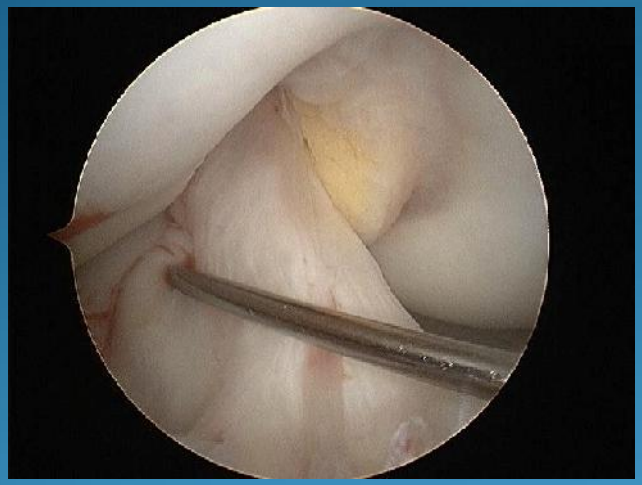
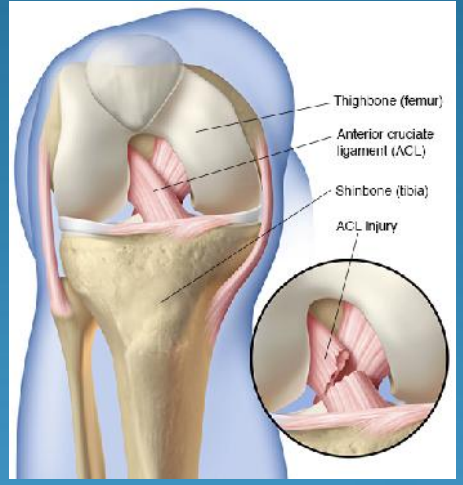
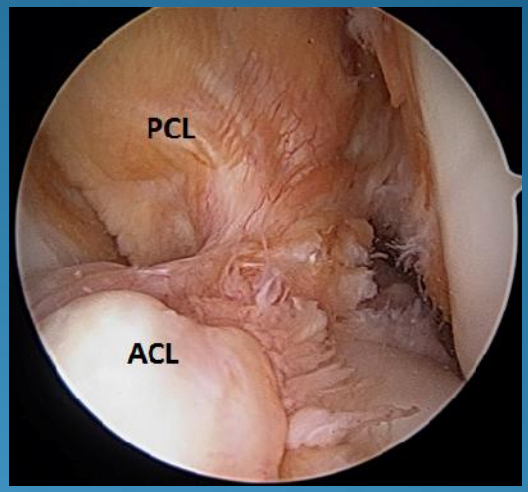
Management of ACL Injuries







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Work Related Injuries Workshop

May 2 & 3, 2016

Disclosures

- **Consultant**
  - Tornier Arthroplasty
  - DePuy Mitek Sports Medicine
- **Scientific and Product Advisory Board**
  - DePuy Mitek Sports Medicine
- **Editorial Board Member**
  - Journal of Bone and Joint Surgery (JBJS) – Sports Medicine Section
  - Orthopedic Reviews
  - World Journal of Orthopaedic
  - Journal of Medical Insight (JOMI) - Equity
- **Reviewer Panel**
  - American Journal of Sports Medicine (AJSM)
  - Journal of Shoulder and Elbow Surgery (JSES)
  - Orthopedics
  - Journal of Orthopaedic Research (JOR)
  - Orthopedic Reviews
  - KSSTA

- **Research Funding**
  - OREF
- **Equity**
  - JOMI

Basics of ACL Reconstruction

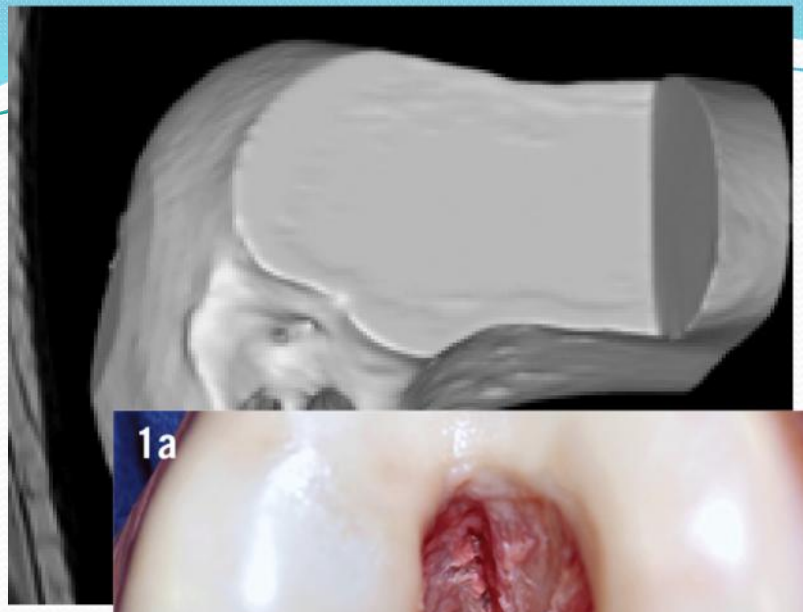
- Most studied Ligament
- Required for running, cutting, and kicking
- Proprioception and viscoelasticity
- 2 bundles and multi-axial function

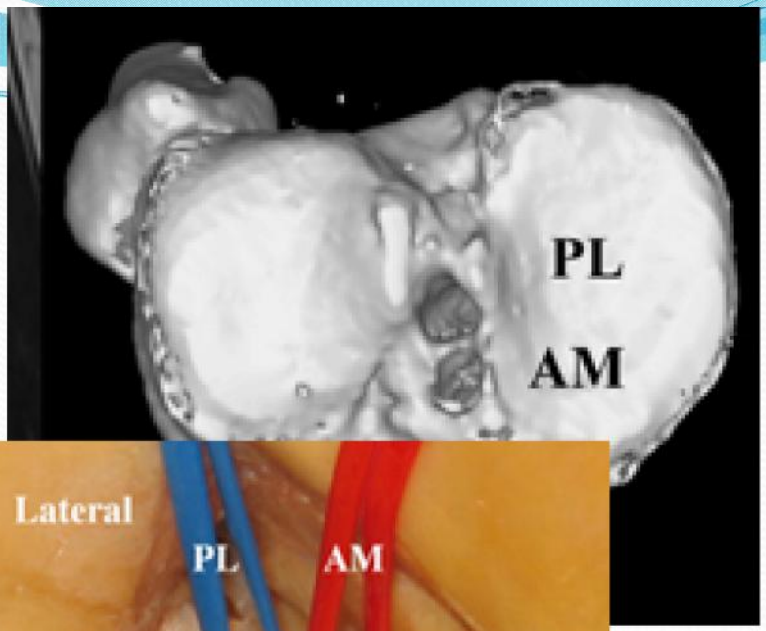
- **Incidence of Injury**
  - 1 / 3,500 ppl / yr (managed care) = ~80,000 to 100,000

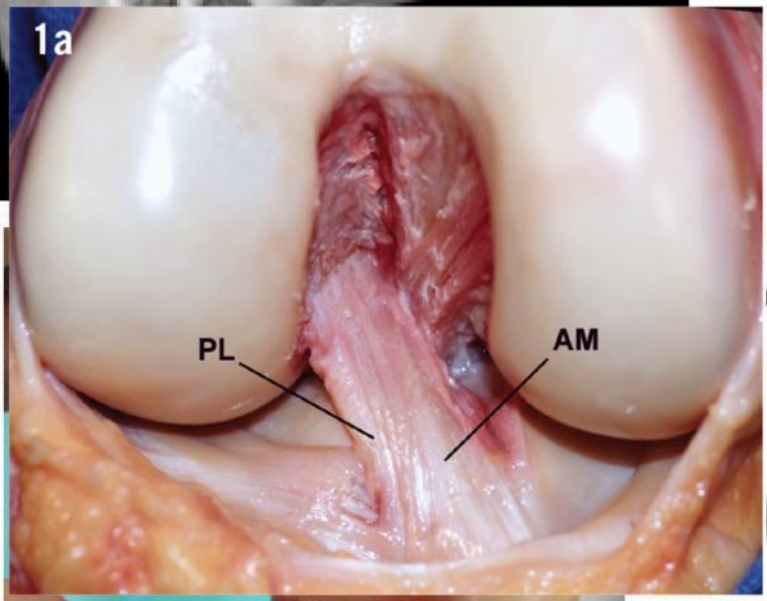
- 50,000 - 80,000 ACL done / yr x $17,000 = ~ $ 850,000,000 to > **$ 1 Billion**
  - Does not take in Lost time work, rehab, conservative mang, etc.

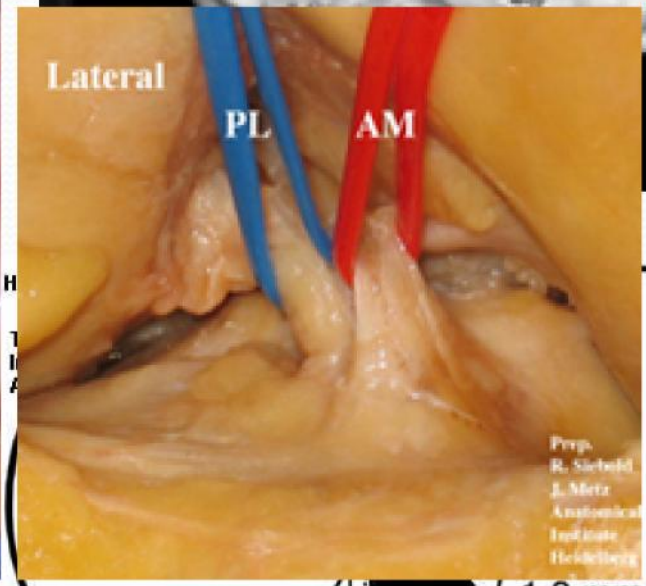
ACL Anatomy

- 30-40 mm long and 11mm wide
- Middle Genicular Artery (popliteal A.)
  - Inf and lateral genicular A -> via fat pads
- Both nerve and mechanoreceptors
- Divided to Antero-Medial and Postero-Lateral Bands
  - Continuation of fibers, but different portions are taut are different ROM.
  - Allow ACL to function in all ROM




PL
AM


1a
PL
AM


Lateral
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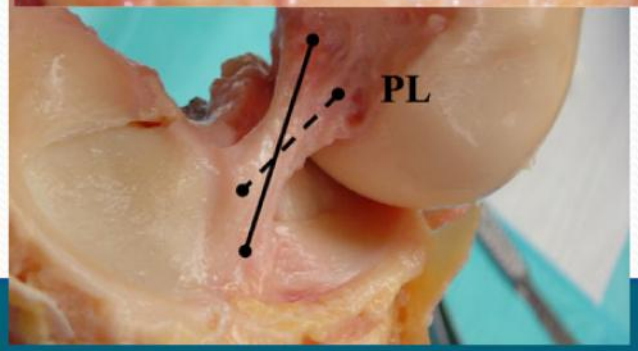
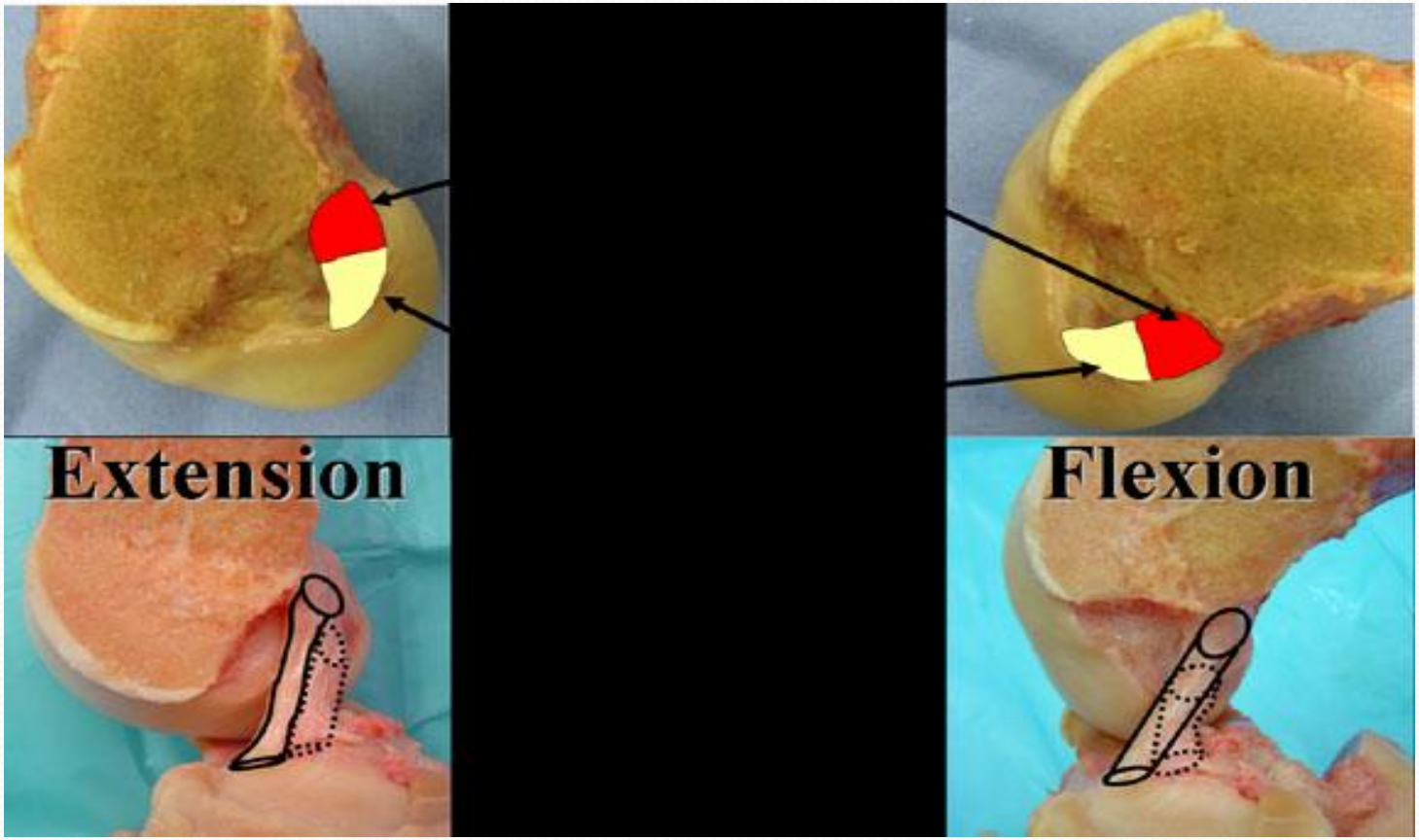

PL

Medial
18.5 mm
1.9 mm
ACL
FOOTPRINT
10.3 mm
Anterior
© KneeJointSurgery

Flexion vs. Extension



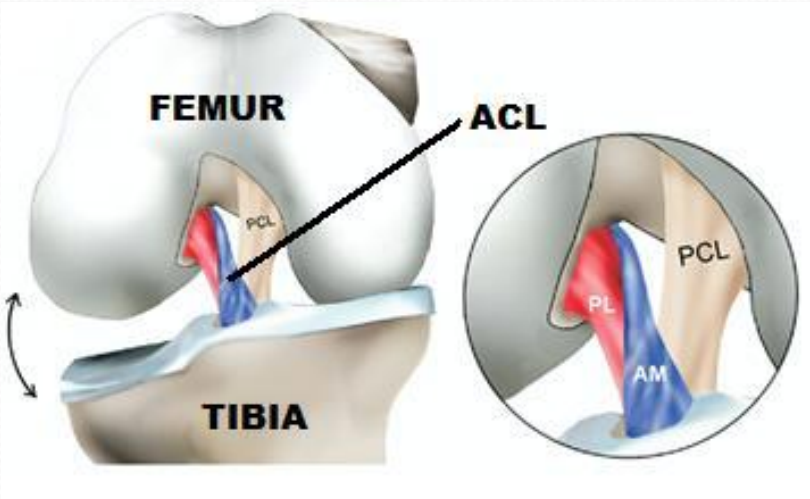
AM Bundle - Biomechanics

- AM fibers resist **anterior** tibial translation in the knee at 90° flexion

Zantop et al. Am J Sports Med, 2007

Biomechanics

- PL fibers control **<u>rotational stability</u>** of the knee, such as in pivoting, twisting, running, and jumping [9,10]



Zantop et al. Am J Sports Med, 2007.

Biomechanics / Function

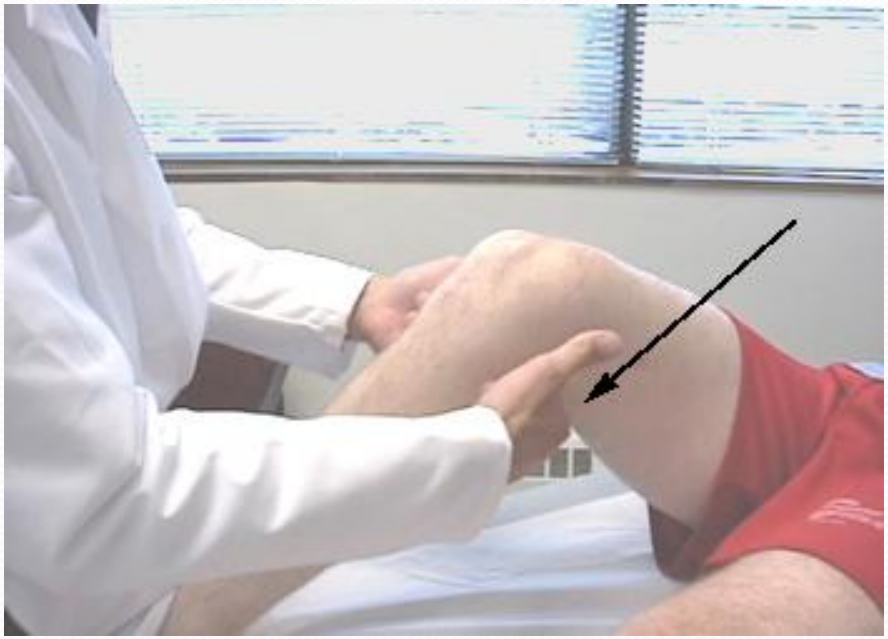
- Limit anterior tibia displacement
- Minor 2nd restraint to varus-valgus at Full Ext
- Great ant. displacement @ 30 flexion
- Rupture ACL = Abn. Ant translation and rotation (tibia)
- Ultimate Tensile properties ACL: 1,725 +/- 269 N
  - Extension: ~ 100 N
  - Walking: ~400 N
  - Cutting / pivoting: ~ 1,700 N

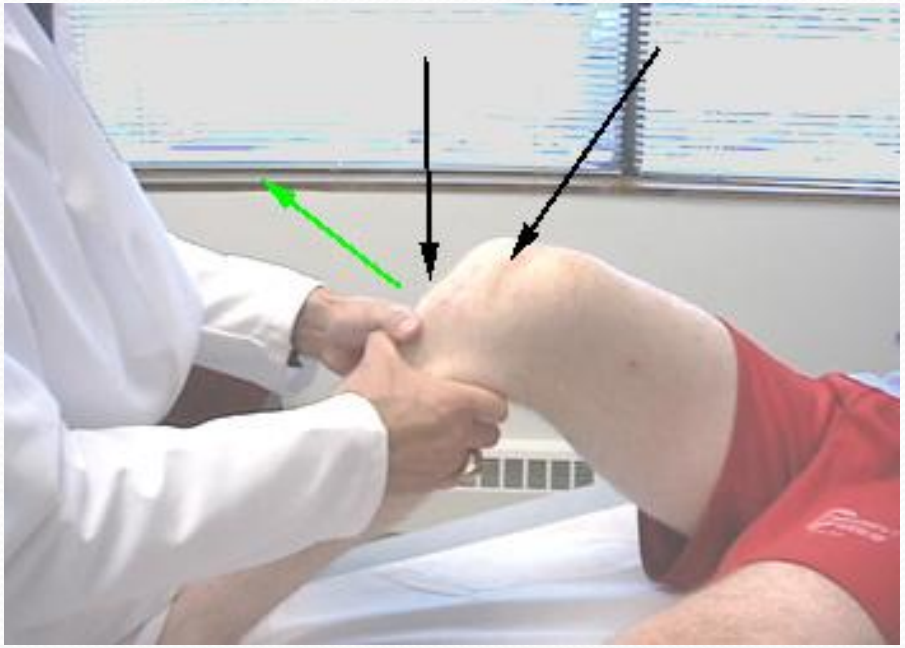
Clinical Sign / Symptoms

- *Non-contact injury* while changing direction or landing
- Twist of knee with "pop", acute hemarthosis, unable to bear weight.
- Locking, catching, or clicking of knee (ROM)
  - ? Meniscal tear +/- displaced bucket handle
  - Loose body

Anterior Drawer

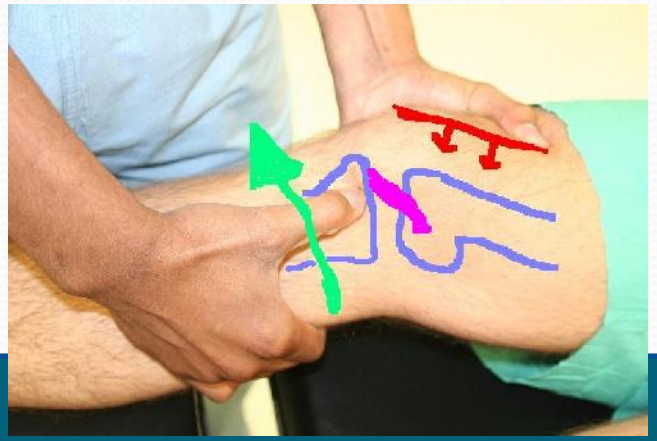
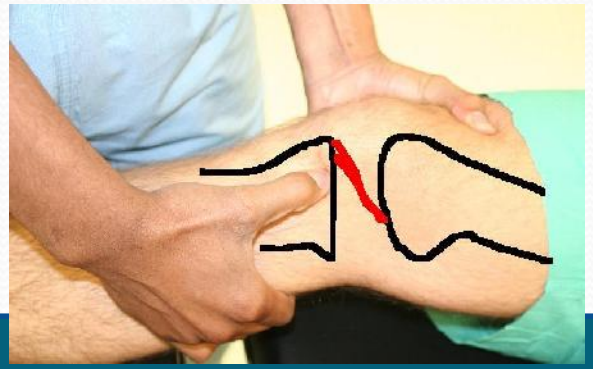
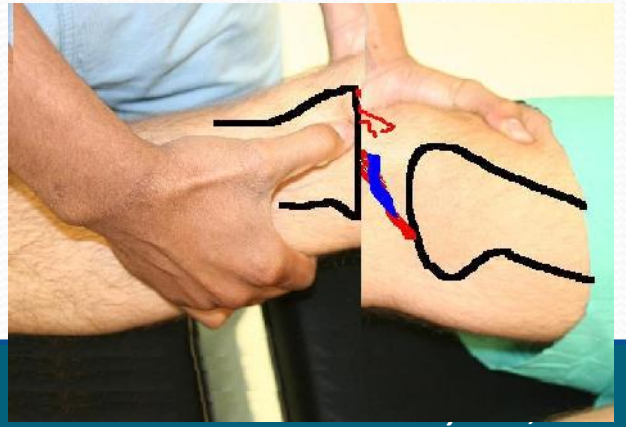
- 90 deg of flexion with anterior force (Tibia)
- Not as sensitive or specific as the Lachman





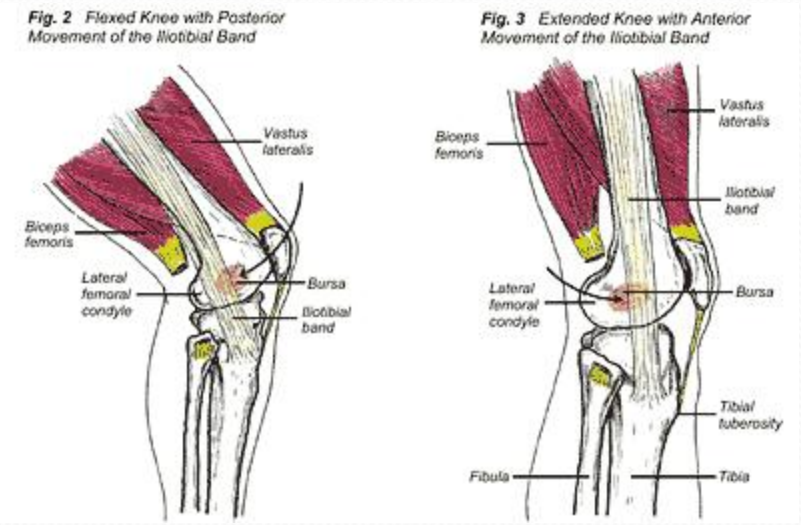
Exam

- Lachman
  - Knee 20-30 deg flexion -> stabilize femur, anterior force on prox tibia.
  - Est displacement (mm) and firmness of end point (firm, marginal, or soft)
  - Grade 1 (0 to 5 mm)
  - Grade 2 (5 to 10 mm)
  - Grade 3 (> 10mm)

Pivot Shift

- Very early flexion: Anterior subluxation of tibia
- Flexion 20-40 deg: Posterior pull of IT reduce tibia
- The relocation event is graded
  - 0: absent
  - 1: pivot glide
  - 2: pivot shift (abrupt reduction)
  - 3: momentary locking



Intra-Operative Exam

ACL and PCL Exam

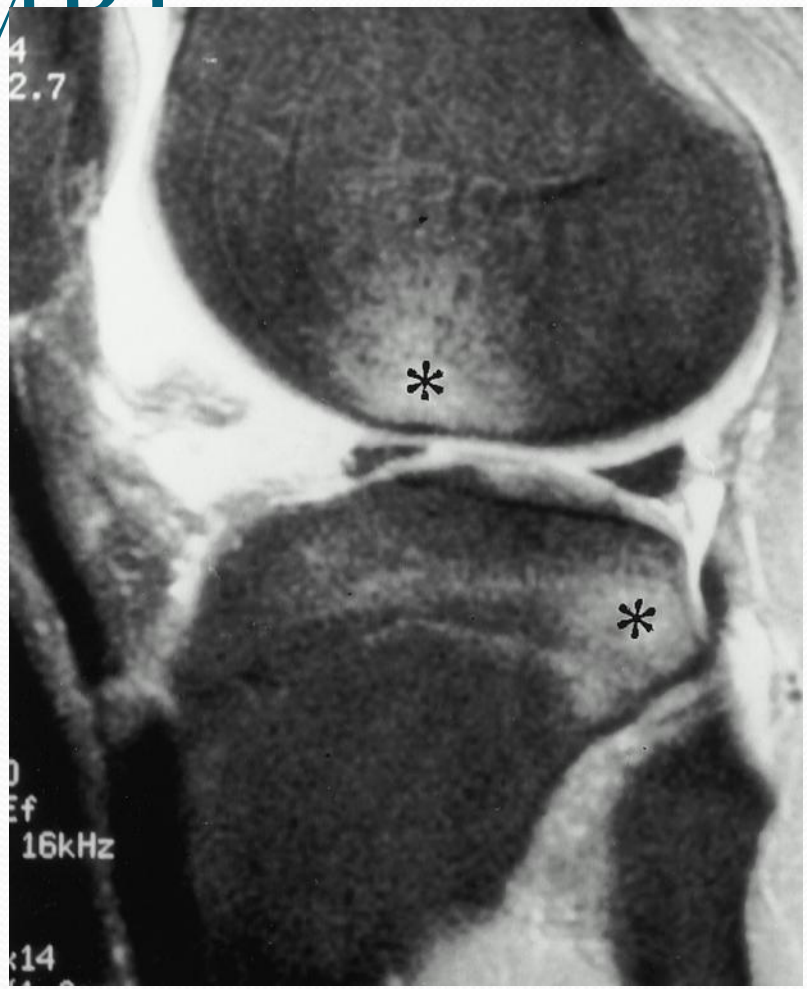
Multi-Lig Exam

Exam the Other Side

maging

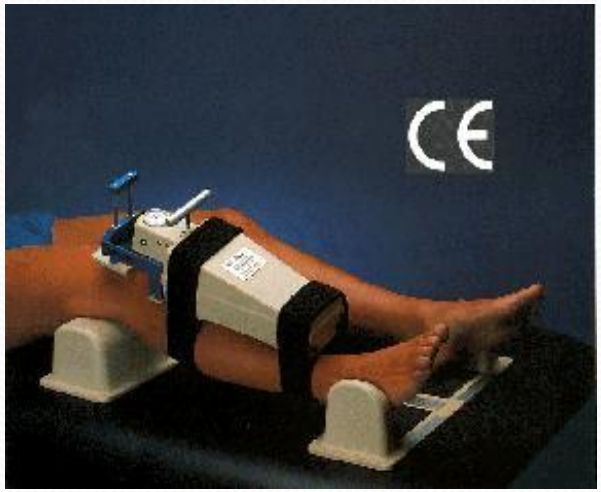
- **Plain radiograph**
  - Rule out fx
  - Segond fx: avulsion fx of lateral joint capsule
- **MR Imaging**
  - Accuracy to detect ACL tear ~ 95%
  - Smooth well defined structure (Sagital)
  - Acute injury
    - T2: edema within ACL substance
    - Bone Bruising (~60%)
  - Acute kinking or ant bending of PCL -> ? ACL tear

MRI



Other Testing

- KT-1000
  - Measure A to P displacement
  - Difference of > 3mm is abnormal
  - Used in research



- Exam under Anesthesia
  - Better when pt is relaxed

Treatment / Patient Selection

- **Operative vs Non Operative based on many variables**
  - Other associated lesions
  - Age and level of activity
  - Degree of instability
  - Type of sports activity
    - Jumping, cutting, pivoting

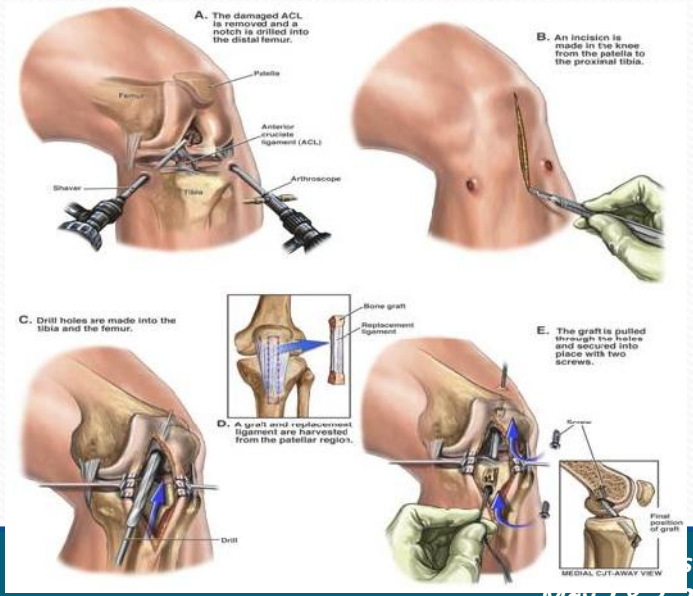
- **Primary Candidates**
  - Active lifestyle w/ acute ACL tears
  - Chronic ACL w/ instability
  - Two factors predictive of surgery
    1) Number of hours / yr in Level I or II sports (50)
    2) Max displacement difference (5MM – 7mm)

Non Operative Treatment

- Bracing, WBAT, Crutches, and early AROM
- PT with Closed Chain exercises
  - Goal return function of Hamstring and Quad
- Obtain Full ROM
- Modification of high risk activities
- Functional Bracing for sports

Operative Management

- Many surgical techniques
  - Transtibial vs. AnteroMedial Drilling
  - 2 Incision Technique
- Many different types of graft choices
- Goal
  - Biology
  - Position / Orientation
  - Fixation
  - Patient Selection



Graft Selection

- Ideal graft
  - Histology and biomechanical characteristics
  - Fast incorporation
  - No risk (Immune vs diesease)
  - Min donor site morbidity
  - Match size and length native ACL
  - Inexpensive and available

Auto vs Allo - Grafts

- Autograft
  - 4 strand hamstring (4HS)
  - Bone-patellar tendon-bone (BPTB)
  - Quad tendon
- Allograft
  - BPTB
  - Achiles
  - Tib anterior or posterior
  - Hamstring

Table 1

Advantages of Autograft and Allograft

Autograft
Higher normal stability rate and lower graft failure rate[1]
Lower infection rate[2]
No risk of disease transmission
No risk of immune reaction[3]
Lower cost[4]
Faster graft incorporation/faster return to full activities[5]
Allograft
Faster immediate postoperative recovery
Less postoperative pain
Graft harvest not part of surgery
No donor site morbidity
Larger grafts available for double-bundle reconstruction
Improved cosmesis

Table 2
Biomechanical Properties of Selected ACL Graft Tissues

Tissue	Ultimate Tensile Load (N)	Stiffness (N/mm)	Cross-sectional Area (mm^2)
Intact anterior cruciate ligament[3]	2,160	242	44
Bone–patellar tendon–bone (10 mm)[6]	2,977	620	35
Quadruple hamstring[5]	4,090	776	53
Quadriceps tendon (10 mm)[7,8]	2,352	463	62

Table 1
Comparison of Anterior Cruciate Ligament Graft Types

Graft	Biomechanical Property: Tensile load (N)	Biomechanical Property: Stiffness (N/mm)	Biologic Incorporation	Method of Fixation	Graft Site Morbidity	Outcomes/ Return to Play (months)
Patellar tendon autograft[3,4]	2,977	620	Bone-to-bone healing (6 wks)	Interference screw	Anterior knee pain; larger incision	4-6
Quadruple semitendinosus/ gracilis[5]	4,090	776	Soft-tissue healing (8-12 wks)	Variable	Hamstring weakness	Increased laxity/6
Patellar tendon allograft[6]	Similar to patellar tendon autograft	Similar to patellar tendon autograft	Bone-to-bone healing, slow incorporation (>6 mos)	Interference screw	None	>6
Quadriceps tendon[7,8]	2,352	463	Bone-to-bone and soft-tissue (6-12 wks)	Variable	Similar to patellar tendon autograft	Limited data

- **Donor site Morbidity**
  - Minimal w/ Autografts
  - Hamstring: mild knee flexion weakness
  - BPTB: Anterior Knee Pain (17% vs 11%)
- **Disease Transmission**
  - Allograft: Very low. 1 death from Kreutzfekdt disease, higher infection rate w/ non irradiated allograft
- **Cost**
  - Allograft: $2,000 to $3,000
  - Double bundle ACL graft: $4,000 to $6,000.

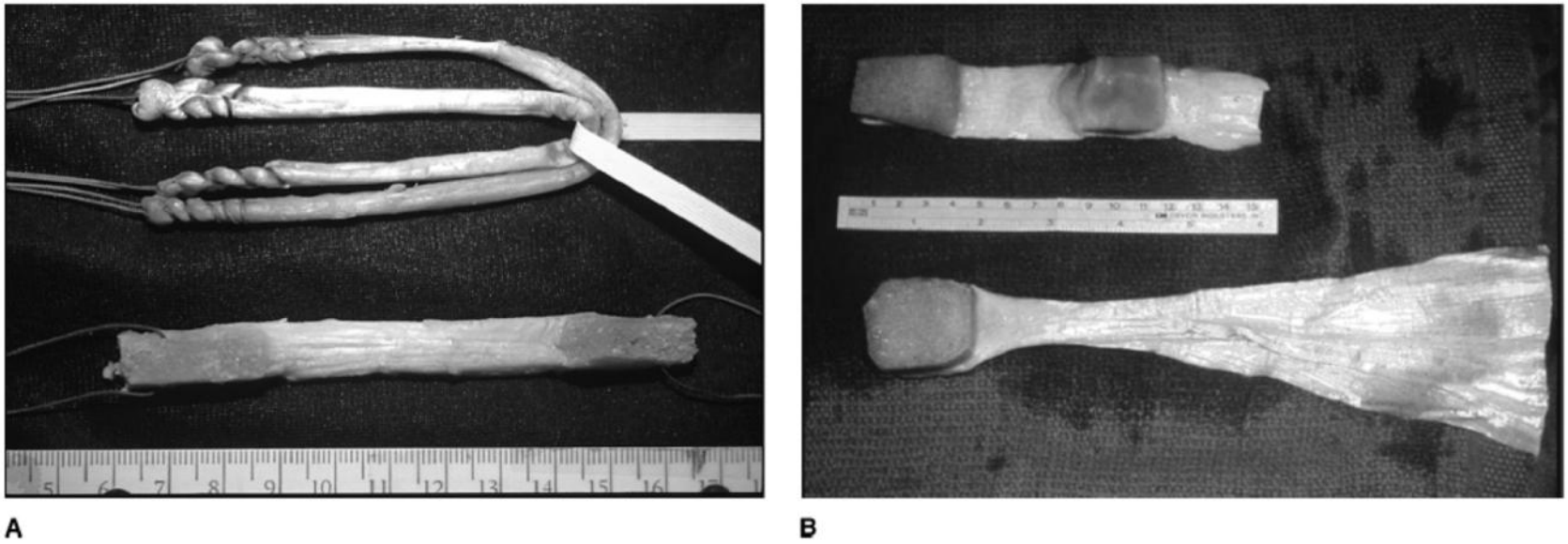
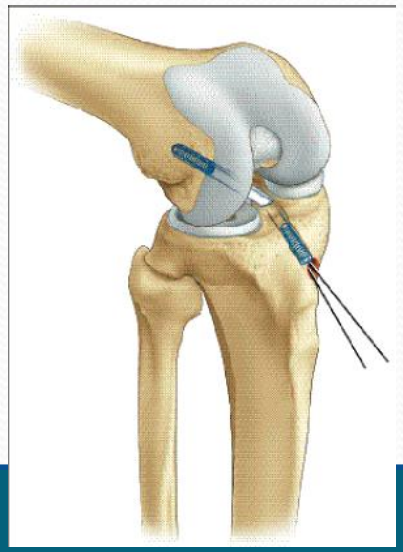
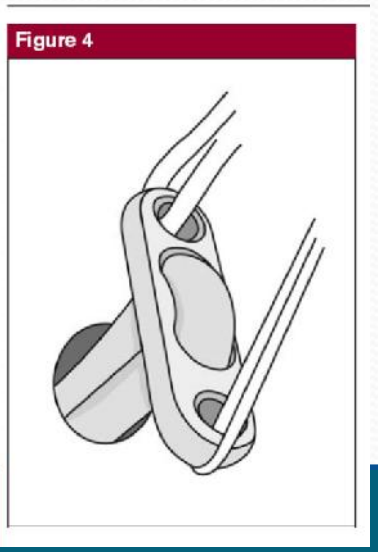


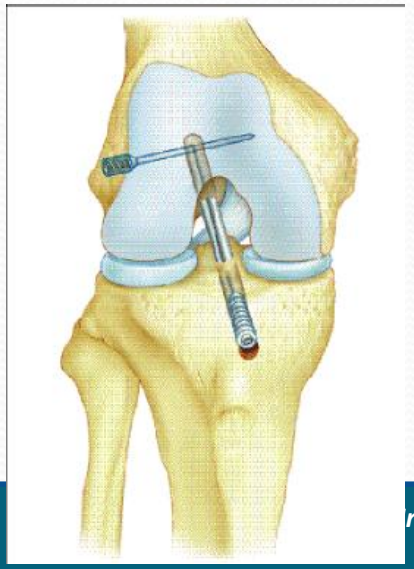
Figure 1 **A,** Autografts. Hamstring (top) and patellar (bottom) tendons. **B,** Allografts. Patellar (top) and Achilles (bottom) tendons.

Graft Fixation Techniques

- **Interference screw fixation** - RCI screw, Softsilk, Bioscrew, Milagro
- **Cortical fixation** - Endobutton, WasherLoc/EZloc, Sutures over button
- **Suspensory fixation** in the aperture- Crosspin, Rigidfix







Biology of Healing

- **Inflammatory phase** (degeneration of graft, cell death)
- **Revascularization** (migration of host cells)
  - 3-6 months
  - Graft weakest @ 6 to 12 weeks
- **Remodeling of graft**
  - Mechanical properties improve (always less @ time of implant)
- **BPTB graft**
  - Faster healing (6 weeks) and stronger vs Hamstring (8-12 wks)
  - Sheep model: robust biological response, increased stability, and increased strength to failure vs allograft.

Fixation

- rehab: ~400-500 N
- Failure typically on tibial side
- Rigid Fix
  - >30 deg divergence = greater failure
- Tibial side: Intrafix is

EndoButton (Smith & Nephew Endoscopy, Andover, MA)[24]	1,086	79
RigidFix (Ethicon, Somerville, NJ)[24]	868	77

Bioabsorbable interference screw[19]	552	—
Soft Tissue (Femoral)		
Bone Mulch Screw (Arthrotek, Warsaw, IN)[24]	1,112	115
EndoButton (Smith & Nephew Endoscopy, Andover, MA)[24]	1,086	79
RigidFix (Ethicon, Somerville, NJ)[24]	868	77
BioScrew (Linvatec)[24]	589	66
RCI Screw (Smith & Nephew Endoscopy)[24]	546	68
Intrafix (Ethicon)[25]	1,332	223
Tandem spiked washer[25]	769	69
SmartScrew ACL[25]	665	115

Intrafix (Ethicon)[25]	1,332	223

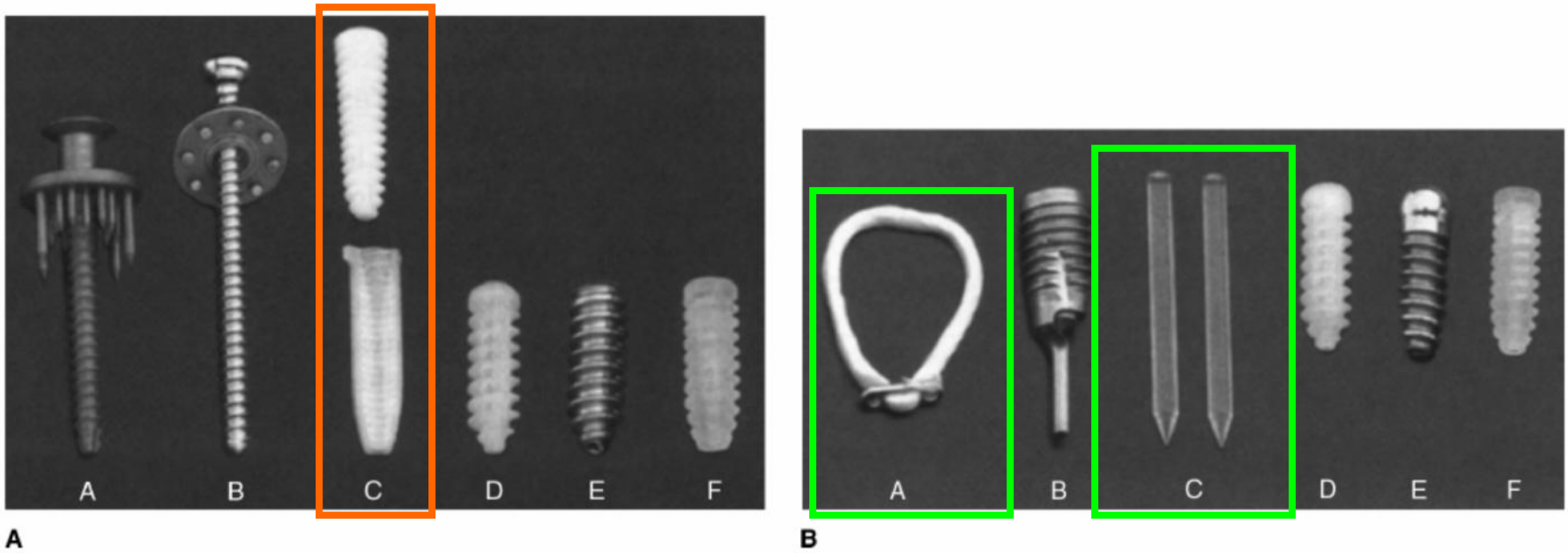


Figure 2 **A,** Tibial side hamstring fixation devices. A = WasherLoc, B = spiked washer, C = Intrafix, D = BioScrew, E = SoftSilk, F = SmartScrew. **B,** Femoral side hamstring fixation devices. A = EndoButton, B = Bone Mulch Screw, C = RigidFix, D = Bioscrew, E = RCI Screw, F = SmartScrew. (Panel A reproduced with permission from Kousa P, Järvinen TL, Vihavainen M, Kannus P, Järvinen M: The fixation strength of six hamstring tendon graft fixation devices in anterior cruciate ligament reconstruction: II. Tibial site. *Am J Sports Med* 2003;31:182-188. Panel B reproduced with permission from Kousa P, Järvinen TL, Vihavainen M, Konnus P, Järvinen M: The fixation strength of six hamstring tendon fixation devices in anterior cruciate ligament reconstruction: I. Femoral revision. *Am J Sports Med* 2003;31:174-181.)

Surgical Technique

- Open vs Endoscopic
- Reproduce ACL Anatomy
  - Full ROM
  - Stability
  - No Impingement
- Tunnel Position
- Graft tensioning
  - 5-8 lbs pull
  - Cycle ~ 10 times
- Trans Tibial, Anterio Medial, 2 incision, Double Bundle, Multiple variations

Complications – ACL Recon

- Infection (<1%)
- DVT (<1%)
- Hardware failure
- Instability (~10%)
- Nerve and vascular injury (<1%)
- Reflex sympathetic dystrophy (<1%)
- Quad weakness and patellar irriability
- Arthrofibrosis (10-30%)
  - Flexion contractures
- Graft donor site morbidity

Thanks