Knee: Cruciates and Collateral Ligaments

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Cruciate Ligaments
ACL BUNDLES

ANTEROMEDIAL

POSTEROLATERAL
ACL tears

• **MR:** 95-100% accurate
  – midportion > proximal > distal (avulsion)
• concomitant injuries common (**MCL, menisci**)
• complete >> partial
• discordant findings
  – T1 vs T2 discordant findings: *believe T2*
  – Sag vs coronal / axial: all helpful – unequivocally intact in **any** plane = **intact**
ACL Tear: Primary Signs

- **Signal changes**
  - Edema on T2w

- **Morphologic changes**
  - Discontinuity of fibers
  - Abrupt angulation/wavy
  - Fibers “fallen” – not parallel to Blumenstadt's line
Complete ACL Tear

Edema, discontinuity of fibers, characteristic bone bruises
Complete ACL Tear: “empty notch sign”
Partial ACL Tear

- Difficult to diagnose by MRI
- One bundle torn
- Edema of ACL
- Some fibers remain intact
- Axial, coronal sections improve accuracy
  - Try to visualize both bundles
- Look for secondary signs (absence not reliable)
Partial ACL Tear

Edema
Some disrupted fibers
Some intact fibers
ACL Tear: Secondary Signs

**Pivot-shift pattern = BEST**
- Characteristic bone contusion pattern
- Deep lateral femoral sulcus

**Anterior drawer**
- PCL buckling
- Anterior tibial translation
Secondary signs ACL Tear

“Pivot-shift” mechanism

+/− valgus stress: MCL, medial meniscal injury

Bone Bruise Pattern
Secondary signs ACL tear

Deep Lateral Femoral Sulcus

*Sulcus terminalis-* junction of patellofemoral and tibiofemoral cartilage surfaces
Secondary Signs ACL tear

Anterior Tibial Translation

Measure at midpoint of lateral femoral condyle

>5mm
Secondary Signs  ACL tear

Fibular Collateral Ligament (FCL) seen on one coronal image = anterior tibial translation
Secondary Signs ACL tear

PCL buckling
ACL Tear: Associated Fractures

• Segond fracture
  • Lateral capsular ligament avulsion
  • Fracture itself minor
  • 90% association with ACL tear
  • 60% association with meniscal tear

• Fracture at tibial attachment of ACL
  • Young males
  • Potential for healing
Segond Fracture

MCL tear

ACL tear
Tibial Spine Avulsion

Potential to heal
Avulsion: Tibial Insertion of ACL
ACL Tear: Aging

• Acute: Edema, mass effect, effusion

• Subacute: Resorbed edema, changes in orientation

• Remote (>8 wks):
  
  Resorbed ACL, fused to PCL

*Marrow edema can last for up to 9 weeks*
Remote ACL Tear (>8wks)

Absent ACL – “absorbed”
Remote ACL Tear

Fusion to PCL
Cruciate Ganglion Cyst

• **Criteria**
  – lobulated fluid
  – mass effect on cruciate fibers or ‘wraps around’ cruciate
  – fluid disproportionate with fluid in joint
  – cruciate bundles intact

• **Symptoms:** pain with flexion/extension

• **Usually no instability**
ACL Ganglion Cyst

Bundles displaced but preserved
ACL Mucoid Degeneration

- Intact ACL, but poorly seen on T1 / PD
- Likely etiology:
  - ACL sheath: synovial tissue
  - Degeneration or synovial proliferation can cause increased signal, mass effect on bundles
- Often co-exists with cruciate cyst
- Must see BOTH BUNDLES are intact to differentiate from partial tear
ACL Mucoid Degeneration

Poorly seen ACL on T1

Intermediate signal on T2

BUNDLES INTACT
ACL Mucoid Degeneration
Anterior Cruciate Ligament Graft

Types of ACL Graft

1. Bone (Patellar) Tendon Bone (BTB)
2. Hamstring (Semitendinosus and Gracilis Autograft)
Normal MR Appearance of BTB ACL Graft

0 to 3 months
- signal identical to native patellar tendon
- low signal on T1- and T2-weighted images
Normal MR Appearance of BTB ACL Graft

4 to 8 months
- graft revascularization
- increased T1- and T2-signal
- should not have fluid signal within graft
Normal MR Appearance of BTB ACL Graft

>12 months

- ligamentization occurs, looks like native ACL
- low signal on T1- and T2-weighted images; may have intermediate stranding in distal fibers
Normal Patellar Tendon Harvest Site

- BTB graft harvested from the middle 1/3 of the patellar tendon
- Defect seen in tendon and bone on MR imaging
- Defect fills in with tendon-like material during the first year
Normal MR Appearance of Hamstring ACL Graft

- Hamstring graft progresses through the same stages as BTB graft
- Fluid present between separate strands of graft
Normal Fluid in Tunnel of Hamstring Graft

Normal finding during first year
Abnormalities of ACL Graft

• Lax Knee
  – *Graft disruption or stretched graft*

• Lack of Full Extension
  – *Graft impingement*
  – *Loose bodies*
  – *Arthrofibrosis*
Disrupted ACL Graft

Discontinuity of fibers
- Graft impacts roof of intercondylar notch during extension of knee
- **Anteriorly** placed tibial tunnel
- **Increased signal** in graft
- **Kinking** of graft
- Graft fibers intact
- Increased signal in fibers
- Fibers kinking/ rubbing against roof of intercondylar notch
Decreased ROM: Arthrofibrosis

- cyclops lesion (nodule of scar tissue anterior to ACL graft)
- dark on PD and T2-weighted images
- limits full extension
Arthrofibrosis

The Cyclops – by Odilon Redon (1840-1916)
(Rijksmuseum Kroller-Muller, Otterlo, the Netherlands)
Graft Tunnel Expansion

• Pathoetiology: unknown
  – Mechanical
    • “windshield wiper”
    • “bungee cord”
  – Inflammatory
    • Granulomatous response or synovitis

• Potential for instability
Status of the Tunnel: Tunnel Expansion

First 3 months after graft placed
Requires two step graft revision
Femoral Tunnel Expansion
PCL Tear

- Rare; 1-5% of cruciate tears
- Mechanism
  - “Dashboard” injury – posterior drawer
  - Hyperextension
  - Dislocation
- usually partial tear (unlike ACL)
- Tear type
  - Midsubstance (genu)
  - interstitial
  - avulsion
- Associated injuries common
  - ACL & posterolateral corner injuries
Hyperextension Injury

Kissing anterior marrow edema pattern

Usually medial
Complete PCL Tear
Complete PCL tear
Knee Dislocation

• Relatively rare
• Motor vehicle accidents / trauma: sports
• Hyperextension injuries
• ACL and PCL tear
Knee Dislocation

ACL and PCL tear: think dislocation!
Knee Dislocation

Dislocation: look at popliteal vessels!!

Popliteal artery pseudoaneurysm
Knee Dislocation

Signs of hyperextension

Thrombosis
Collateral Ligaments
Medial Collateral Ligament

- Superficial portion (="MCL")
- Deep portion
  - Meniscofemoral (coronary) lig
  - Meniscotibial lig
  - Very tight attachment
- Injury from valgus stress, external rotation
- Combo injury: 95% ACL
MCL Tear: Site of Rupture

• Proximal attachment to femur (most common)
• Mid-substance (uncommon)
• Distal attachment to tibia (rare)
MCL Injuries

- Grade 1 -> micro-tearing or stretching of the ligament; integrity of ligament preserved = **STABLE**
- Grade 2 -> partial tear; painful to stress with detectable laxity but with endpoint
- Grade 3 -> complete tear with laxity = **UNSTABLE**
MCL Sprain: Grade I

Stretching injury
Edema around intact ligament
→ conservative treatment
MCL Sprain: Grade II

Edema within ligament → conservative treatment
MCL Tear: Grade III

Complete tear → may require surgery
DDx: MCL Sprain

- Ruptured Baker’s cyst
- Medial meniscal tear
- ‘leaking’ marrow edema: hyperemia
- Medial compartment OA
“MCL Bursitis”

- Between SUPERFICIAL & DEEP LAYERS of the MCL
- Always associated with meniscal tear or other pathology
MCL: Healed Tear

Thickening, no edema

Most isolated MCL injuries heal spontaneously with thickened ligament or ossific. (Pellegrini-Steida)
LCL Complex

- Lateral ‘ligamentous’ complex
  - Iliotibial band
  - Fibular collateral ligament (‘LCL’)
  - Biceps femoris

- Other posterolateral stabilizers
  - Popliteus tendon
  - Arcuate ligament
  - Popliteofibular ligament
  - Fabellofibular ligament

- unlike MCL, often requires reconstruction
LCL Complex

- Lateral ‘ligamentous’ complex
  - Iliotibial band
  - Fibular collateral ligament (‘LCL’)
  - Biceps femoris
- Association: PCL injuries
- Unlike MCL, often requires reconstruction
Iliotibial Band Syndrome

- Runners
- Friction: iliotibial band, lateral femoral condyle
- Edema, pain
Complete Fibular Collateral Ligament Tear
Biceps + FCL Tear
Posterolateral Corner

Why is this area challenging?

- Complex, variable anatomy
- No characteristic marrow edema pattern
- Many structures out of plane on MRI
- Often in setting of ACL or PCL injury

Why does it matter?

Functions to prevent:
- External rotation
- Varus angulation
- Posterior translation
Posterolateral Corner Injury: Mechanism

- High-energy force
  - Contact sports: American football and soccer
  - Pedestrians in traffic accidents
  - Falls
  - Knee dislocation
- **Mechanism:** *Direct or Indirect*
  - Varus
  - Hyperextension
  - External rotation
- Isolated injuries are far less common than combined
Posterolateral Corner:

- Fibular collateral ligament
- Biceps femoris tendon
- Popliteus muscle-tendon unit
- Popliteofibular ligament - identified in the majority of knees
- Fabellofibular ligament
- Arcuate ligament

Arcuate complex
Tips:

- Follow it from muscle (behind tibia) superiorly
- Locate other structures in relation to it
- Structures are highly variable: non-visualization of PFL, FFL, especially arcuate ligament not uncommon
Popliteofibular ligament

Seen on sagittal and coronal images, particularly when a joint effusion is present

Visible as an individual structure in 90% - 100% of dissected knees, but MR visualization is variable
Arcuate ligament
* Located deep to the geniculate blood vessels

Fabellofibular ligament
* Located superficial to the geniculate blood vessels

Popliteus
* Located deep to the geniculate blood vessels
Popliteus Tear

Myotendinous junction most common
Posterolateral Corner Injury: Pop-fib Ligament

Normal

Sprain
Popliteofibular ligament tear
Common Peroneal N.

wraps around proximal fibula
Fibular Fracture: Common Peroneal Nerve Injury
Knee Ligaments: Take Home Points

- Mechanism
  - Cruciate injury?
- Integrity of main collateral structures
  - MCL, IT band, FCL, Biceps, popliteus
- Integrity of posterolateral corner
  - Pop-fib ligament, arcuate, etc.
Collateral Ligament Injuries: Take Home Points

- Grade I/II sprains → treated conservatively
- Grade III sprains / disruptions - when combined with other injuries → treated with stapling or suturing
ACL Grafts: Take Home Point

Should look like native ligaments at 12 months and > post op

(low signal on T1- and T2-weighted images)
Thank You!