PRESENTATION OF A COMMON SPORTS-RELATED KNEE INJURY
Agenda

- Presentation of our patient
- Normal anatomy of the knee
- Common sports related knee injuries
- Menu of radiologic tests
- Imaging algorithm for post-traumatic knee pain
25-year-old female with no significant past medical or past surgical history presents with left lateral knee pain s/p soccer injury

Patient’s foot was caught in the turf, felt her left knee shift

Heard a “pop” and needed to be helped off of the field

In ED, notable tenderness laterally and with varus stress – originally diagnosed with knee sprain

In Ortho consultation two days later – walking with limp, knee showed moderate effusion, motion of knee was limited by pain, tenderness medially to palpation along the joint line, grade 1-2 opening with valgus stress, positive Lachman maneuver, no significant opening with varus stress or with posterior lateral rotation
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Knee Anatomy

- The cruciate ligaments (ACL and PCL) act as major restraints to lateral rotation as well as antero-posterior motion. They are secondary restraints to varus and valgus stress.
- The collateral ligaments (MCL and LCL) support the knee medially and laterally and act as secondary restraints to lateral and antero-posterior movement.


http://www.conformis.com/Patients/About-Knee-Replacement-surgery/Anatomy-of-a-Knee
Knee Anatomy Continued

- Menisci are important for knee function and contribute to distributing compressive and torsional forces (1)
- Vertically oriented forces are converted into hoop stress in the menisci thereby decreasing axial load on articular cartilage (2)
- Shock absorbers, lubrication, provide secondary stabilization (2)

Thornton, DD and Rubin, DA (2000)

(1) Carrino, JA and Schweitzer, ME (2002)
(2) Thornton, DD and Rubin, DA (2000)
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Sports-Related Knee Injuries

- In a 10-year-study following 6434 patients with sports injuries related to the knee joint:
  - ACL lesion (20.3%)
  - Medial meniscus lesion (10.8%)
  - Lateral meniscus lesion (3.7%)
  - MCL lesion (7.9%)
  - LCL lesion (1.1%)
  - PCL lesion (0.65%)

- Leading activities leading to injury were soccer (35%) and skiing (26%)

Majewksi, M, et al. (2006)
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Menu of Radiologic Tests for Post-Trauma Knee Pain

- Plain radiograph
- MRI
- Arthrography
- CT
- Bone scan
- Sonography
- Single photon emission computed tomography (SPECT)
- CT angiography

Resnick, CS, et al. (2008) and Department of Health Western Australia (2007)
Plain Radiograph

- Initial study of choice for evaluation of post-traumatic knee pain and instability
- Rule out any fracture
- Can detect subtle fractures or avulsions caused by detachment of the ligaments
- Dislocation
MRI

- Study of choice for post-traumatic knee pain and instability
- Can detect:
  - Meniscal tears
  - Ligament tears
  - Bone contusions
  - Osteochondral defects
  - Also can detect less common pathologies
- Advantages:
  - Non-invasive
  - No ionizing radiation exposure
  - Superior soft tissue imaging
  - Intra- and extra-articular processes imaged
  - Multiplanar
  - Cost-effective in reducing number of arthroscopies
- Limitations:
  - Decreased diagnostic ability with multiple knee injuries
  - High cost and availability

Department of Health Western Australia (2007)
Arthrography

- 50%-75% accuracy in diagnosing ligamentous and/or meniscal injuries
- Has been replaced by MRI
- Limitations:
  - Only surface evaluation of menisci
- Disadvantages:
  - Invasive
  - Injection of intra-articular contrast
  - Ionizing radiation exposure
  - Complications post-procedure
CT

- Comparable to MRI for tibial plateau fractures
- Ruling out fracture in a significantly injured patient
- Useful for looking for retro-patellar problems and loose bodies
- Multi-slice has been shown to have high accuracy in diagnosing ACL and related meniscal lesions and articular pathology
- Limited evaluation of soft tissue: difficult to assess edema and strain on cartilage, menisci and muscles

Department of Health Western Australia (2007)
Radionuclide Bone Scan

- Can detect radiographically occult injuries
- Useful in chronic knee pathology
- Focal increased uptake at sites of bone repair: fractures, avulsions, torn menisci or infarctions

Limitations:
- Non-specific
- Inferior anatomic definition

Department of Health Western Australia (2007)
Sonography

- Has been reported to be 91% sensitive and 100% specific for diagnosing an acute ACL tear within 10 weeks of an acute hemarthrosis when there is no prior trauma or bone abnormalities.
- Highly operator dependent and most U.S. institutions don’t have experience with MSK ultrasound.

Resnick, CS, et al. (2008)
SPECT

- Proposed for diagnosing meniscal injuries
- A specific crescentic uptake pattern on transaxial view has sensitivity of 77% and specificity of 74% of identifying meniscal tear

Resnick, CS, et al. (2008)
CT Angiography

- Used mainly for blunt and penetrating trauma to the knee
- Can accurately assess injuries to the extremity arteries

Resnick, CS, et al. (2008)
ACR Appropriateness Criteria for Acute Knee Trauma: First Radiologic Study

**Variant 2:**

Patient any age (excluding infants); fall or twisting injury, with one or more of the following: focal tenderness, effusion, inability to bear weight. First study.

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<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
<th>RRL*</th>
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<td>X-ray knee</td>
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<td>MRI knee without contrast</td>
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<td>Tc-99m bone scan with SPECT lower extremity</td>
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<td>CT knee without contrast</td>
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<tr>
<td>US knee</td>
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<tr>
<td>MRA knee</td>
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<td>None</td>
<td></td>
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</tbody>
</table>

*Rating Scale: 1=Least appropriate, 9=Most appropriate

*Relative Radiation Level
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Imaging Algorithm

POST TRAUMATIC KNEE PAIN

Application of Ottawa Rules
Knee x-rays are indicated when any of the following are present:
- Age 55 years or older
- Tenderness at head of the fibula
- Isolated tenderness of the patella
- Inability to flex knee to 90 degrees
- Inability to weight bear 4 steps both immediately and in the emergency department

X-rays indicated
- Fracture
  - Treat (may need CT for treatment plan)
- No Fracture
  - Ongoing suspicion of fracture
    - CT
      - Normal with high clinical suspicion
        - Bone Scan
      - MRI when available (or arthrography/arthroscopy)

X-rays not indicated
- Likely soft tissue injury
Our Patient: Application of Algorithm

- Now that we’ve discussed the menu of radiologic tests and an algorithm for imaging lets return to our patient.
- Our patient had knee tenderness to palpation laterally and with movement, and was unable to bear weight immediately after the injury.
- Following the Ottawa criteria, a plain radiograph was indicated.
Our Patient: Plain Radiograph of the Knee

Plain radiograph of left knee (AP view) taken in the ED

Findings:
- no fracture
- no dislocation
- no degenerative changes
- no joint effusion
- no foreign body

Impression:
- normal radiograph
Our Patient: Plain Radiograph of Knee (oblique view)

Plain radiograph of left knee (oblique view)

Findings:
- no fracture
- no dislocation
- no degenerative changes
- no joint effusion
- no foreign body

Impression:
- normal radiograph
Our Patient: Plain Radiograph of Knee (lateral view)

Plain radiograph of left knee (lateral view)

Findings:
- no fracture
- no dislocation
- no degenerative changes
- no joint effusion
- no foreign body

Impression:
- normal radiograph
The plain films were normal; however, on physical exam, our patient was found to have signs of soft tissue damage:

- Positive Lachman test – indicative of an ACL tear
- Grade 1-2 opening with valgus stress – indicative of an MCL tear

Given the exam findings, an MRI is indicated
Our Patient: ACL tear on T2 fat-saturated MRI

T2 FS MRI sagittal view of left knee:
- Full-thickness ACL tear in mid-portion with increased fluid signal
Companion Patient #1: Normal ACL on T2 FS MRI

Our patient

T2 FS MRI sagittal view of left knee:
- increased fluid signal indicative of edema
- full thickness tear of ACL

Companion Patient #1

T2 FS MRI sagittal view of left knee:
- no increased fluid signal
- no evidence of tear
- normal ACL
Our Patient: ACL tear on Proton Density MRI

PD MRI sagittal view of left knee:
- Wavy, discontinuous appearance of ACL fibers on PD
- Border of ACL not parallel to Blumenstaat’s line
Companion Patient #1: Normal ACL on PD MRI

Our patient

-PACS, BIDMC

PD MRI sagittal view of left knee:
- wavy, discontinuous fibers
- ACL not parallel to Blumenstaat’s line

Companion Patient #1

-PACS, BIDMC

PD MRI sagittal view of left knee:
- no fraying or wavy fibers
- ACL runs parallel to Blumenstaat’s line
- normal ACL
Our Patient: MCL tear on MRI

T2 fat saturated coronal image of left knee:
- increased T2 signal in the MCL and surrounding fascia indicating edema
- thickening of MCL
- indicative of grade II MCL sprain/tear
- bone marrow edema evident on lateral femoral condyle
Grades of MCL sprain/tear on MRI

- **Grade I:**
  - Edema and possibly hemorrhage, which extends into the subcutaneous fat. The ligament is continuous, thin and dark.

- **Grade II:**
  - Morphologic disruption or internal high signal of fluid in the MCL bursa

- **Grade III:**
  - Complete disruption of the ligament

Our Patient: Lateral Meniscal Tear on MRI

PD MRI sagittal view of left lateral knee (two contiguous images):
- Complex tear of the posterior horn of the lateral meniscus (grade 3)
Diagnosis of Meniscal Tear by MRI

- The diagnosis of meniscal tear by MRI requires that either of two criteria be met:
  - Presence of increased intrameniscal signal on a short TE image that definitively contacts an articular surface
  - Abnormal meniscal morphology in the absence of prior meniscal surgery. The meniscus should have: normal height, width and contour

- Tears can be more confidently diagnosed when seen on two or more contiguous images or when seen on both the coronal and sagittal planes

Thornton, DD and Rubin, DA (2000)
Grades of Meniscal Signal on MRI

- **Grade I:**
  - Irregular intrameniscal increased signal that does not extend to the articular surface, and is believed to reflect early degenerative findings or normal variation

- **Grade II:**
  - Signal is linear and may connect to capsular margin, and is believed to reflect more severe degenerative findings

- **Grade IIc:**
  - Linear signal that extends to articular surface on a single section
  - Approximately 50% are tears

- **Grade III:**
  - Linear or complex signal that extends to the articular surface on more than one section

Carrino, JA and Schweitzer, ME (2002)
Our Patient: Bone Marrow Edema on MRI

T2 FS MRI sagittal view of lateral left knee:
- Lateral femoral bone marrow edema
- BME of posterior margin of tibial plateau
  - Indicative of kissing contusion

T2 FS MRI sagittal view of medial left knee:
- Posterior medial tibial plateau BME
Kissing Contusions

- Common secondary finding in acute ACL injury
- Most common is BME in lateral femoral condyle and posterolateral tibia
- Caused by tibia rotation internally relative to the femur leading to the lateral femoral condyle being compressed against the posterior lateral tibial plateau
- ACL tear has also been associated with BME in the posterior lip of the medial tibial plateau

Our Patient: Possible Tear of Medial Meniscus on MRI

T2 FS MRI coronal view of left knee:
- abnormal signal in the medial portion of the medial meniscus, but does not appear to reach articular surface
- indicates possible tear of medial meniscus
Our Patient: Normal PCL on MRI

T2 FS MRI (left image) and PD MRI (right image) sagittal view of left knee:
- normal appearing, intact PCL
- well defined borders, homogenous signal intensity, boomerang appearance that is convex posteriorly
Our Patient: Summary of Radiologic Findings

- ACL tear with kissing contusions
- Grade II MCL sprain
- Lateral meniscal tear
- Suspected medial meniscal tear
- Intact PCL
O’Donoghue’s Unhappy Triad

- Original inclusion criteria (1):
  - Rupture of the medial collateral ligament
  - Damage to the medial meniscus
  - Rupture of the anterior cruciate ligament

- New findings:
  - 80% of ACL/MCL injuries are associated with lateral meniscus tear (1)
  - Medial meniscus tears were only found in 25% of these cases and only in conjunction with torn lateral meniscus (1)
  - A second study also found that lateral meniscus tears far outnumbered medial meniscus tears in patients with ACL/MCL injuries (2)
  - Both studies concluded that the classic O’Donoghue triad is unusual clinically and is better described as ACL, MCL and lateral meniscus

(1) Barber, FA (1992)
(2) Shelbourne, KD and Nitz, PA (1991)
Companion Patient #2: Segond Fracture on Plain Film

Plain film (AP view) of left knee:
- acute fracture arising from lateral aspect of left proximal tibia
- likely Segond fracture
Segond Fracture

- The Segond fracture results from excessive internal rotation combined with flexion of the knee.
- It is an avulsion fracture of the insertion site of the meniscotibial portion of the lateral capsular ligament.
- Associated with ACL tears in 75%-100% of patients.

Valkering, KP and Breederveld, RS (2008)
Companion patient #2: ACL Tear on MRI

T2 fat-saturated sagittal view of left knee:
- tear of the ACL with increased fluid signal
Companion Patient #2: Partial PCL Tear on MRI

T2 fat-saturated sagittal view of left knee:

- abnormal high signal near distal tibial attachment representing partial tear of PCL
Companion Patient #3: LCL tear on MRI

T2 FS coronal image of knee:
- tear of lateral collateral ligament at the femoral attachment with increased signal

Stork, A et al. (2000)
Our Patient: Follow-up

- The MCL was allowed to heal on its own for 6 weeks in a hinge brace until full extension and 125 degrees of knee flexion were achieved.
- The ACL was reconstructed with autologous hamstring graft with the semitendinosus and gracilis tendons harvested.
- The lateral meniscus tear was not deemed appropriate for healing and patient underwent arthroscopic partial lateral meniscectomy.
- Post-surgical physical therapy to regain strength and motion.
Summary

- Sports-related knee trauma can include any of the ligaments or menisci.
- Plain film is the initial study of choice for acute knee trauma, but one should follow the Ottawa Criteria.
- MRI is the study of choice.
- The classic O’Donoghue’s unhappy triad consists of ACL, MCL and medial meniscus injuries.
- The common clinical “terrible triad” is actually ACL, MCL and lateral meniscus injury.
- ACL tear is associated with:
  - Kissing contusions (seen in index patient)
  - Segond fracture (seen in companion patient #2)
References

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