ACL Injuries in Female Athletes

Katie Freeman, MD
Allina Health Orthopedics
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Disclosures

- None

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Objectives

- Anatomy
- Epidemiology
- Understand the risk factors of ACL tears in female athletes
- Diagnosis
- Review treatment of ACL injuries in female athletes
- Review ACL injury prevention strategies

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Overview

- One of the most frequently studied injuries
- Incidence of ACL tears in the general population is 68/100,000 people
  - About 75% of patients undergo reconstruction

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Anatomy

- Lateral aspect of the notch to the anterior tibia
- 2 Bundles
  - **Anteromedial**
    - Restrains anterior tibial translation
  - **Posterolateral**
    - Rotatory stability

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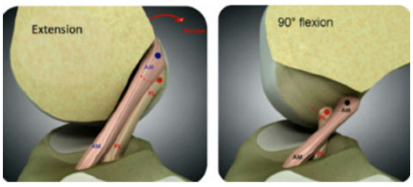

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Epidemiology

- **<u>Female athletes</u>** are **<u>2-8x</u>** more likely to tear their ACL
  - High risk sports- soccer, basketball, lacrosse, gymnastics
    - 70% non-contact injuries
  - Elite female soccer players have 7x higher risk than male soccer players

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Recurrent ACL injury

- 4x higher risk of reinjury to ipsilateral knee compared to males
- Female soccer athletes have a higher risk for a **2nd ACL injury (ipsilateral or contralateral)** after ACLR compared to other sports
  - 28% of all female soccer players and 34% of female soccer players who returned to same level of play had a 2nd ACL injury
    - 9.8% in male soccer players
    - Compared to 6% in other female athletes (basketball, skiing, volleyball, track)
      - *Allen et al. AJSM. 2016*

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Why?

- Increased Q angle
- Intercondylar notch
- ACL size
- Posterior tibial slope
- Biomechanical and Neuromuscular Differences

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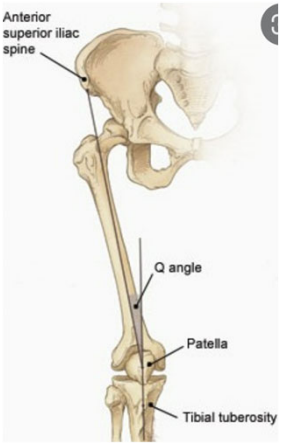
Increased Q angle

- Q angle has been shown to be **3.4 to 4.9 degrees greater** in females
- Larger Q angle → more laterally directed pull of the quadriceps
  - Places ACL in a position which may be more prone to rupture



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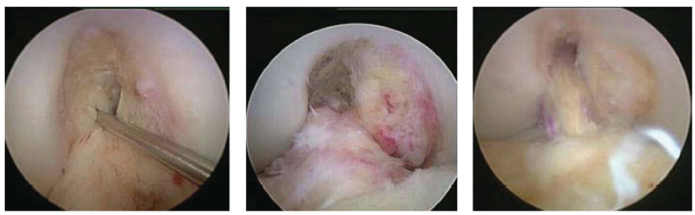
Intercondylar Notch

- Increased risk of ACL tear with narrow intercondylar notch
  - Direct impingement of the ACL on the notch in hyperextension or contact with LFC during rotational activities
  - Found to be an independent risk factor in females but not males
    - *Barnum et al. Am J Sports Med. 2021*



Sutton K. JAAOS. 2013

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Size

- Cross sectional area **20-30% less** than males
- **Fewer collagen fibrils** per unit area
- Female ACL sees **higher strain** when knee is in compromised position
  - *Lipps et al. Am J Sports Med. 2012*

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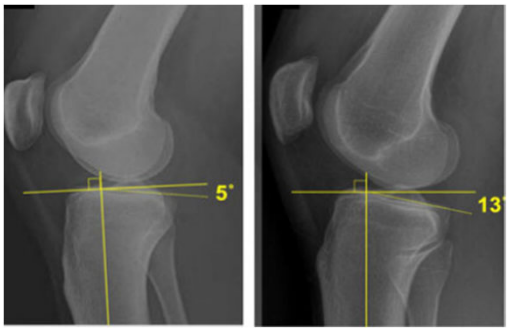
Increased Posterior Tibial Slope

- Normal <12°
- Places tibia **more anterior** to femur
- Puts increased strain on the ACL
- Increased PTS in females with ACL tear compared to non-injured controls
  - **21.7% increased risk** of noncontact ACL injury with **each degree increase** of the lateral tibial plateau slope among females but not among males
    - *Beynnon et al. Am J Sports Med. 2014.*



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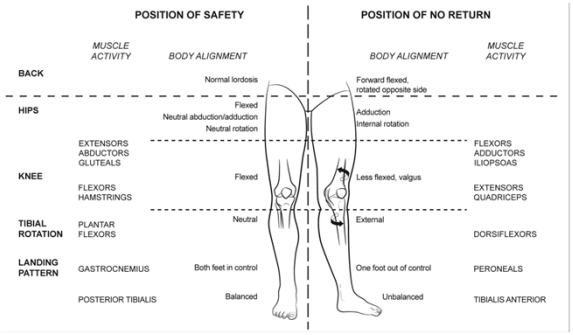
Biomechanical and Neuromuscular Differences

- Females land from jumping with **<u>more knee extension</u>**
- Have a higher degree of **<u>external rotation</u>** compared to males
- Higher **<u>knee valgus/abduction</u>** angle



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Diagnosis

- **History**
  - Non-contact injury, Feels or hears a “pop”
  - Swelling
  - Instability
- **Physical Exam**
  - Effusion
  - + Lachman, + Pivot Shift
- **Imaging**
  - Radiographs usually normal
    - effusion
  - MRI- torn ACL, “pivot shift” bone contusion pattern

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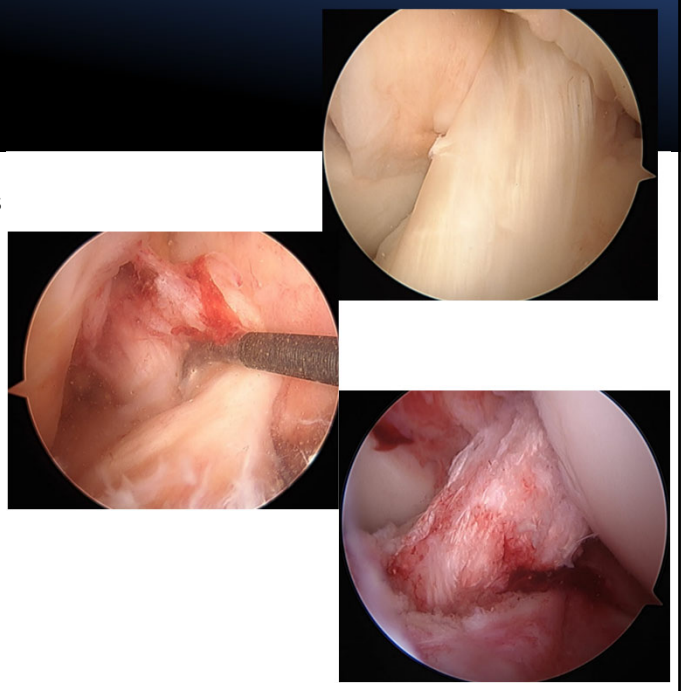
Treatment

- In athletes, recommend ACL reconstruction
  - Can also consider ACL repair in select patients with certain tear types
- Graft choice
  - ***<u>**Autograft**</u>***
    - Quadriceps tendon
    - Patellar tendon (BTB)
    - Hamstring
  - Allograft
    - <u>**Not recommended**</u> for young (<25yo), athletic population
      - 9.6% graft failure rate vs 25% failure in allograft
- Recovery time
  - <u>**~9-12 months**</u>



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Graft Choice

Graft Type	Indications	Advantages	Disadvantages	Complications
Allograft	• Patients aged >40 years • Multiligament knee injuries • Patient preference • Previous harvest from other donor sites • Inadequate autograft tissue	• Decreased surgical time • Predictable graft size • Decreased morbidity • Easier recovery • Double-bundle reconstructions • Over-the-top reconstructions • Multiple types of allograft available (eg, patellar tendon, tibialis anterior or posterior, HSs, peroneals, iliotibial band, and Achilles tendon)	• Cost • Infectious disease transmission • Delayed incorporation • Higher failure rate (up to 25%)[21] • Lower return-to-sport rate compared with autograft (43.3% versus 75%)[22]	• Infection • Intraoperative fracture of allograft bone given its softness
Autograft				
BPTB	• Young, athletic individuals who are skeletally mature[14] • Sports or professions that do not involve kneeling[4]	• Reliable, time-tested results[7] • Fastest incorporation and healing (6 weeks versus 8-12 weeks)[4] • Good outcomes in young, active patients[7,15] • Improved rates of return to sport compared with HS[5,16-20] • Lower revision rate compared with HS (1.9%-6.6% versus 4.9%-17.5%)[18-20]	• Donor site morbidity (anterior knee pain 17.4%)[10] • Risk of patellar fracture • Contraindicated in skeletally immature patients • Increased risk of OA compared with HS (39% versus 18% at 10 years)[16,17]	• Patellar fracture (zero-2%)[4] • Patellar tendon rupture (0.25%)[4] • Patellar tendonitis • Anterior knee pain (17.4%)[4,10]
HS	• Young, athletic individuals who are skeletally mature or immature • Sports that do not rely heavily on HSs (ie, sprinters)	• Option in skeletally immature patients • Greater cross-sectional area than BTB (53 versus 35 mm^2)[3,16] • Maintenance of the integrity of the extensor mechanism[16] • Lower harvest site morbidity • Smaller incision than BTB[4] • Less postoperative knee pain than BTB (11.5% versus 17.4%)[10]	• Donor site morbidity (knee flexion weakness)[16] • Less predictable graft size[16] • Compromise of medial knee structures[16] • Higher rerupture rates than other autografts (17.5% versus 6.4% BTB)[20] • Longer graft integration times (8-12 weeks)[4] • Higher infection rates (0.6% versus 0.07% BTB)[20]	• Bone tunnel enlargement due to windshield wiper effect[24] • Residual HS weakness[16]

Graft Type	Indications	Advantages	Disadvantages	Complications
QT	• Young, athletic individuals who are skeletally mature or immature (no bone block)	• Reliable and robust graft (cross-sectional area 62 mm^2)[4] • Can be used with or without bone block	• Prolonged quadriceps weakness with full-thickness grafts • Donor site pain • Fluid extravasation during arthroscopy	• Postoperative hematoma[25] • Patellar fracture with bone block harvest[25] • Rectus femoris retraction[25]
	• ACL with large footprint (>16 mm) • Athletes who rely on their HSs (sprinters) • Athletes or laborers who spend time on their knees (eg, wrestlers, judo, and carpenters)	• Less risk of infection compared with HS • Less risk of injury to the infrasaphenous branch (1.5% versus 53.3% in BTB)[13] • Low donor site morbidity (zero-15% versus 18%-51% in BTB)[13,17,25] • Less anterior knee pain (4.6% versus 26.7% in BTB)[13] • Can be harvested minimally invasively		

Buerba RA. JAAOS Glob Res Rev. 2021

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Prevention Strategies

- Neuromuscular Training Programs (NMT)
  - Can reduce the risk of ACL injury **up to 50%** in female athletes
  - Strength training, balance exercises, plyometrics and stretching
    - Targets imbalances and improves muscle activation

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Prevention

- NMT is more effective **if started in younger female athletes**
  - Systematic review of 27,231 female athletes
    - 347 sustained an ACL injury
    - NMT reduced the risk of ACL injury from 1 in 54 to 1 in 111
    - NMT targeting **middle and high school aged athletes** reduced injury to a greater degree than NMT in college- or professional athletes
    - Programs that included lower body strengthening and landing stabilization most effective
      - *Petushek et al. AJSM. 2019.*

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Thank You!

Questions?

katie.freeman@allina.com

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