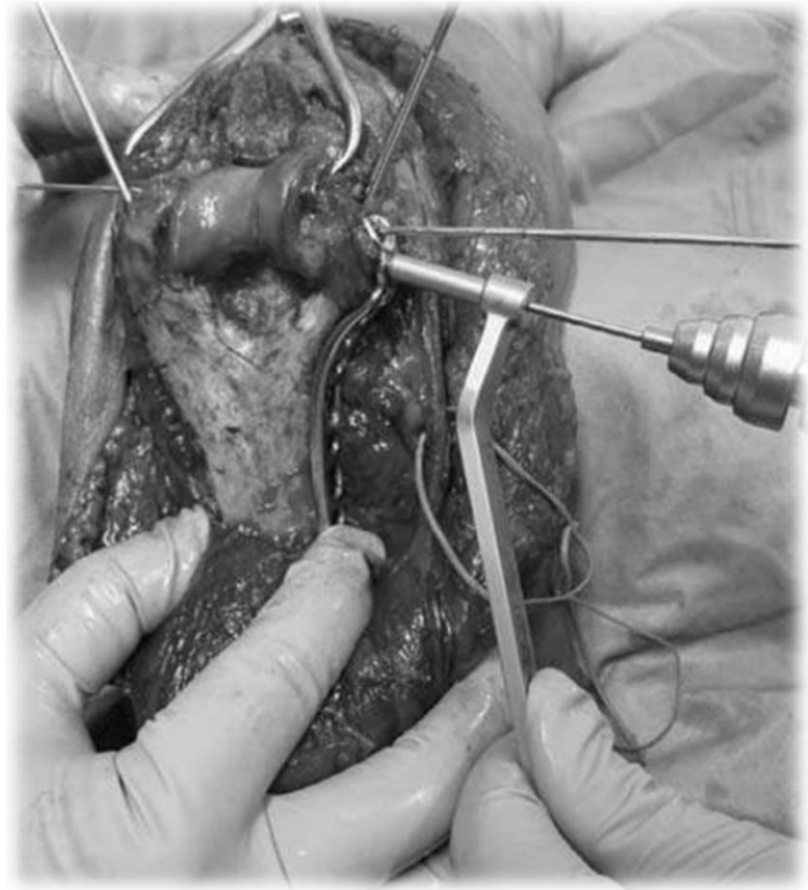
Surgical Technique

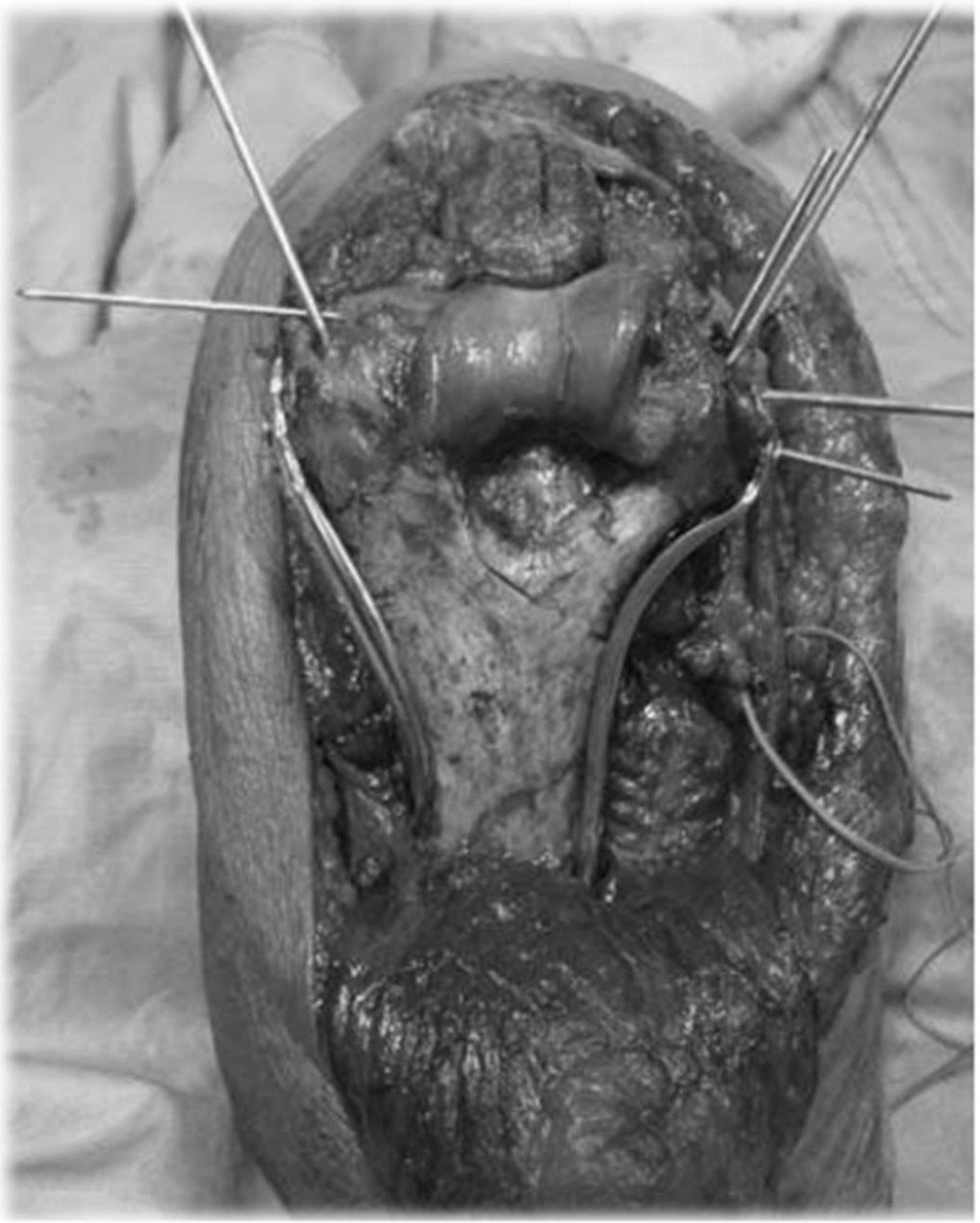













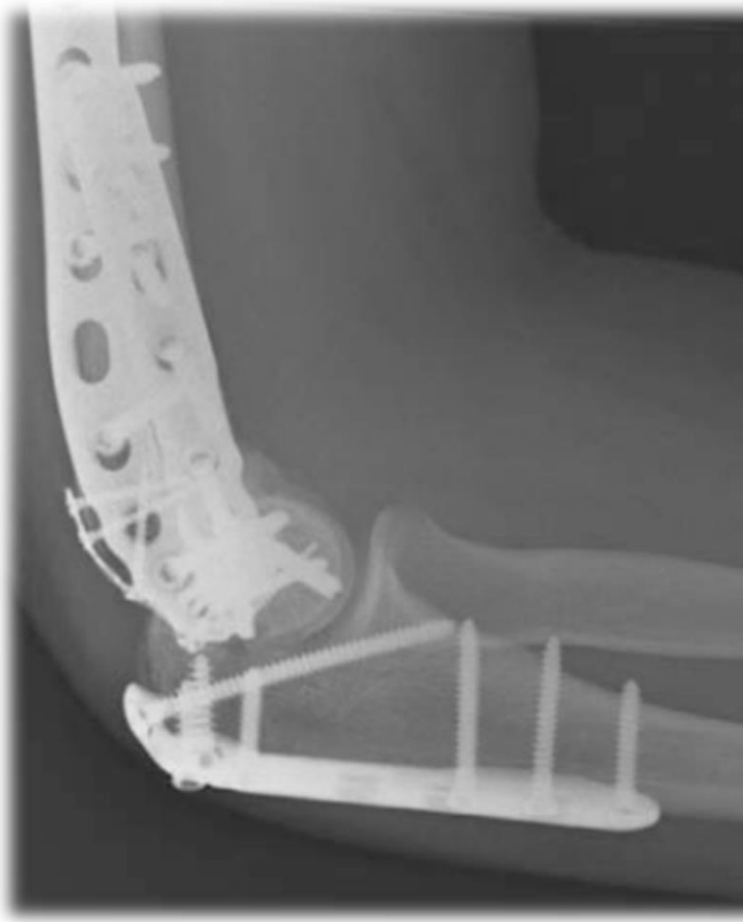
CHOICE OF IMPLANT

- **Type A:**
  - 3.5 or 4.0 mm screws are more reliable than K-wires.

- **Type B:**
  - For simple isolated lateral column injuries, single plate may be used or screws alone

- **Type C:**
  - Two plates are needed for adequate strength.
  - Increased by placing them at right angels to each other.
  - For firm fixation, the lateral plate should reach down to the joint line.
  - Plate bending and twisting equipment.


c



Surgical challenges

- Metaphyseal bone loss >> shortening and grafting
- Rigid fixation wasn’t achieved by dual plating >> Triple plating
  - Gofton, Jupitar and mehne Recommendations.
- Associated coronal plane fracture >> Triple plating
- Precontoured plating not matching the anatomy >> keep binders close
  - Be Careful with screws trajectory as it is predetermined.

B3 Fractures

- Lateral approach: post vs lat incision
- Reduction maneuver
- Provisional fixation with Thin wire
- Definite fixation with countersunk screw
- Anterior to posterior / posterior to anterior or combined (Stability??)
- Posterior Comminution impaction:
  - Disimpaction and grafting
  - Posterior plate if severe
- Type II might be excised
- Type IV need good exposure can be accessed By:
  - LCL Release and reinsertion
  - Separate Medial approach
  - Olecranon osteotomy.
- Arthroscopic Percutaneous approach is described also

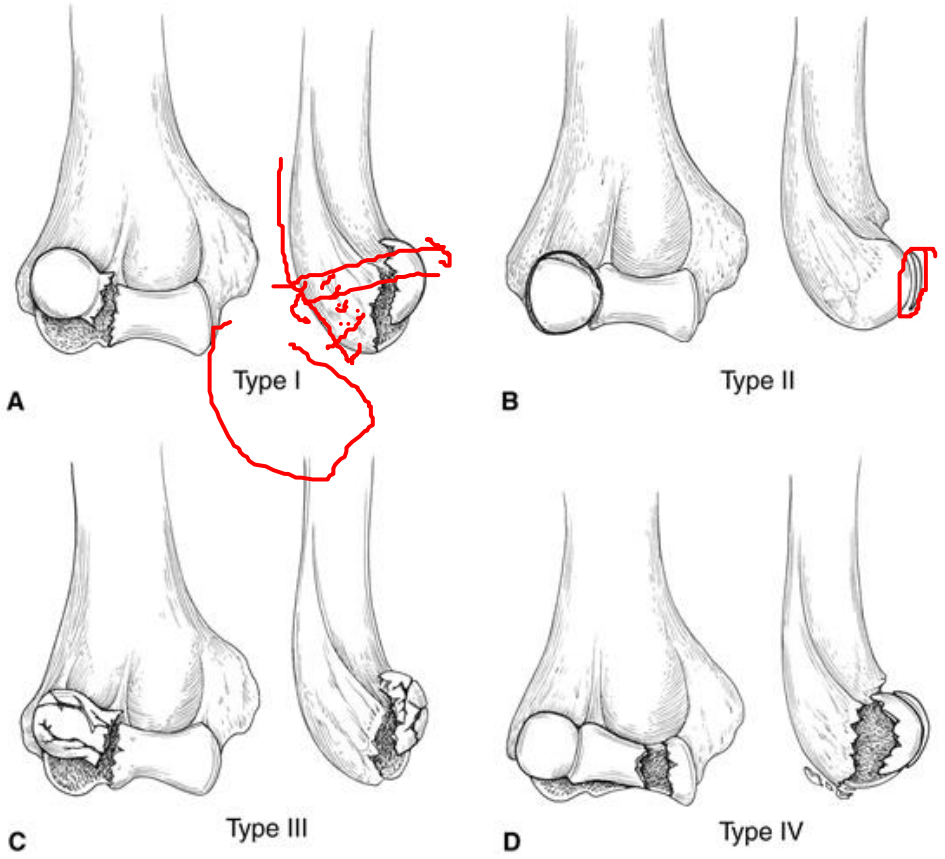


TABLE 35-4 Potential Pitfalls and Preventions for ORIF of Distal Humerus Fractures

Distal Humerus Fracture
Potential Pitfalls and Preventions

Pitfall	Prevention
Missed skin tenting, excessive swelling, fracture blisters	Application of a well-padded splint while awaiting surgery Re-check skin, soft tissues, and neurovascular status immediately before surgery
Unrecognized coronal shear fractures and articular comminution (fracture line between medial trochlea and medial epicondyle)	CT scan for complex fracture patterns (preferred) or traction radiographs Appropriate surgical approach for visualization Have supplementary fixation available (headless compression screws, threaded K-wires, and/or bioabsorbable pins)
Failure to recognize bone loss in open fractures	CT scan for complex fracture patterns Be prepared for bone grafting by adding it to the surgical consent form and by prepping and draping the iliac crest. Understand technique of supracondylar shortening
Ineffective surgical exposure	Critically examine fracture pattern and choose an approach that balances required visualization for ORIF vs. complications Understand extensile options
Irreparable distal humerus fracture with comminution and osteopenia in an elderly patient	Be prepared for total elbow arthroplasty, add to consent, and have the system available Conduct a surgical approach that is conducive for elbow arthroplasty
Radial nerve injury with placement of a long lateral plate	Understand radial nerve anatomy Radial nerve identification and protection for "high" lateral column fractures
Inadequate fixation of "low" transcolumn fractures	Place as many screws as possible into the distal articular segment Use fracture-specific plates that allow high-density distal screw placement
Screws placed across the olecranon fossa causing impingement	Use fluoroscopy to ensure all hardware is extra-articular and of appropriate length Check elbow range of motion to ensure there is no impingement Visually confirm the absence of intra-articular or impinging screws
Supracondylar nonunion	Compress the articular segment to the shaft with plate compression technique Be prepared to bonegraft or conduct supracondylar shortening in cases with bone loss
Ulnar neuropathy	Identify and protect ulnar nerve during surgical approach and ORIF Preoperative neurologic examination to document pre-existing nerve injuries

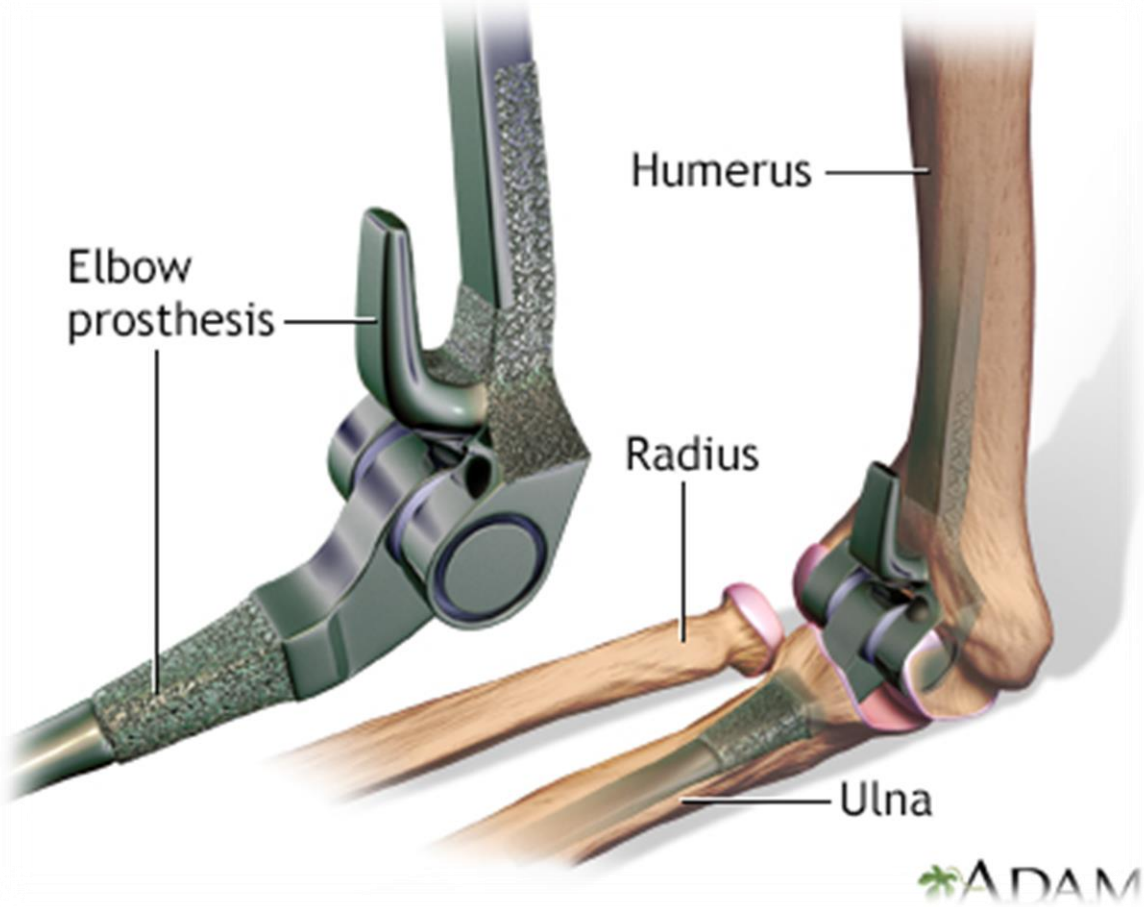
TOTAL ELBOW ARTHROPLASTY

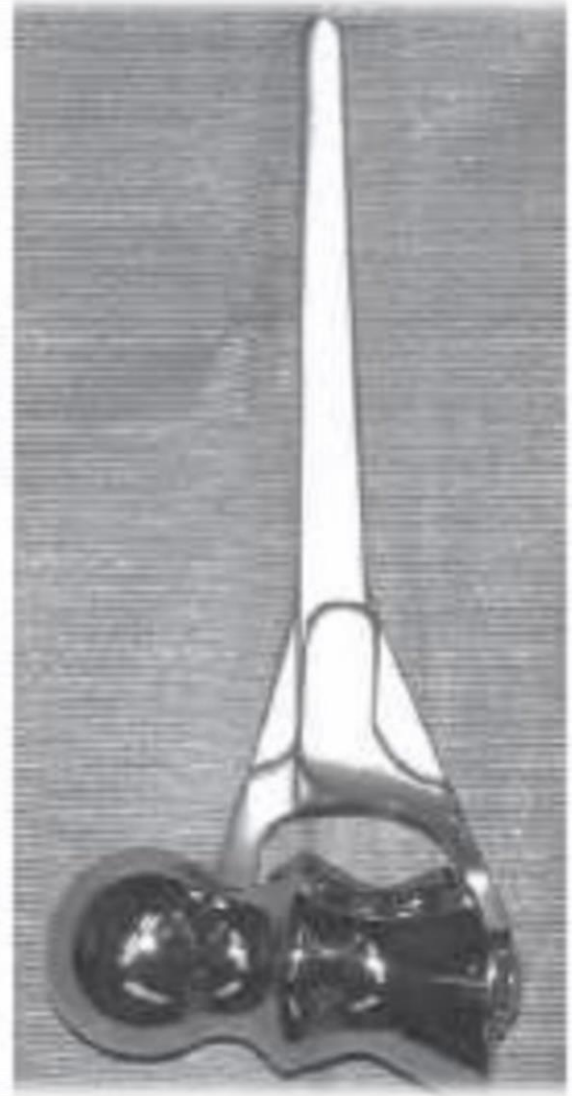
- Indications –
  - When ORIF is not attainable in elderly due to osteopenia, comminution, articular fragmentation or pre existing conditions.

- Contraindications
  - Active infection
  - Insufficient soft tissue coverage
  - Younger active patient

HEMIARTHROPLASTY

- Indications.
- Advantages –
  - Absence of Polyethylene wear debris / Osteolysis/ Aseptic loosening
- No literature evidence.


Humerus
Elbow prosthesis
Radius
Ulna
A.D.A.M.



COMPLICATIONS

- Non union
- Elbow stiffness
- Heterotopic ossification.
- Wound complications
- Infections
- Ulnar neuropathy.
- Olecranon osteotomy
- TEA - Complications.

Thanks For Your attention !!