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

https://www.youtube.com/watch?v=yYJFh8d_oE0&list=PLuBRb5B7fa_eLlhgRt2DFNKetmQ5nDLZJ&index=8

مجموعة جراحة الاصابات الرياضية والمناظير الاردنية
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ANATOMY

The double bundle Concept

The Ribbon Concept

Anatomy
The double bundle Concept

33mm long ,
11 mm in diameter
(Range)

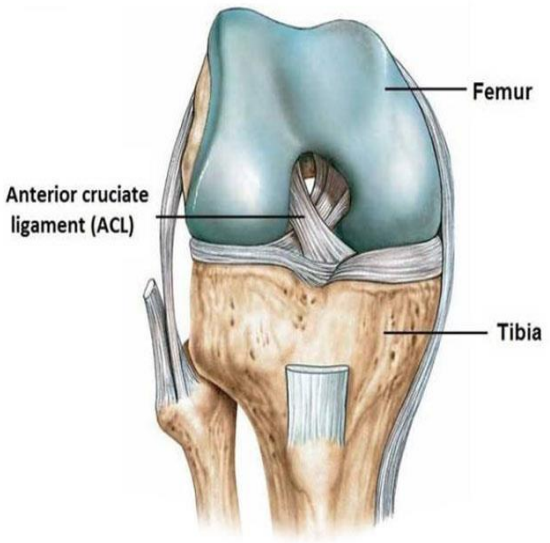
2 bundles :
Anteriomedial bundle
posteriolateral bundle
supplied by middle geniculate artery
90% type 1 and 10 % type III collagen

- **ORIGIN**

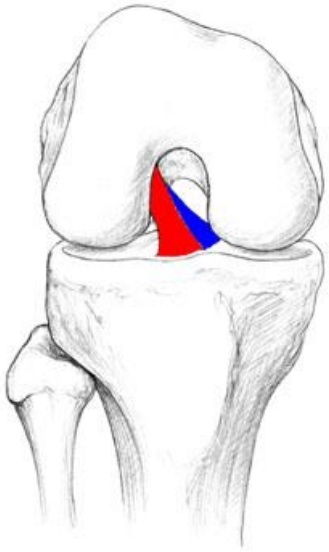
  - From the posteromedial corner of medial aspect of the LFC in the intercondylar notch

- **INSERTION**

- anterior tibia, between intercondylar eminences



The double bundle concept

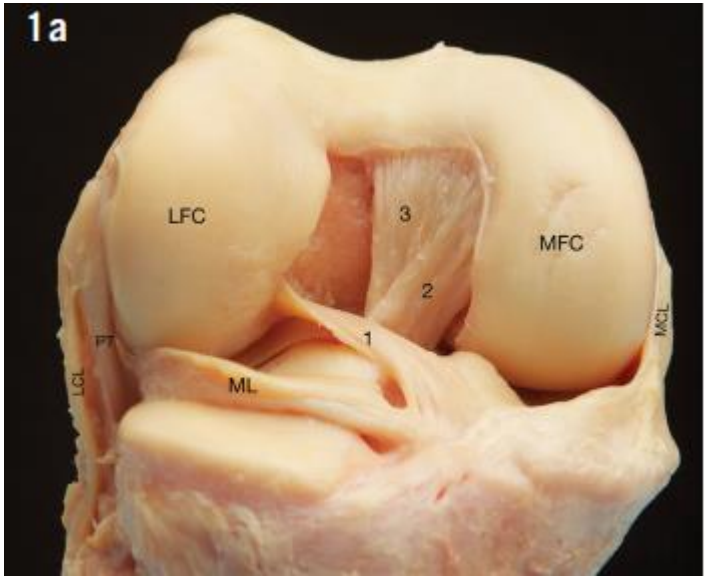


- anteromedial bundle
  - more isometric
  - tight throughout knee ROM, but tightest in flexion
  - primarily responsible for restraining anterior tibial translation (anterior drawer test)
- posterolateral bundle
  - greater length changes
  - tightest in extension, slack in mid-flexion
  - primarily responsible for rotational stability (pivot shift test)

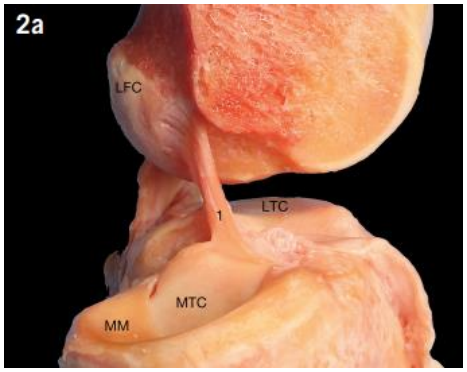
The RIBBON CONCEPT

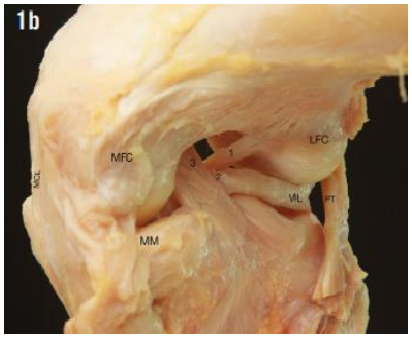
ACL formed a flat, ribbon-like ligament . Its average **width** (at the level of 2 mm from femoral insertion) was 16 mm, while the mean **thickness** was 3.54 mm, The authors could not differentiate two bundles within the ACL.

ACL is not a CYLINDER ,



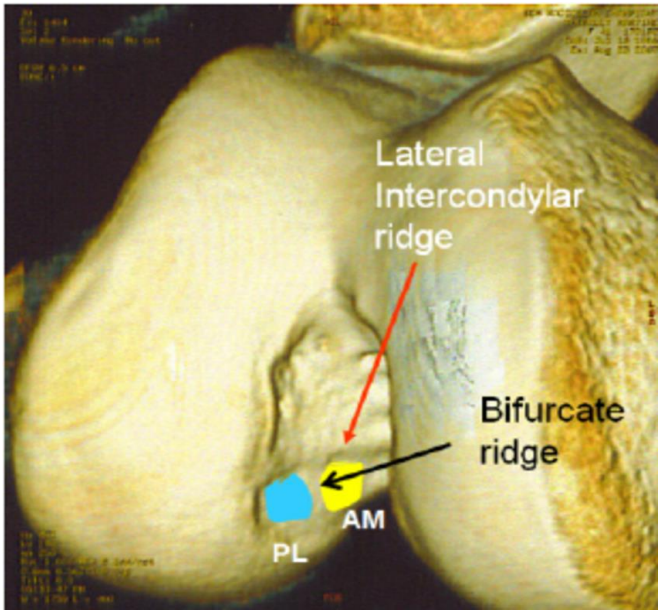
notice the ACL mid-substance and the way it changes its position during knee flexion-extension, one may notice a ‘double bundle effect’, created by the twisted flat ribbon-like structure. With different knee flexion angles, different groups of ACL fibres become tight –or loose. With the knee in full extension, the ACL lies vertically (in the sagittal planeand with knee flexion the ACL lies more horizontally.





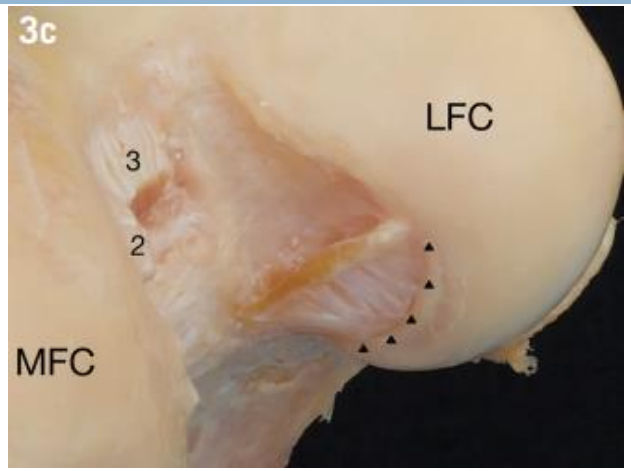
ACL ORIGIN

- lateral intercondylar ridge demarcates the anterior edge of the ACL
- bifurcate ridge separates the anteromedial and posterolateral bundle attachment



The Ribbons concept
Femoral Attachment

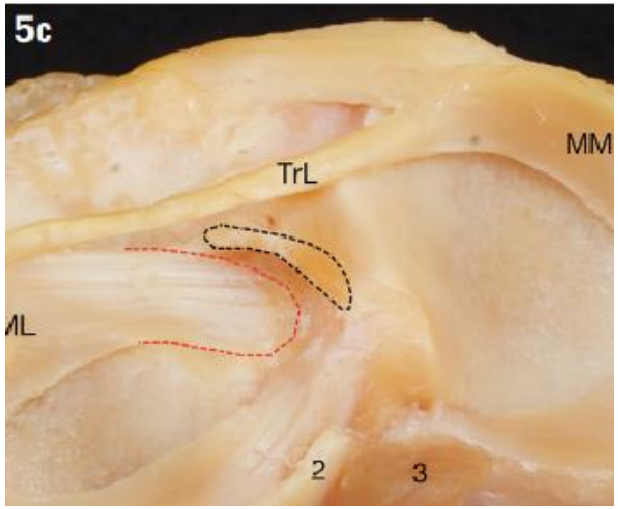
The ACL femoral attachment is a semilunar , It extends posteriorly and superiorly to the articular cartilage margin. The ACL midsubstance arises from the resident's ridge DIRECT origin : is at LFC fibrocartiage interference, Indirect Origin : more posterior and has no transitional fibrocartilage

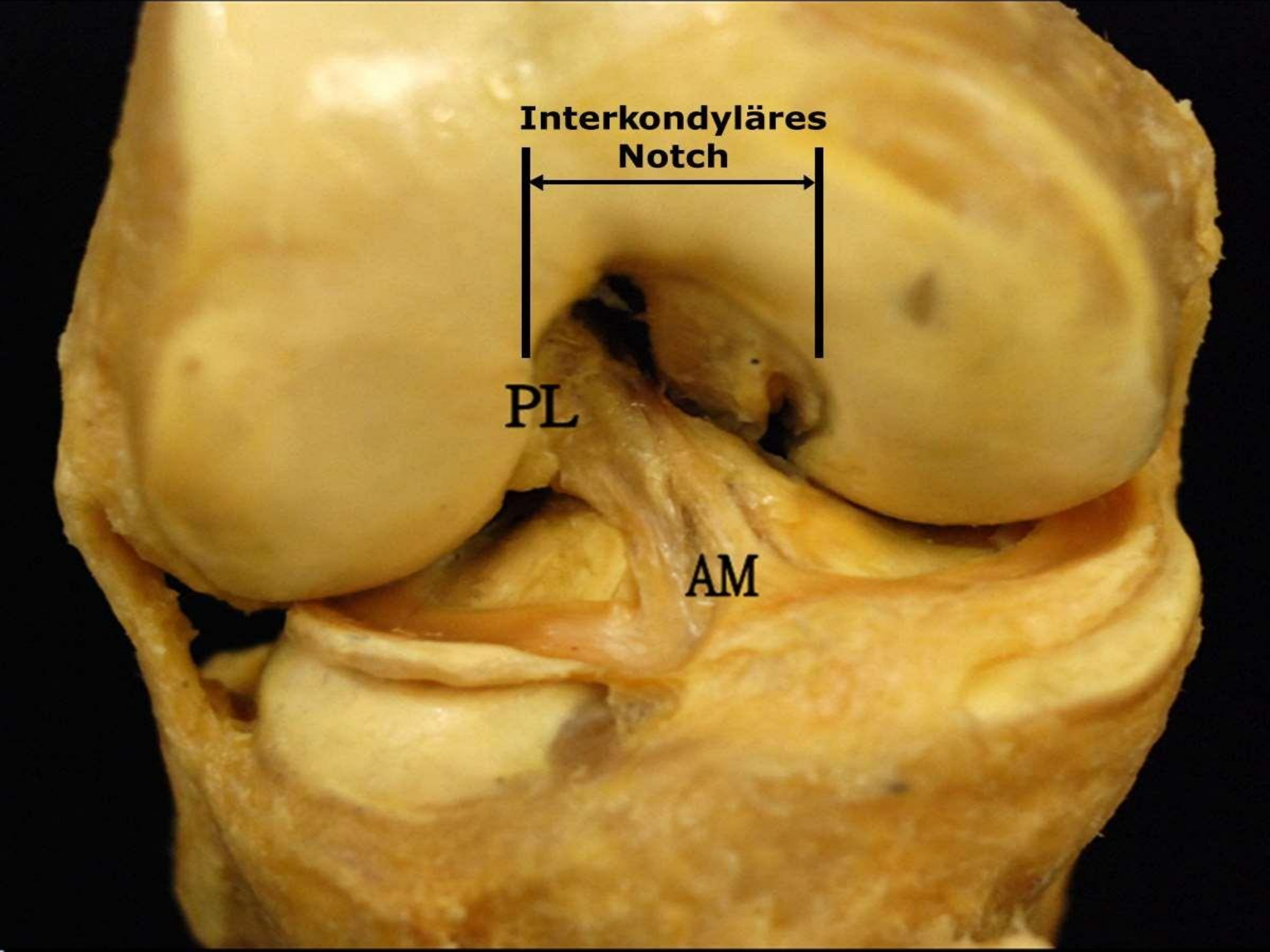


The Ribbons Concept
Tibial Attachment

The tibial attachment of the ACL is ‘Cshaped, The centre of the ‘C’ is the bony attachment of the anterior root of the lateral meniscus. The ACL surrounds and covers the anterior root of the lateral meniscus. This is the crucial difference between ‘double-bundle’ and ‘ribbon-like’ theories of ACL anatomy.

So it could be C-shape , J shape , Double J shape




Interkondyläres
Notch
PL
AM

ACTION

ACL Function _ _ _

•provides 85% of the stability to prevent anterior translation of the tibia relative to the femur

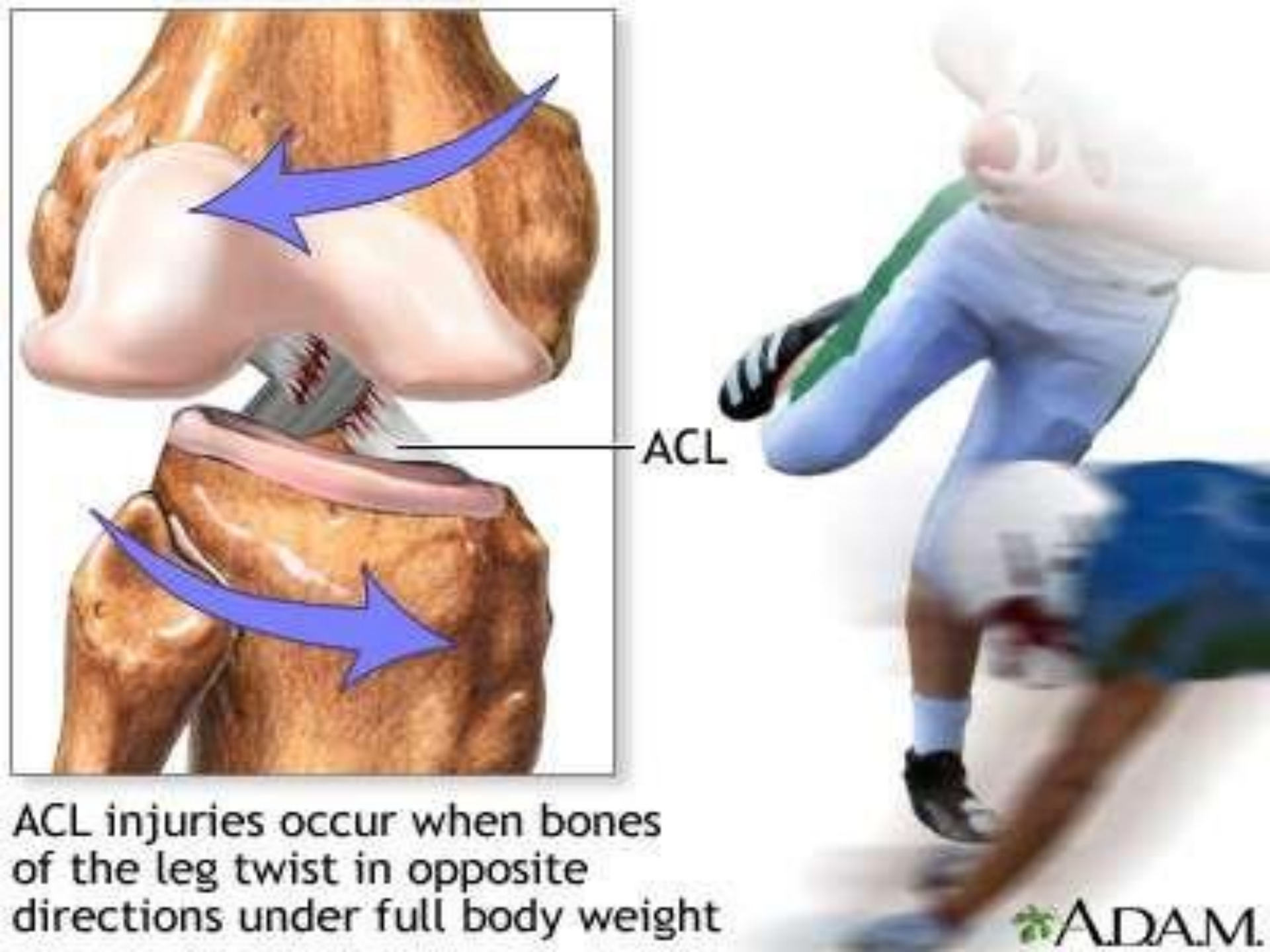
•acts as a secondary restraint to tibial rotation .

Pattern of injury

A twisting and hyperextension injury commonly causes an ACL +/- PCL tear.

A hyperextension injury in a nonweight bearing leg can cause an ACL or PCL tear.

A hyperflexion injury such as a fall in skiing causes an ACL tear.


ACL
ACL injuries occur when bones of the leg twist in opposite directions under full body weight
A.D.A.M.

- Several studies have shown that female athletes have a higher incidence of ACL injury than male athletes because of :
- landing biomechanics and neuromuscular activation patterns (quadriceps dominant) play the biggest role

Different neuromuscular recruitment patterns (high quadriceps-to-hamstring activity ratio) and landing/cutting biomechanics (decreased hip and knee flexion, increased knee external rotation with subsequent dynamic knee valgus) contribute most to the increased incidence of anterior cruciate ligament (ACL) tears in female athletes.

Associated Injuries

- Often associated with a meniscal tear
  - lateral meniscal tears in 54% of acute ACL tears
- Chronic ACL deficient knees associated with
  - chondral injuries
  - complex unrepairable meniscal tears
  - relation with arthritis is controversial

SYMPTOMS

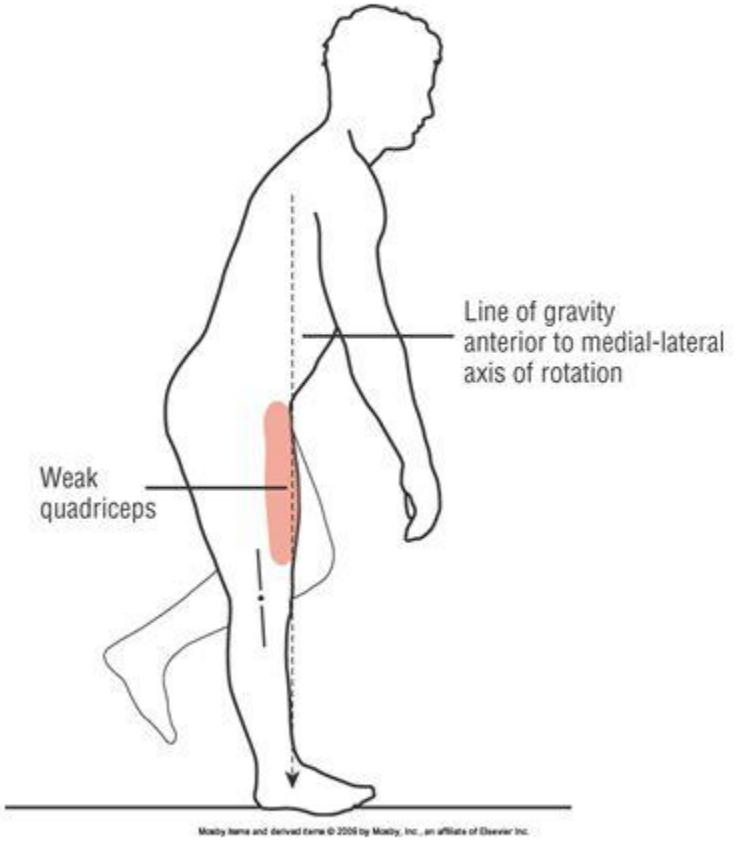
felt a "pop"
pain deep in the knee
immediate swelling (70%) / hemarthrosis

Physical Exam

Effusion
Locking
Quadriceps Atrophy
Quadriceps avoidance gait (does not actively extend knee)

Weak Quadriceps Gait

- Knee remains fully extended throughout stance, combined with excessive forward lean of trunk
- Impairment
  - Weakness or avoidance of activation of quadriceps muscle
- Reason for deviation
  - Forward lean of trunk shifts line of gravity anterior to medial-lateral axis of knee



PHYSICAL EXAMINATION

Special Tests

Clinical Examination

Stability Testing:

The Lachman test is the most Sensitive test in DxACL tear

History:

- *Noulis test (Georges Noulis Thesis in Paris, 1875)*
- *Ritchley test (1960)*
- *Ritchley-Lachman test (Torg et al 1976)*

Curtesy of Mr Panos Thomas

LACHMAN'S TEST

- This is a variant of the anterior drawer test
- The examination is carried out with the knee in 15 deg of flexion, and external rotation (relaxes IT band)
- For a right knee, the examiner's right hand grips the inner aspect of the calf and the left hand grasps outer aspect of the distal thigh
- Attempt to quantify the displacement in mm is done by

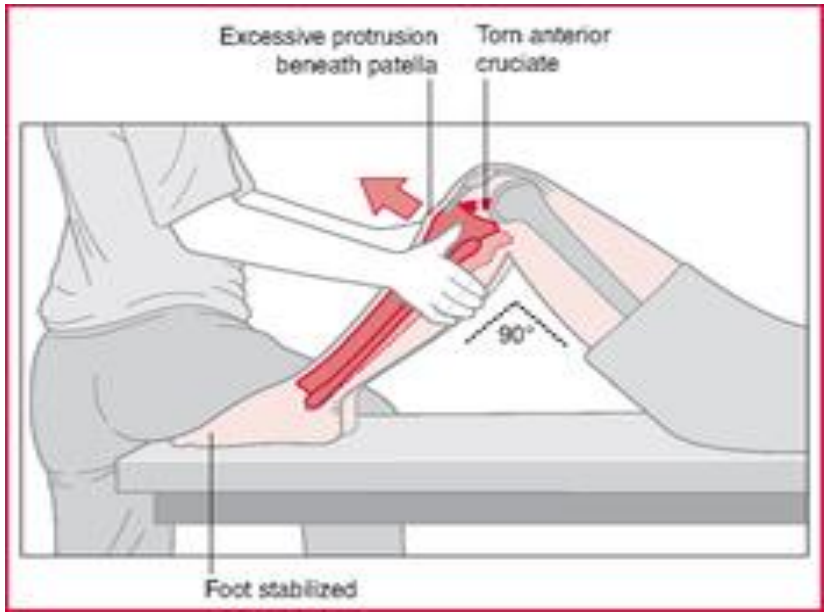
- End point should be graded as hard or soft
  - End point is said to be hard when the ACL
  abruptly halts the forward motion of the tibia on
  the femur
  - End point is soft when there is no ACL & restraints are more elastic secondary stabilizers;

GRADING

gradingA= firm endpoint, B= no endpoint
Grade 1: 3-5 mm translation
Grade 2 A/B: 5-10mm translation
Grade 3 A/B: > 10mm translation

ANTERIOR DRAWER TEST

- To perform anterior drawer test, examiner grasps pt's tibia & pulls it forward with hip flexed 70 degree and the knee 90 degree while noting degree of anterior tibial displacement

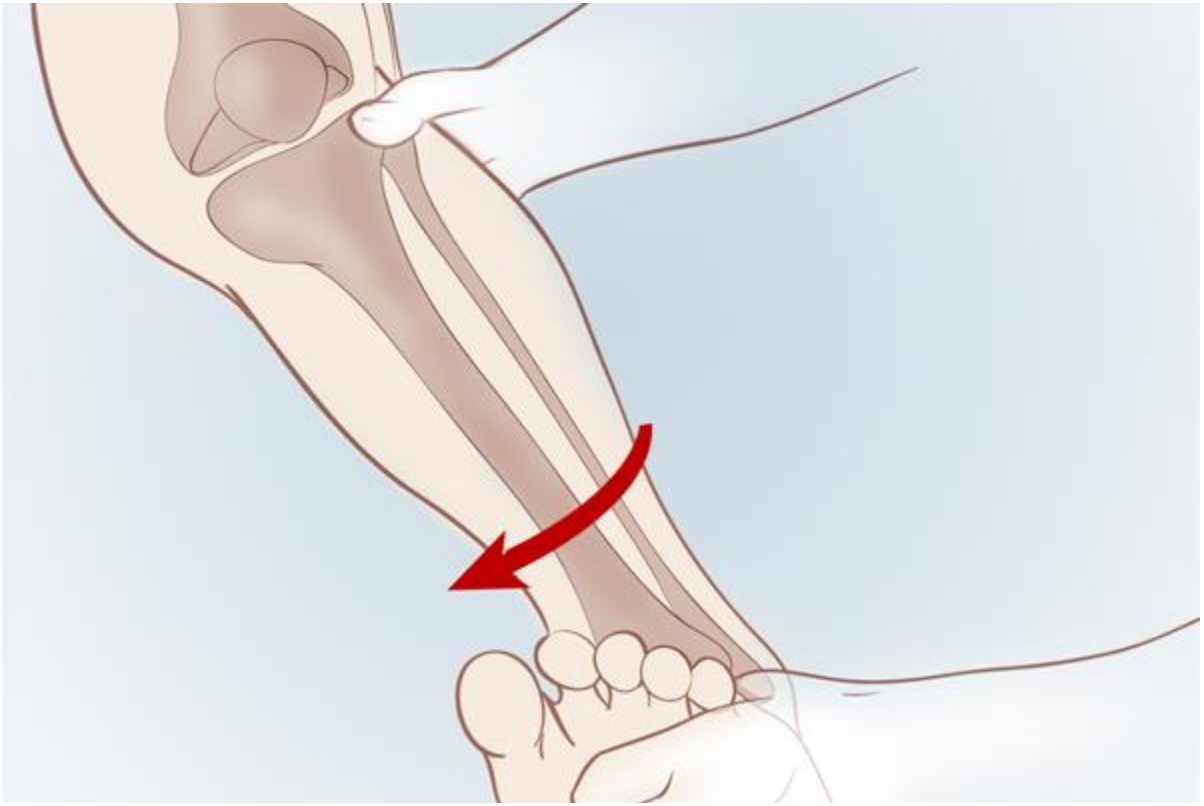


PIVOT SHIFT TEST

- During this test,
  pt is kept in supine & examiner holds pt's leg with both hands

  abduct the pt’s hip (to relax the ITB and allow the tibia to rotate)

Holding the heel in one hand and applying a valgus stress in the other hand, the knee is slowly flexed



- The tibia, as well as the valgus, subluxes easily if anterior force is applied.

- After the anterior subluxation of the tibia is noticed, the knee is slowly flexed, and the tibia will reduce with a snap at about 20° to 30°of flexion.

INVESTIGATIONS

- XRAY
- MRI
- Arthroscopy

X-RAY

Segond fracture (avulsion fracture of the proximal lateral tibia) is usually pathognomonic for an ACL tear represents bony avulsion by the anterolateral ligament (ALL)
associated with ACL tear 75-100% of the time

X-RAY

deep sulcus (terminalis) sign _depression on the lateral femoral condyle at the terminal sulcus, a junction between the weight bearing tibial articular surface and the patellar articular surface of the femoral condyle.

MRI

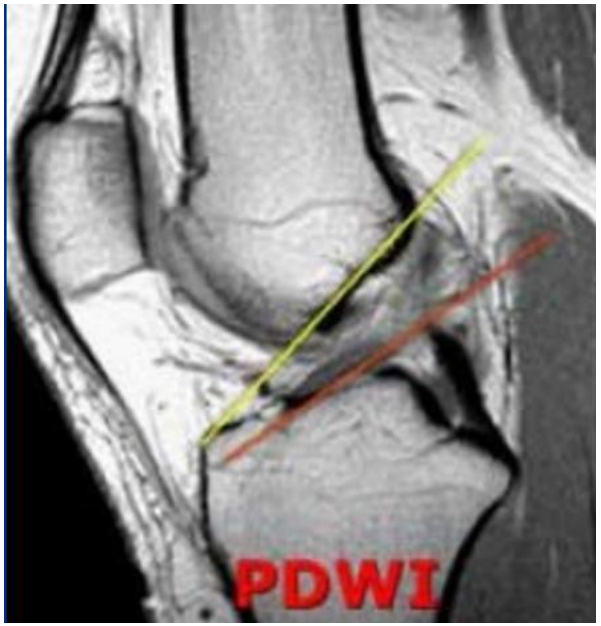
coronal view
discontinuity of fibers (do not reach the femur)

MRI

- fluid against the lateral wall ("empty notch sign")

Sagittal view

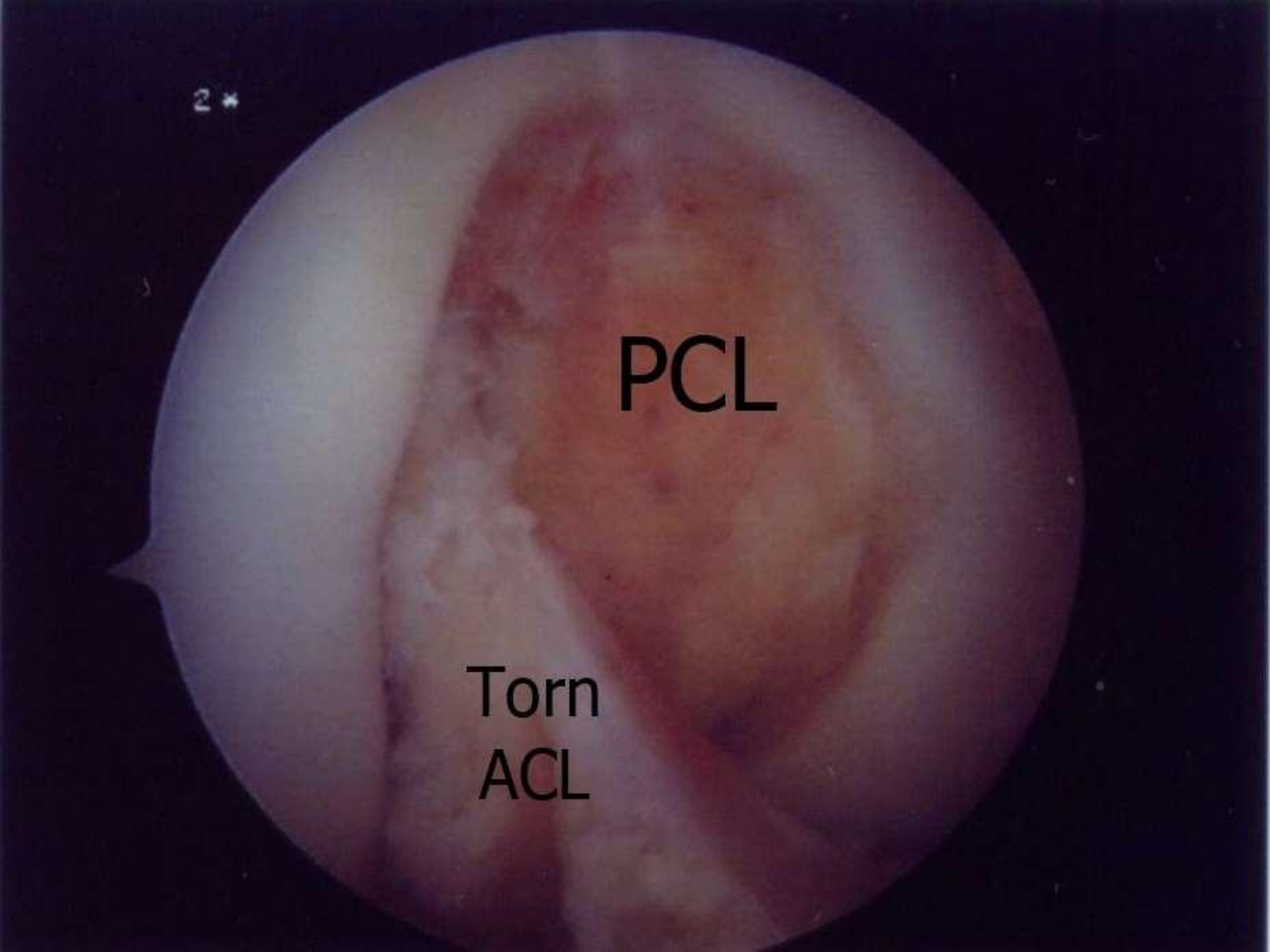
discontinuity of fibers on T2
abnormal orientation
- too "flat" compared with intercondylar roof / Blumensaat's line
- this acute angle is common in chronic cases where ACL scars to the PCL



bone bruising in > half of acute ACL tears middle 1/3 of LFC (sulcus terminalis)
posterior 1/3 of the lateral and medial tibial plateau
subchondral changes on MRI can persist years after injury

MRI

Secondary findings :
Buckling of the PCL
Anterior tibial translation
Bone edema
Bone brusing is the least sensitive of ACL stability


PCL
Torn
ACL

MANAGEMENT

- Immediately after injury
  - **R.I.C.E** (**R**est **I**ce **C**ompression **E**levation ()
  - Exercise (after swelling decreases and weight-bearing progresses)

TREATMENT

- NON-SURGICAL METHOD
- SURGICAL METHOD

Nonsurgical Treatment

physical therapy & lifestyle modifications

low demand patients with decreased laxity

increased meniscal/cartilage damage linked to

- loss of meniscal integrity
- the frequency of buckling episodes
- level I and II activity (e.g. jumping, cutting, side-to-side sports, heavy manual labor

Precautions

- Modification of active lifestyle to avoid high demand activities
- Muscle strengthening exercises for life
- May require knee brace
- Despite above precautions ,secondary damage to knee cartilage & meniscus leading to premature arthritis

Surgical Treatment

- Timing of Surgery
- 1) Swelling in the knee must go down to near-normal levels
- 2) Range-of-motion (bending and straightening) of the injured knee must be nearly equal to the uninjured knee
- 3) Good Quadriceps muscle strength must be present.
- Usually it takes a couple of weeks after injury before ACL reconstruction can be performed.
- The presence of any associated injuries to the knee joint involving cartilage, meniscus, or other ligaments may change the time-frame for surgery

Surgical Treatment

- ACL tears are not usually repaired using suture to

  sew it back together, because repaired ACLs have

  generally been shown to fail over time

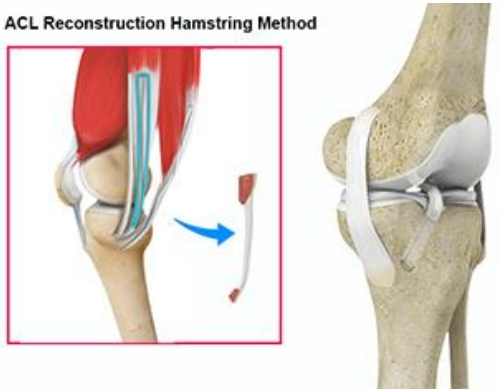
- Therefore, the torn ACL is generally replaced by a

  substitute graft made of tendon

The **grafts commonly used** to replace the ACL include

autograft	Allograft
Patellar tendon Hamstring tendon Quadriceps tendon	patellar tendon, Achilles tendon, semitendinosus, gracilis, or posterior tibialis tendon

Quadruple Hamstring autograft



may be taken from contralateral side in revision situation when allograft is not desirable or available

pros and cons

smaller incision, less perioperative pain, less anterior knee pain

fixation strength may be less than Bone-PT-Bone

maximum load to failure is approximately 4000 Newtons

decreased peak flexion strength at 3 years compared to Bone-PT-Bone

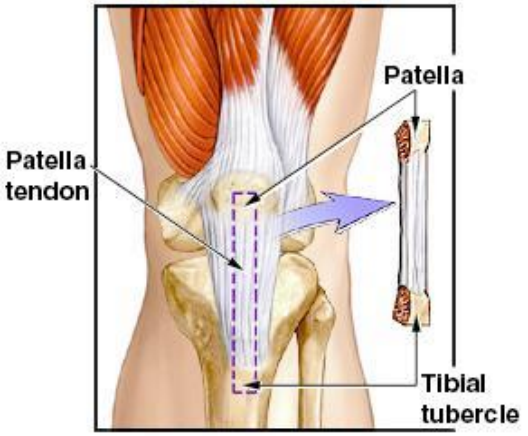
concern about hamstring weakness in female athletes leading to increased risk of re-rupture

complications

"**windshield wiper**" effect (suspensory fixation away from joint line causes tunnel abrasion and expansion with flexion/extension of knee) **, bungi jump effect** ,

residual hamstring weakness

BONE PATELLAR BONE AUTOGRAFT



Bone-patellar-bone autograft advantages of autograft

- using patient's own tissue
- most common source of graft
- faster incorporation
- less immune reaction
- no chance of acquiring someone else's infection

pros and cons of bone-patella-bone

- the longest history of use and considered previously the "gold standard"
- bone to bone healing
- ability to rigidly fix the joint line (screws)
- the highest incidence of anterior knee pain (up to 10-30%)
- maximum load to failure is 2600 Newtons (intact ACL is 1725 Newtons)

complications

- patella fracture (usually postop during rehab), patellar tendon rupture
- re-rupture

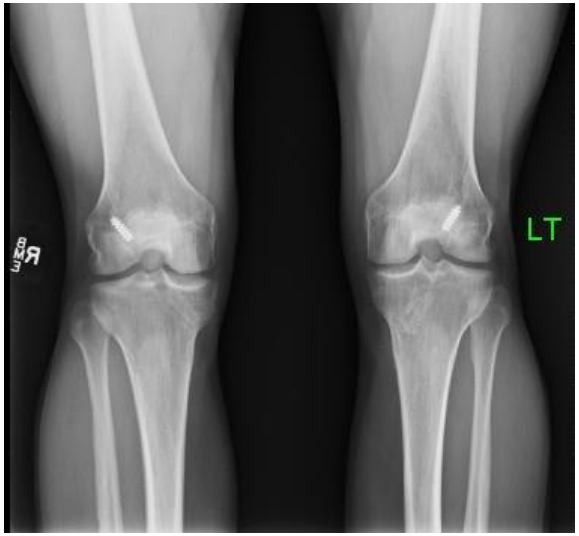
allografts

Allograftpros & cons

- useful in revisions
- longer incorporation time
- risk of disease transmission (HIV is < 1:1 million, hepatitis is even greater)
- increased risk of re-rupture in young athletes
  - odds of graft re-rupture are 4.3 x higher in allograft for athletes aged 10-19

Femoral tunnel placement
The clock phase

- sagittal plane
  - 1-2 mm rim of bone between the tunnel and posterior cortex of the femur
- coronal plane
  - the tunnel should be placed on the lateral wall (at 2 (left knee) or 10 (right knee) o'clock position) to create a more horizontal graft - remember 2 and 10



(I.D.E.A.L) FEMORAL TUNNEL POSITION

ISOMETRIC GRAFT WILL HAVE LENGTH TENSION RELATIONSHIP SIMILAR TO NATIVE ACL

DIRECT DIRECT FIBER S INSERTION ON THE ACL FOOT PRINT

ECCENTRIC HIGHER IN THE FOOT PRINT & IN THE ANTEROMEDIAL PART OF ACL

EQUIDISTANT ½ WAY BETW.TOP & BOTTOM OF NOTCH

ANATOMIC FIBERS OF GRAFT WITHIN THE BOUNDARIES OF NATIVE ACL HIGHER IN FOOTPRINT

LOW TENSION GRAFT SHOULD HAVE LOW TENSION FLEXION PATTERN SIMILAR TO NATIVE ACL

Tibial tunnel placement

sagittal plane

- the center of tunnel entrance into joint should be at the stump of the ACL (ACL REMENANT) ,or 6mm infront of the anterior border of the PCL

coronal plane

- tunnel trajectory of < 75° from horizontal
  - obtain by moving tibial starting point halfway between tibial tubercle and a posterior medial edge of the tibia.

Single or Double bundle technique?

Anatomical Single-Bundle Technique

Advantages:

1) Simplicity
2) Broad spectrum of grafts
3) Simpler graft passage
4) Lower cost

Disadvantages:

1) Inadequate rotational stability

Double-Bundle Technique

Advantages:

1) ?Better rotational stability
2) Allowance for individual variables

Disadvantages:

1) Anatomic or not? (Numerous double bundle techniques)
2) Technically demanding
3) Longer operating time
4) Limited graft selection

PHYSIOTHERAPY

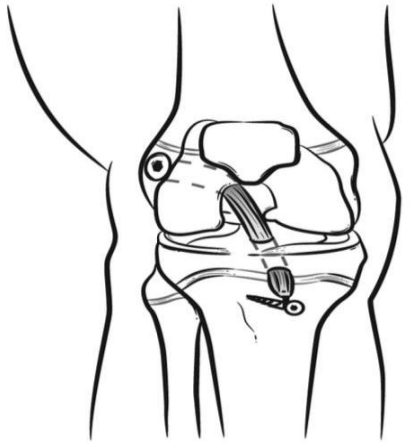
- Early postoperativeimmediate
  - aggressive cryotherapy (ice)
  - immediate weight bearing (shown to reduce patellofemoral pain)
  - emphasize early full passive extension.
- early rehab
  - focus rehab on exercises that do not place excess stress on graft
    - appropriate rehab
      - eccentric strengthening at 3 weeks has been shown to result in increased quadriceps volume and strength
      - isometric hamstring contractions at any angle
      - isometric quadriceps, or simultaneous quadriceps and hamstrings contraction
      - active knee motion between 35 degrees and 90 degrees of flexion
      - emphasize closed chain (foot planted) exercises
    - avoid
      - isokinetic quadricep strengthening (15-30°) during early rehab
      - open chain quadriceps strengthening

Pediatrics Consedirations

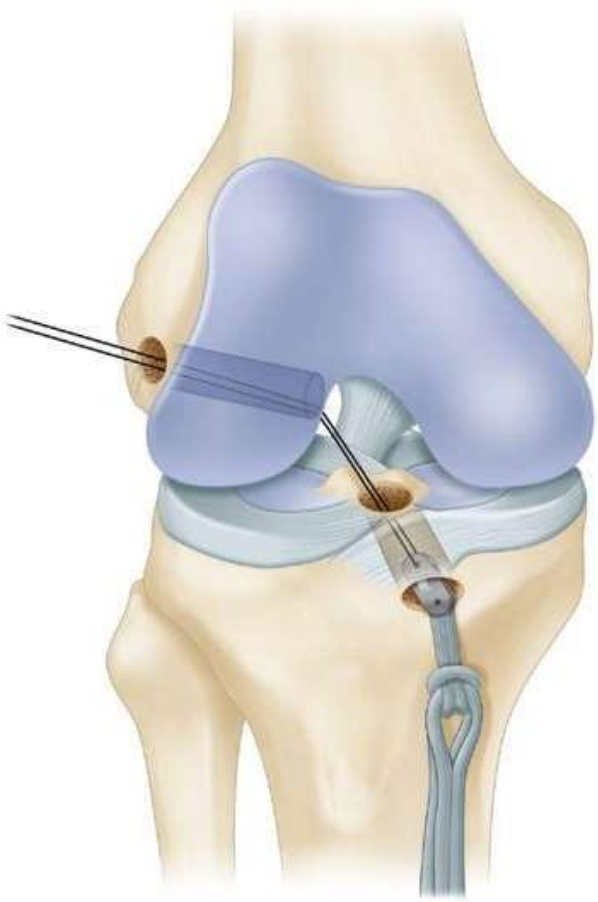
- Physis
  - < 14 yrs with open physis
  - the onset of menarche is the best determinant of skeletal maturity in females
- Treatment
  - Nonoperative
    - indications
      - compliant, low demand patient with no additional intra-articular pathologies
      - partial ACL tear (60% of adolescents have partial tears) with near normal Lachman and pivot shift
  - Surgery
    - indications
      - complete ACL tear

Techniques

- intra-articular
  - physis-sparing (all intra-epiphyseal)
  - transphyseal (males ≤13-16, females ≤ 12-14)
  - partial transphyseal
    - leave either distal femoral or proximal tibial physis undisturbed
  - no significant difference in growth disturbances between techniques



Anderson transepiphyseal replacement of anterior cruciate ligament using quadruple hamstring grafts



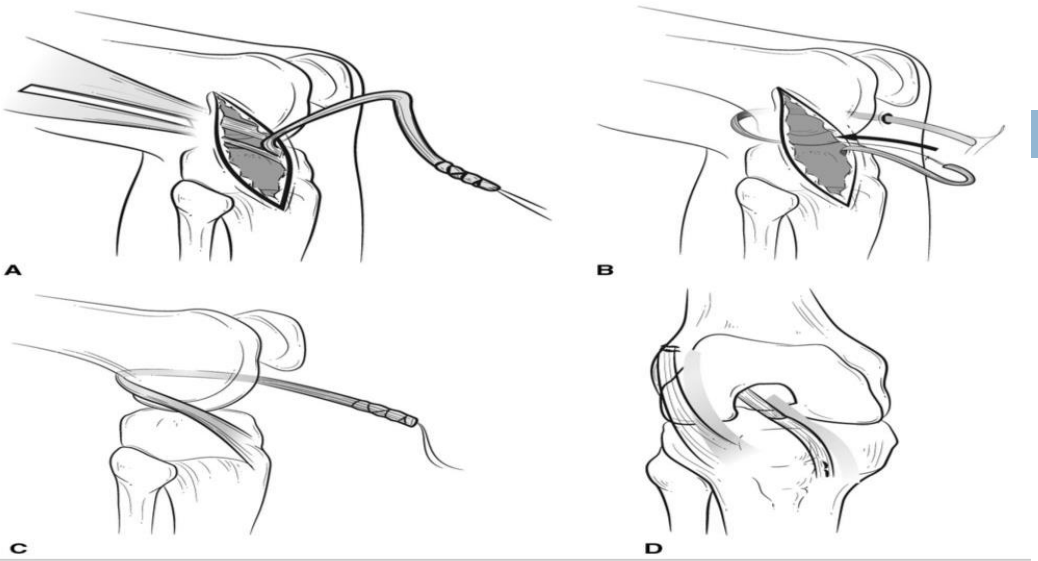
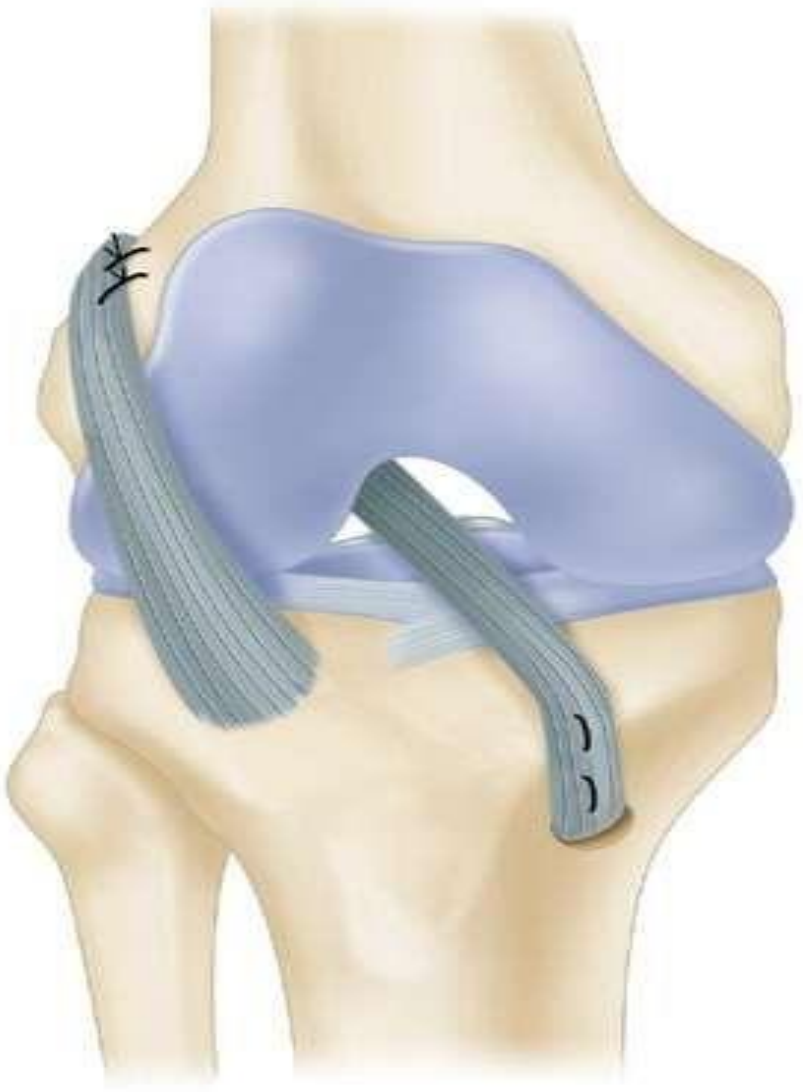


Illustration of physeal-sparing combined extra- and intra-articular anterior cruciate ligament reconstruction using autogenous iliotibial band. **A,** The iliotibial band is harvested free proximally and left attached distally to the Gerdy tubercle. **B,** The graft is brought through the knee in the over-the-top position. **C,** The graft is brought through the notch and under the intermeniscal ligament anteriorly. **D,** The final intra- and extra-articular reconstruction construct after the graft is sutured to the lateral femoral condyle and proximal tibia.

Combined intra- and extra-articular (males ≤12, females ≤ 11)

- autogenous ITB harvested free proximally, left attached distally to Gerdy's tubercle
- looped through the knee in over the top position
- passed through the notch and under intermeniscal ligament anteriorly
- sutured to lateral femoral condyle and proximal tibia

physeal-sparing, combined intraarticular and extraarticular reconstruction of acl by Kocher, Garg, and Micheli



COMPLICATIONS

FIGURE 51-36 Causes of complications of anterior cruciate ligament reconstruction.