Knee Ligament Injuries

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Anterior Cruciate Ligament (ACL) [1, 2]

Anatomy/Biomechanics

- Primary restraint to anterior translation of the tibia relative to the femur
- Secondary restraint to tibial rotation
- Anteromedial (AM) bundle:
  - More isometric
  - Tight in flexion
- Posterolateral (PL) bundle:
  - Tight in extension
  - Contributes primarily to rotational stability

Diagnosis

History

- Contact or noncontact sports injury
- Pivoting knee injury
- "Pop" followed by knee effusion (swelling)

Physical Exam

- Anterior drawer
- Lachman exam:
  - Anteriorly directed force on the tibia with the knee flexed 30°
  - Grading:
    - I = 3–5 mm translation
    - II = 6–10 mm
    - III > 10 mm:
      - A = Firm endpoint
      - B = Soft endpoint
- Pivot shift exam:
  - Valgus force as the knee is brought from extension into flexion.
  - In extension, the tibia subluxated anteriorly and reduces at 20–30° of flexion as IT band transitions from knee extensor to flexor thus reducing the tibia.

Imaging

- X-ray:
  - "Segond fracture," avulsion fracture off the anterolateral proximal tibia; classically associated with ACL rupture
- MRI: definitive diagnosis

Treatment

Nonoperative

- Low-demand patients
- Primarily consists of activity/lifestyle modification
- PT to emphasize hamstring strength
- ACL specific bracing with activity

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Operative

- Active, high-demand patients.
- Failed nonoperative treatment (persistent knee instability).
- Reconstruction is current gold standard (as opposed to repair).

Surgical Options

- Single vs. double bundle:
  - Double bundle may better reproduce knee kinematics [3].
  - No clear difference in clinical outcomes between single and double bundle.
- Graft choice:
  - Hamstring (semitendinosus, gracilis):
    - Smaller patients yield smaller grafts:
      - Graft size <8 mm associated with higher risk of failure [4]
    - No bone-bone healing
  - Bone-patellar tendon-bone:
    - Longest history of use
    - "Gold standard"
    - Bone-bone healing
    - Donor-site morbidity (anterior knee pain)
    - Complication – patella fracture
  - Quadriceps tendon
- Allograft vs. autograft [5]:
  - Autograft:
    - Pro: patient's own tissue, no risk of disease transmission, and faster graft incorporation
    - Cons: donor-site morbidity
  - Allograft:
    - Pro: no donor-site morbidity and can select graft size.
    - Cons: slower graft incorporation, theoretic risk of disease transmission, and irradiated allograft may be associated with higher failure rates.
- Femoral tunnel drilling:
  - Transtibial:
    - More "traditional" technique
    - Femoral tunnel location accessed via the tibial tunnel
  - Independent tunnel:
    - May allow for more "anatomic" femoral tunnel placement by allowing more oblique drill trajectory
    - Requires knee hyperflexion to prevent posterior wall "blowout"
  - Retrograde or "outside-in" drilling:
    - Requires specialized instrumentation
    - Allows independent femoral tunnel drilling without need for knee hyperflexion

Rehab/Injury Prevention [6]

- Neuromuscular training/jump training
- Jump landing in valgus and relative extension implicated in increased risk of injury
- Address relative hamstring weakness

Complications

- Re-rupture:
  - Most common cause – tunnel malposition
- Loss of motion/arthrofibrosis:
  - Delay surgery until patients regain motion and swelling from acute injury controlled
- Tunnel osteolysis
- Fixation failure
- "Cyclops" lesion:
  - Due to fibroproliferative tissue within the intercondylar notch
  - Blocks extension
  - Treat with arthroscopic debridement
- Posttraumatic arthritis:
  - May be associated with concomitant meniscal pathology

Posterior Cruciate Ligament (PCL) [7, 8]

Anatomy/Biomechanics

- Anterolateral (AL) bundle:
  - Tight in flexion
- Posteromedial (PM) bundle:
  - Tight in extension
- Meniscofemoral ligaments:

  - Originate from posterior horn lateral meniscus and insert onto PCL
  - Anterior, ligament of Humphrey; posterior, ligament of Wrisberg

Diagnosis

History
- Posteriorly directed blow to the flexed knee (i.e., "dashboard" injury)
- Knee hyperflexion injury with the plantar-flexed foot

Physical Exam
- Posterior drawer test:
  - Grading:
    - I = 1–5 mm translation
    - II = 6–10 mm
    - III > 10 mm
- Posterior sag sign:
  - With the knee at 90° flexion, the tibia lies posterior relative to the femoral condyles compared to contralateral side.
- Quadriceps active test:
  - With the knee flexed at 90°, the tibia subluxated posteriorly relative to the femur; resisted activation of the quadriceps reduces the tibia anteriorly.
- Dial test:
  - See section below (posterolateral corner injuries).

Imaging
- X-ray:
  - May show avulsion fracture off posterior tibial insertion
  - Posterior drawer stress test → posterior subluxation of the tibia
- MRI

Treatment [9]

Nonoperative
- Most isolated PCL tears (Grade I–II)
- Rehab to concentrate on quadriceps strengthening

Operative
- Isolated Grade III tears with persistent functional instability
- Multi-ligament knee injury

Surgical Options
- Tibial avulsion fracture → direct repair
- Reconstruction options:
  - Transtibial technique:
    - Beware of "killer turn":
      - PCL graft is passed from anterior to posterior through tibial tunnel; graft then passed from posterior to anterior into femoral tunnel.
      - May cause attenuation of graft tissue.
  - Tibial inlay technique:
    - Avoids "killer turn":
      - Tibial portion of graft seated into the socket in posterior aspect of the tibia
  - Graft choice:
    - Allograft vs. autograft:
      - Same inherent issues as above.
      - Allograft affords more graft options especially during multi-ligament knee reconstruction.

Medial Collateral Ligament (MCL) [10]

Anatomy/Biomechanics

- Superficial MCL:
  - Primary restraint to valgus stress of the knee
- Deep MCL:
  - Secondary restraint to valgus stress.
  - Attaches to the medial meniscus.
  - Posterior fibers blend with the posteromedial capsule and the posterior oblique ligament (POL).

Diagnosis

History
- Commonly associated with ACL rupture

Physical Exam
- Tenderness along medial aspect of the knee.
- Valgus stress testing at 30° knee flexion isolates superficial MCL.
- Grading:
  - I = 1–4 mm medial joint line gapping
  - II = 5–9 mm
  - III ≥ 10 mm
- Valgus stress at 0° knee flexion indicates posteromedial capsule or cruciate ligament injury.

Imaging
- X-ray:
  - Rule out bony injury.
  - Valgus stress test may show medial joint line gapping.
- MRI:
  - Can characterize sprain vs. partial vs. complete tear

Treatment

Nonoperative
- Primary treatment in both isolated and combined ACL injury
- NSAIDs, rest, physical therapy, and bracing (to resist valgus)

Operative treatment
- Relative indications:
  - Acute repair in Grade III (complete) injuries
  - Multi-ligament knee injury
- Reconstruction indicated in chronic injuries with persistent functional instability

Posterolateral Corner (PLC) [11, 12]

Anatomy/Biomechanics [13]

- PLC structures consist of static and dynamic structures:
  - Static:
    - Lateral collateral ligament (LCL)
    - Popliteus tendon
    - Popliteofibular ligament (PFL)
    - Lateral capsule
    - Arcuate ligament
    - Fabellofibular ligament
  - Dynamic:
    - Biceps femoris
    - Popliteus muscle
    - Iliotibial band
    - Lateral head of gastrocnemius
- PLC resists external rotation, varus, and posterior translation.

Diagnosis

History
- Acute injuries:
  - Be suspicious with high-energy injury mechanisms and multi-ligamentous knee injury (i.e., knee dislocation).

Physical Exam
- Varus thrust with gait exam
- Varus stress at 30° knee flexion:
  - Grading:
    - I = 0–5 mm lateral joint line gapping
    - II = 6–10 mm
    - III > 10 mm
- Varus laxity at 0° (LCL + cruciate injury)
- Dial test:
  - Tests for isolated PLC vs. PLC + PCL injury.
  - External rotation of tibia at 30° and 90° of knee flexion.
  - Positive test is >10° of side-to-side difference:
    - + test @ 30° and 90° flexion → PLC + PCL injury
    - + test @ 30° flexion only → isolated PLC injury
- Reverse pivot shift:
  - Valgus/external rotation force as the knee is brought from flexion into extension.
  - In flexion, the tibia subluxated posteriorly and reduces at approximately 20–30° of flexion as IT band transitions from knee flexor to extensor.

Imaging

- X-rays:
  - Avulsion fracture off the fibula ("arcuate fracture") represents bony avulsion of lateral ligamentous complex.
- MRI:
  - Imaging of choice

Treatment

Nonoperative

- Isolated PLC Grade I/II injuries
- Knee immobilizer with protected weight-bearing ×2 weeks followed by progressive rehab

Operative

- PLC repair:
  - Indicated only in acute injuries (within 2 weeks from injury)
  - Fibular avulsion → ORIF
- PLC reconstruction:
  - Grade III injury
  - Chronic injuries
  - Correct varus malalignment (if present) with high tibial osteotomy in chronic injuries
- Reconstruction techniques:
  - Multiple described
  - Goal: reconstruct LCL and PFL
- Acute multi-ligament knee injury:
  - Staged reconstruction:
    - Repair/reconstruct PLC early (within 2 weeks of injury).
    - Reconstruct PLC prior to ACL.

Complications

- Knee stiffness/arthrofibrosis
- Missed PLC injury:
  - Unrecognized PLC injury may lead to failed ACL reconstruction.
- Peroneal nerve injury

References

1. Beynnon BD, Johnson RJ, Abate JA, Fleming BC, Nichols CE. Treatment of anterior cruciate ligament injuries, part I. Am J Sports Med. 2005;33(10):1579–602.
2. Beynnon BD, Johnson RJ, Abate JA, Fleming BC, Nichols CE. Treatment of anterior cruciate ligament injuries, part 2. Am J Sports Med. 2005;33(11):1751–67.
3. Kopf S, Musahl V, Bignozzi S, Irrgang JJ, Zaffagnini S, Fu FH. In vivo kinematic evaluation of anatomic double-bundle anterior cruciate ligament reconstruction. Am J Sports Med. 2014;42(9):2172–7.
4. Mariscalco MW, Flanigan DC, Mitchell J, et al. The influence of hamstring autograft size on patient-reported outcomes and risk of revision after anterior cruciate ligament reconstruction: a Multicenter Orthopedic Outcomes Network (MOON) Cohort Study. Arthroscopy. 2013;29(12):1948–53.
5. Kaeding CC, Pedroza AD, Reinke EK, Huston LJ, Consortium M, Spindler KP. Risk factors and predictors of subsequent ACL injury in either knee after ACL reconstruction: prospective analysis of 2488 primary ACL reconstructions from the MOON cohort. Am J Sports Med. 2015;43(7):1583–90.
6. Donnell-Fink LA, Klara K, Collins JE, et al. Effectiveness of knee injury and anterior cruciate ligament tear prevention programs: a meta-analysis. PLoS One. 2015;10(12):e0144063.
7. Sekiya JK, Whiddon DR, Zehms CT, Miller MD. A clinically relevant assessment of posterior cruciate ligament and posterolateral corner injuries. Evaluation of isolated and combined deficiency. J Bone Joint Surg Am. 2008;90(8):1621–7.
8. Lee BK, Nam SW. Rupture of posterior cruciate ligament: diagnosis and treatment principles. Knee Surg Relat Res. 2011;23(3):135–41.
9. Montgomery SR, Johnson JS, McAllister DR, Petrigliano FA. Surgical management of PCL injuries: indications, techniques, and outcomes. Curr Rev Muscoskelet Med. 2013;6(2):115–23.
10. Roach CJ, Haley CA, Cameron KL, Pallis M, Svoboda SJ, Owens BD. The epidemiology of medial collateral ligament sprains in young athletes. Am J Sports Med. 2014;42(5):1103–9.
11. Ranawat A, Baker 3rd CL, Henry S, Harner CD. Posterolateral corner injury of the knee: evaluation and management. J Am Acad Orthop Surg. 2008;16(9):506–18.
12. LaPrade RF, Wentorf F. Diagnosis and treatment of posterolateral knee injuries. Clin Orthop Relat Res. 2002;402:110–21.
13. LaPrade RF, Bollom TS, Wentorf FA, Wills NJ, Meister K. Mechanical properties of the posterolateral structures of the knee. Am J Sports Med. 2005;33(9):1386–91.