Imaging of ACL Reconstruction

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Declaration of Relevant Financial Interests or Relationships

Speaker Name: Lynne Steinbach, MD

I have no relevant financial interest or relationship to disclose with regard to the subject matter of this presentation.

ACL Injury Background

- United States
  - 3000 new ACL tears/yr
  - 200,000 ACL reconstructions
- Common sports
  - Football
  - Basketball
  - Soccer
  - Skiing

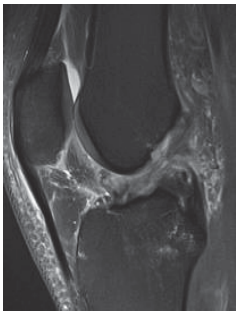
Danny Moloshok / Reuters

ACL Reconstruction

- ACL tears are associated with
  - Joint instability
  - Meniscal tears
  - Cartilage damage
- This leads to osteoarthritis
- Indications
  - Prevention of joint instability
  - Young people
  - Physically active

ACL Injury

- 17-20 year follow up in 54 patients
  - 94% of patients undergoing ACL reconstruction had stable knees with a lower percentage of OA as compared to conservatively treated patients
- Mihelic, et al., International Orthopedics, 2011; 35: 1093-1097



ACL Reconstruction Materials

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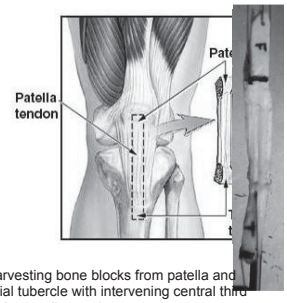
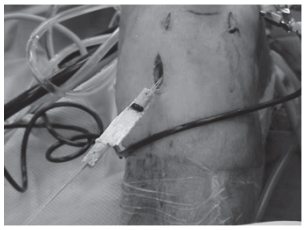
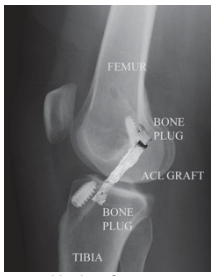
- Autograft
  - Central patellar tendon with attached bone
    - Bone-patellar tendon-bone graft (BPTB)
  - Distal hamstring tendons
- Allograft tendons
  - Posterior tibial
  - Patella
- Synthetic
  - High failure rates



Harvesting bone blocks from patella and tibial tubercle with intervening central third of the patellar tendon

BPTB Autograft Placement Through Tibial Tunnel





Bone Plugs are secured by interference screws

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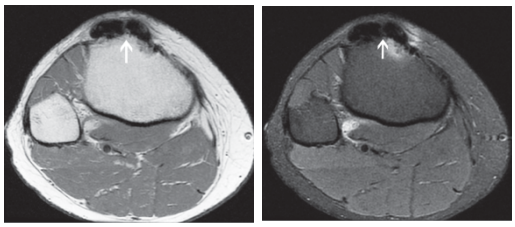
Donor Site-- Intact Autologous BPTB ACL Graft

T1 **T2FS**

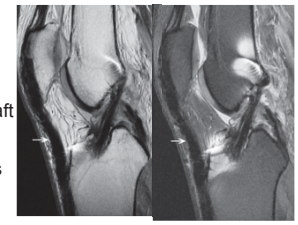
Defect in the central third of patellar tendon



Giaconi J, Allen C, Steinbach L. Topics in Magnetic Resonance Imaging 2010 20:129-50

BPTB ACL Reconstruction

- Interference screw fixation gold standard
- BTPB graft stronger than native ACL
- Ligamentization (vascularization) of graft should occur by 3-6 months postop
- Postop signal changes in patellar tendon and ill-definition should disappear by 12-18 months



Thickened patellar tendon

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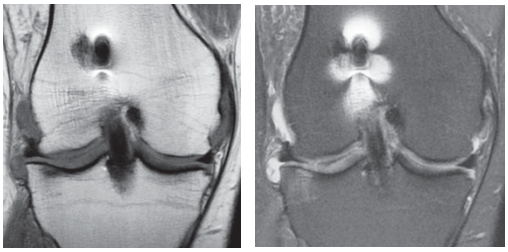
Intact Autologous BTPB ACL Graft Coronal Plane

T1 **T2FS**



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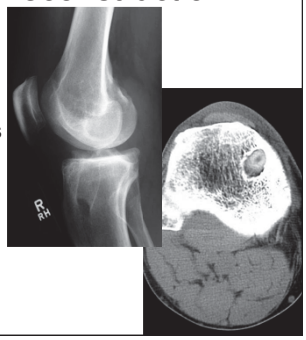
BPTB ACL Reconstruction

- Bioabsorbable interference screws should have resorbed by 2 years



Harvest of Hamstring Autograft

- Semitendinosis and/or gracilis
- Harvested from musculotendinous junction to tibial insertion
- Sutured together and doubled back

4 stranded hamstring graft

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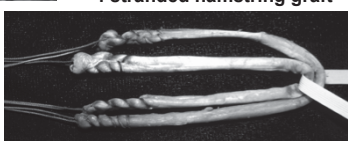
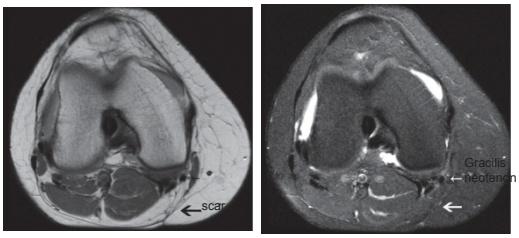


Harvest Site– Hamstring Autograft 4 Yrs After ACL Reconstruction

Scar in region of harvest **Absent ST tendon**



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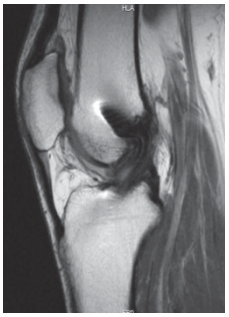
Gracilis-Semitendinosis Graft

- No consensus on best fixation technique
- Hamstring vs. PBTB graft
  - Less anterior knee pain
  - Stronger but also stiffer than BPTB graft
  - Takes longer to heal



Gracilis-Semitendinosus Autograft Sagittal Plane

Four years after ACL reconstruction

PD **T2FS**

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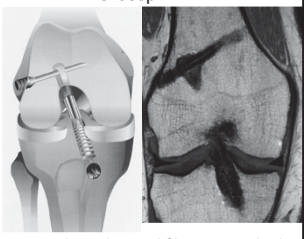
Suspensory Fixation

- Suspensory fixation approaches include:
  - Graft fixation using a screw and washer
  - Graft fixation using sutures suspended from a femoral fixation device
    - Corticocancellous fixation
    - Endobutton/cross-pin

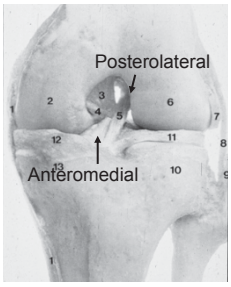
Crosspin



www.mooreortho.net/ scope-ACL-reconstruction.jpg

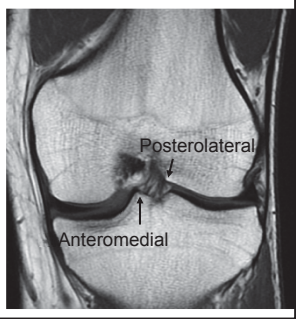
Anterior Cruciate Ligament

- Composed of II anteromedial and posterolateral bundles named according to tibial insertion
- Clear separation is limited-evaluate in multiple planes



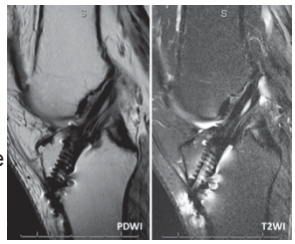
Anterior Cruciate Ligament

- Composed of II anteromedial and posterolateral collagen type 1 bundles named according to tibial insertion
- Clear separation of the bundles is limited-evaluate in multiple planes



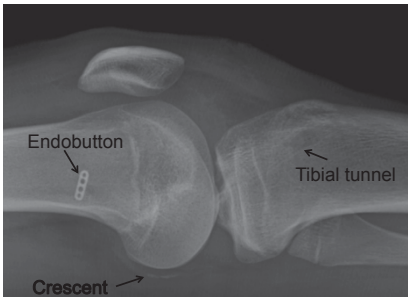
Double Bundle ACL Reconstruction

- Restore both bundles to maintain anatomy and kinematics of knee
- Further studies needed to determine if this is necessary



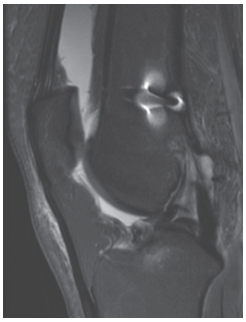
Miyawaki M, et al. Knee Surg Sports Traumatol Arthrosc 2014;22:1002-8

Normal Postop Bone Crescent



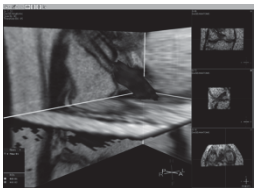
MRI Technique

- Standard extremity coil
- 1.5 or 3.0T preferred
- Fat suppression generally not a problem
- Metal techniques usually not needed



Diffusion Tractography

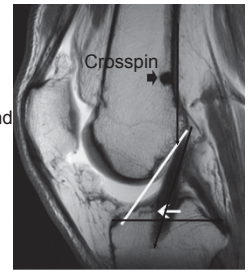
- On the horizon
- Can provide quantitative measurements
- 3D reconstruction of fiber tracts of the neoligament



Yang X, et al. J Comput Assist Tomogr (in press)

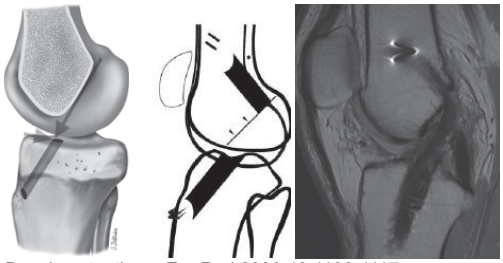
Normal ACL Graft Placement Sagittal Position

- Knee in full extension
- Graft parallel or more vertical to Blumensaat's line
- Graft enters knee at junction of posterior femoral cortex and posterior intercondylar roof
- Tibial tunnel begins behind extended Blumensaat's line
  - 1/4-1/2 distance from anterior to posterior tibial cortex



Correct tibial tunnel placement important for preventing impingement

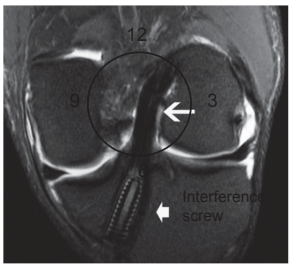
Normal ACL Graft Placement



Papakonstantinou, Eur Rad 2003;13:1106-1117
Bencardino J T et al. Radiographics 2009;29:2115-2126

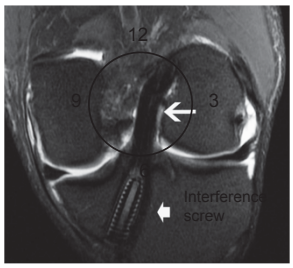
Normal ACL Graft Placement Coronal Position

- Femoral tunnel
  - 10-11 o'clock R knee
  - 1-2 o'clock L knee
  - 78 degree angle
- Tibial tunnel
  - 47% of width of tibial plateau
  - 65-70 degree angle



L Knee

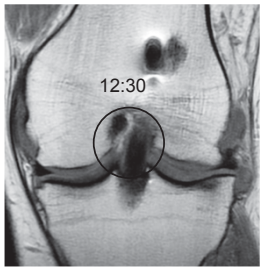
Normal ACL Graft Placement Coronal Position



Bencardino J T et al. Radiographics 2009;29:2115-2126

L Knee

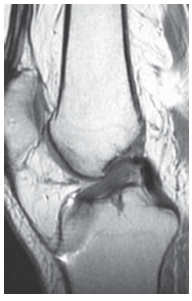
Vertical Graft Poor Placement

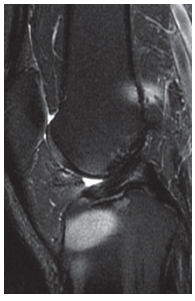


Graft Failure

- Pathologic laxity of the reconstructed ACL
- Recurrent instability in 1-8%
- Early failures < 6 mos
  - Poor surgical technique (most common)
  - Failure of graft incorporation
  - Errors in rehabilitation
- Late failures >1 year
  - New trauma
  - Torn graft
  - Functional instability

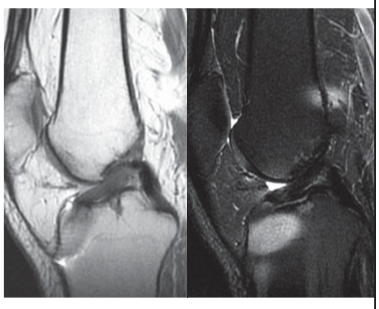
Knee Pain 1 Year After ACL Reconstruction





ACL Graft Failure Impingement

- Abnormal anterior tibial tunnel position
- Distal aspect of roof impinges upon anterior surface of graft during knee extension
- Leads to loss of terminal extension and increased likelihood of graft rupture



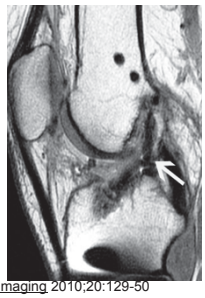
ACL Graft Impingement

- Graft abuts roof/wall intercondylar notch
- Causes pain or loss of extension
- Etiologies
  - Anterior tibial tunnel placement
  - Intercondylar notch
    - Sidewall osteophytes
    - Small intercondylar notch
  - Tightening of posterior restraints during surgery

Anterior tunnel placement

ACL Graft Failure
Graft Laxity

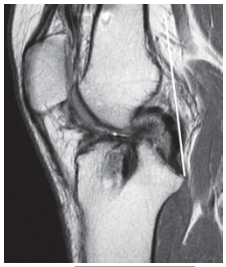
- Higher likelihood with hamstring graft
- Tunnel issues
  - Anterior femoral tunnel
  - Vertical femoral tunnel
  - Posterior tibial tunnel



Giaconi J, et al. Topics in Magnetic Resonance Imaging 2010;20:129-50

Lax ACL graft

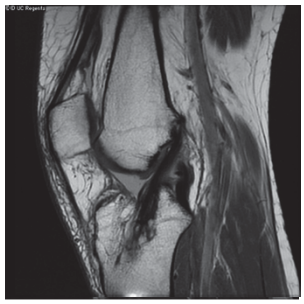
- Wavy graft not always seen
- Buckled PCL
- Anterior tibial translation with respect to femur
- Uncovered PHLM
- Best evaluated clinically



Buckled PCL

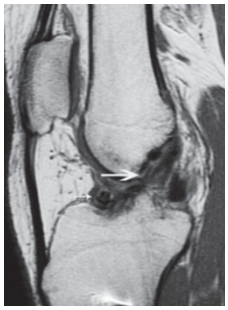
ACL Graft Failure

ACL Graft Failure



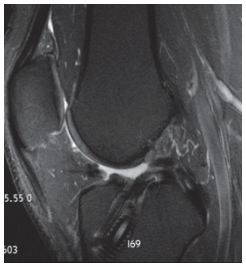
ACL Graft Failure

ACL graft partial tear



ACL Graft
Full Thickness **Tear**

- Often result of
  - Recurrent injury
  - Nonisotropic positioning
- MRI
  - Increased signal interrupting graft
  - Graft resorption
  - Horizontal graft
  - Effusion
  - Lateral contusions



ACL Graft
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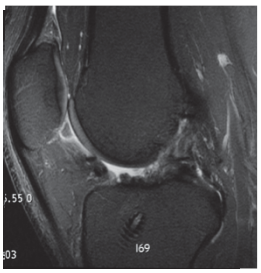
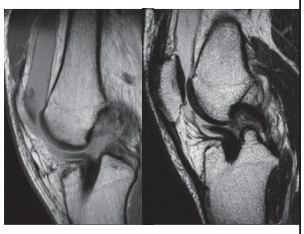
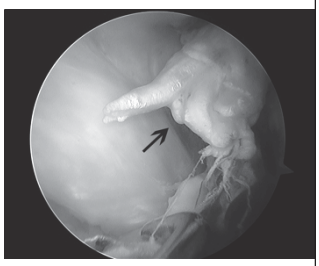


ACL Graft Failure
Re-injury: Partial and Full Thickness Tears

- Often a result of recurrent trauma
- Abnormal stress on graft during normal range of motion due to tunnel position

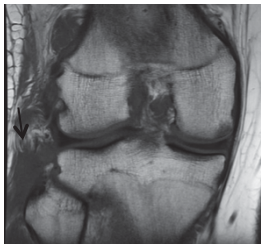


ACL Graft
Tear

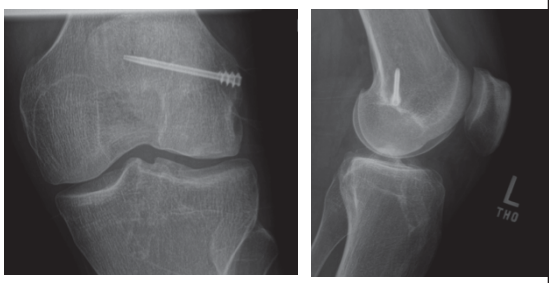


Diagnostic Error
Failure to Recognize and Treat Other Injuries

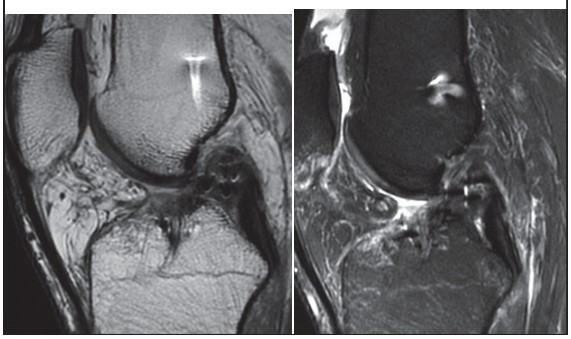
- Posterolateral corner injury
  - Most common diagnostic error
  - Present in 15% of chronically ACL-deficient knees



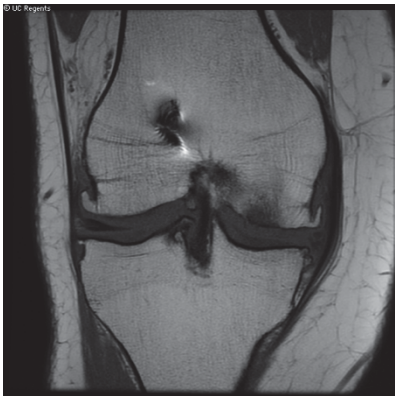
Unstable Knee S/P ACL Reconstruction

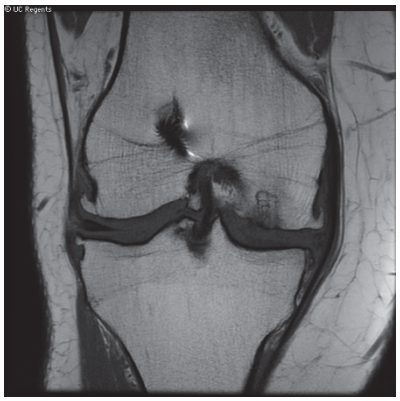


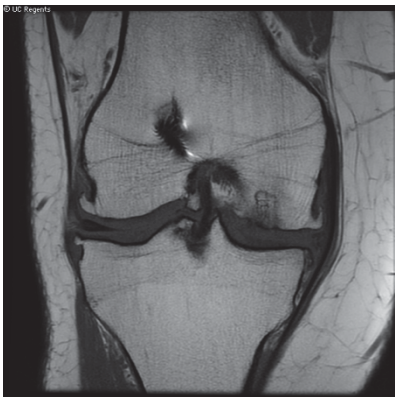
Torn ACL Graft

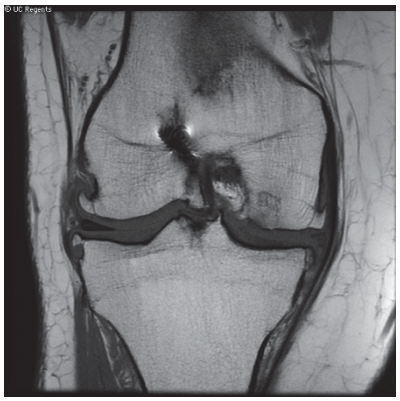


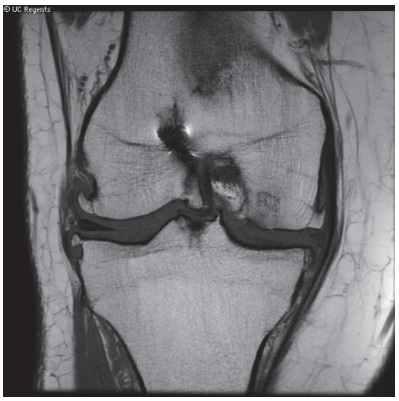
Revision of ACL Reconstruction





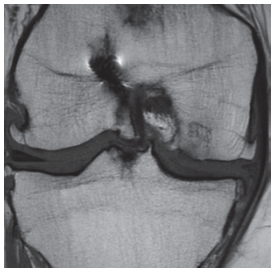






Notch Osteophytes

- Can impinge on graft
- Treated with notchplasty



Diagnostic Error Failure to Recognize and Treat Other Injuries

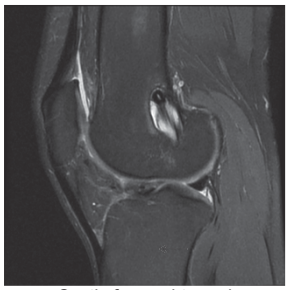
- Posterolateral corner injury
  - Most common diagnostic error
  - Present in 15% of chronically ACL-deficient knees
- MCL, meniscal and posterior capsular injuries

Posterolateral corner injury

ACL and Posterolateral Corner Reconstruction

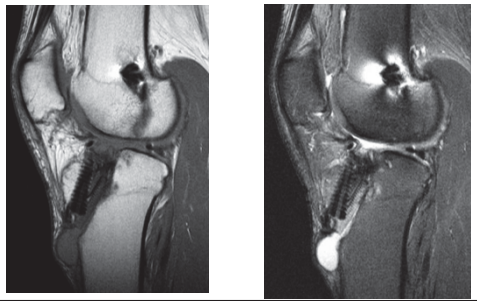
Tunnel Fluid

- Usually not associated with graft failure
  - Ghazikhanian V. Skeletal Radiol 2012;41:1375-79
- Pain and loss of motion
- Can expand tunnels with need for bone graft
- Causes
  - Incomplete incorporation of graft
  - Bioabsorbable screws
  - Suture fragments
  - Joint fluid leakage



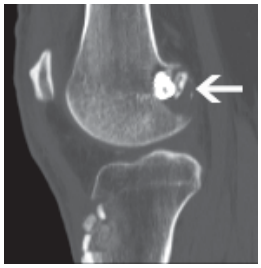
Cystic femoral tunnel

Tibial Tunnel Syndrome
Pretibial Cyst

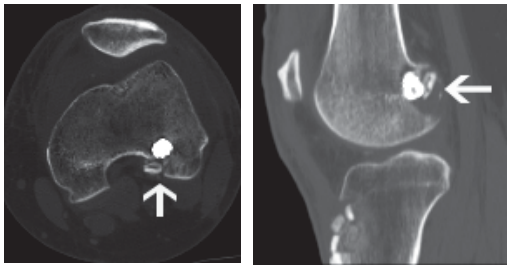


Anterior Femoral Tunnel Placement

- Excess tension on the graft in flexion which restricts ROM
- Produces graft fixation site tension and stretching of the graft

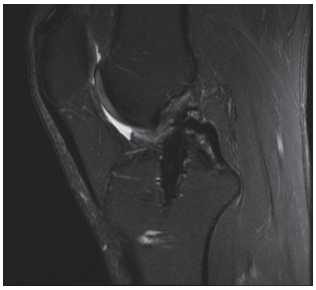


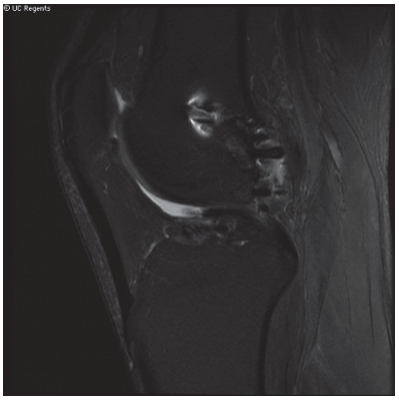
Posterior Femoral Tunnel Wall Blow-Out



Giaconi J, et al. Topics in Magnetic Resonance Imaging 2010; 20:129-50

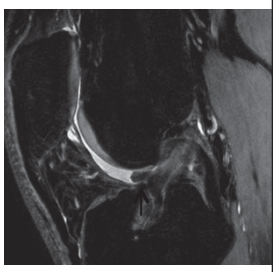
35 yo Male With Locking Following ACL Reconstruction





Cyclops Lesion

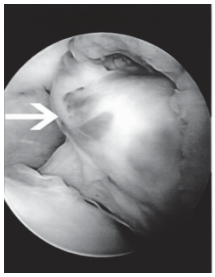
- Focal mass anterior to the ACL seen in up to 10% of post op ACLs
- Low to intermediate signal intensity on all sequences
- Surgical resection for symptomatic cyclops

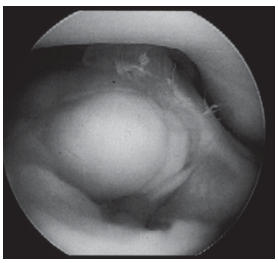


Cyclops Lesion Two Types

- True cyclops nodule
  - Chondral and membranous ossification
  - Associated with loss of extension
- Cyclopoid scar
  - Fibroproliferative tissue without ossification
  - Softer, does not cause loss of extension

Cyclops Lesions Arthroscopy





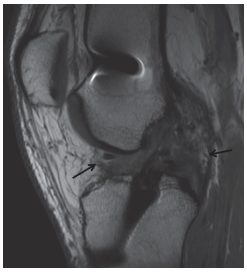
Pseudocyclops

- Partial graft tear mimicking a cyclops lesion
- Graft material extends into mass

Simpfendorfer C, et al. Skeletal Radiol 2015

Arthrofibrosis

- Scar tissue in at least one compartment of the knee joint
- Leads to decreased ROM and mechanical block
- 4-35% of ACL reconstructions



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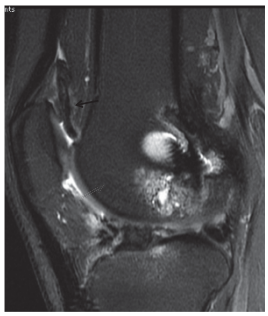
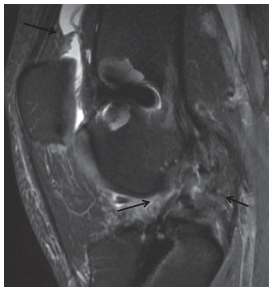


Arthrofibrosis

- Generalized form more common in patients undergoing surgery less than 4 weeks after injury
- Associations
  - Preoperative irritation (swelling, effusion and hyperthermia)
  - Less than 90 degrees of flexion preoperatively



Mayr, et al., Arch Orthop Trauma Surg, 2004;124:518-524.

Extensor Mechanism Complications After BPTB Graft

- Patellar fracture
- Patellar tendinosis
  - Signal abnormality after 18 months
  - Thickening persists as a normal finding
- Quadriceps weakness
  - Check for muscle atrophy and fatty infiltration

Jerry Rice's 166th career TD cost him the rest of the year AP

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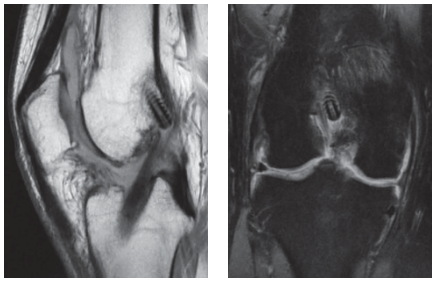
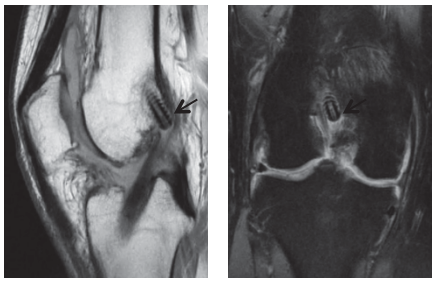
Stein DA, et al. Arthroscopy 2002;18:578

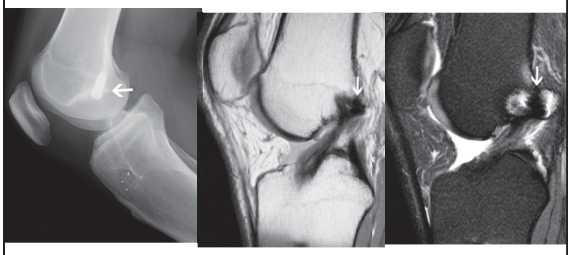
Something Is Not Right



Hardware Complications
Interference Screw Migration



Hardware Complications
Proud Femoral Tunnel Screw
Intact ACL Graft



Hardware Complications

- Bone graft/screw migration
- Screw impingement on graft
- Pin or screw fracture
  - More common with bioabsorbable screws at time of graft placement
- Dislodged screws

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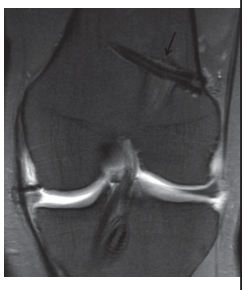
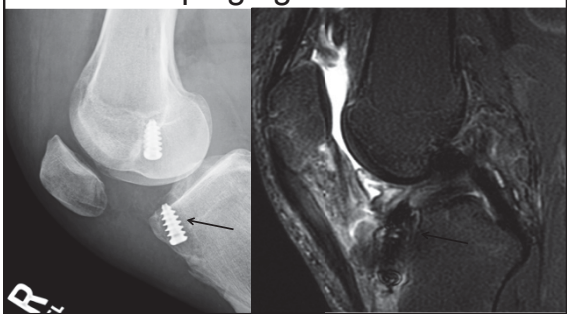
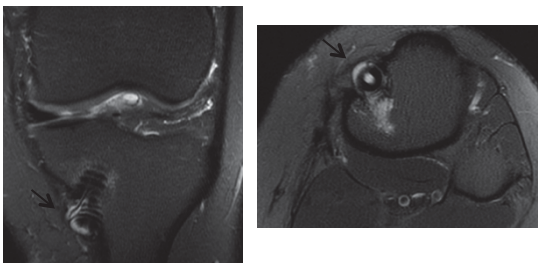


Fractured bioabsorbable crosspin

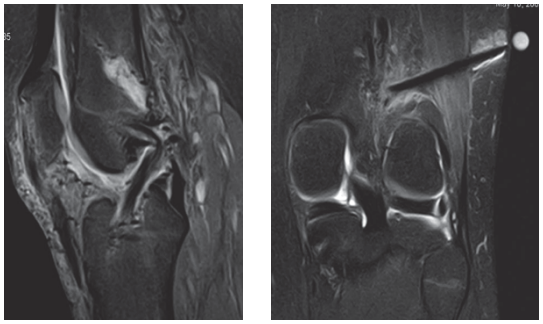
Proud Tibial Tunnel Screw Impinging on Graft



Distally Migrated Tibial Tunnel Screw



Hardware Complications
Dislodged Crosspin



Postoperative ACL Imaging

- Be familiar with the normal appearance and complications including
  - Impingement
  - Laxity
  - Unrecognized posterolateral corner injury
  - Tear
  - Arthrofibrosis
  - Cyclops lesion
  - Tunnel widening/fluid
  - Screw migration
  - Fracture
  - Infection