Knee Imaging

3 Bones

Bones
- Patella
- Femur
- Tibia

Radiographs
- Fluid
- Fractures
- Ligaments
- Menisci

Patella: [L] "shallow pan"

Largest sesamoid bone
- Sesamoid: "Bone embedded within a tendon"
- From 4 quadriceps muscles
  - Vastus Lateralis, Medialis, Intermedius
  - Rectus Femoris
- To tibial tubercle (tuberosity)
- "Extensor Mechanism"
- Patellofemoral Compartment

Articular Surfaces

As opposed to the round articular surfaces of the femoral condyles, the tibial articular surfaces are flat.
- Tibial plateau: [Fr] "plate"
- Patellar eminence separates the lateral and medial compartments
- Intercondylar notch

Femoral Condyles

Anterior View
- Lateral View
- Posterior View
- Intercondylar Notch

Articular Surfaces

Tibial Eminence

Lateral Compartment

Medial Compartment

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Knee Imaging

Jan: “Hurt knee skiing”
Nov: “Knocked down by dog”

Fracture tibial eminence
Transverse fracture ↔ Avulsion fracture
Avulsion of ACL (Anterior Cruciate Ligament)

Knee Imaging

Radiographs (78%)
➢ Primary modality for knee pain
   ▶ Arthritis (joint narrowing, osteophytes)
   ▶ Fractures, loose bodies
MR (21%)
➢ Internal derangement
   ▶ Ligament/meniscal tears, cartilage defects
   ▶ Occult fractures
CT (1%)
➢ Surgical planning (of fx seen on radiographs)

Knee Imaging

AP View

Shows width of lateral, medial compartments
➢ Assess for arthritis
➢ Doesn’t show patello-femoral compartment
Articular surfaces
➢ Weight-bearing portions femoral condyles
➢ Tibial plateau
➢ Assess for displaced fractures

Knee Imaging

Lateral View

Shows lateral view of femoral condyles & tibial plateau
➢ Doesn’t show mediat compartments
Shows lateral view of patella
➢ Assess for patella fracture
➢ Doesn’t show patellofemoral compartment
Can show sizable joint effusions...
physical exam is more sensitive!
Sunrise View (Laurin View)

Shows patellofemoral compartment
- Important view to assess arthritis
- Shows alignment between patella & trochlear groove.

Notch View (Rosenberg)

Shows width of posterior lateral, medial compartments
- Assess for arthritis
- Doesn’t show patellofemoral compartment

Articular surfaces
- Posterior portions femoral condyles
- Tibial plateau
- Assess for displaced fractures

Fluid in Joint: Effusion

Synovial fluid
- From inflamed synovium
- Arthritis

Blood: “Hemarthrosis”
- From torn vascularized structure
- Anterior Cruciate Ligament tear

Fat + Blood: “Lipohemarthrosis”
- Fat comes from fatty yellow bone marrow
- Indicates presence of intra-articular fracture

Suprapatellar Pouch

The knee can hold a lot of fluid… not between articular surfaces.
- Joint effusions collect in the suprapatellar pouch.
- Synovial lined space
- Normal extension of the joint capsule
- Can easily hold > 40ml

Effusion on Lateral View

No effusion (radiographically)
- Large effusion

Radiographs can show sizeable joint effusions… but physical exam is more sensitive!
**Effusion on MR**

- **Bones**
- **Radiographs**
- **Fluid**
  - Suprapatellar
  - Baker cyst
  - Prepatellar
  - Loose bodies
  - Fabella
- **Fractures**
- **Ligaments**
- **Menisci**

**Baker Cyst (Popliteal Cyst)**

- **Suprapatellar pouch**
- **Synovial lined space**
- **Normal place fluid collects**
- **Baker cyst**
- **Synovial lined space**
- **Abnormal place fluid collects**
- **Posterior extension joint capsule**
- **Medial, between:**
  - Medial gastrocnemius muscle
  - One of the calf muscles
  - Semi-Membranosus tendon
  - One of the hamstring muscles

**Bones**

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- **Fluid**
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Prepatellar Bursitis

- Synovial lined space
- Does not communicate with knee joint capsule
- Normally contains little/no fluid
- Irritation of bursa → marked increase bursal fluid
- Prepatellar bursitis reported in people who kneel frequently
  - Housemaid’s knee
  - Preacher’s knee

Prepatellar Bursitis

- Often diagnosed by exam

Loose Bodies

- Fragments of bone/cartilage in capsule
  - Loose osteochondral fragment
- May be inconsequential if outside joint
  - If remain in suprapatellar pouch,
  - or in Baker cyst
- But if between articular surfaces...
  - May cause locking,
  - Destruction articular cartilage
**Knee Imaging**

**Fabella:** [L] little bean

- **Sesamoid lateral gastrocnemius**
- Present 10-30% people
- Bilateral 80%

**Fractures**

- **Patella**
  - Uncommon
  - Direct trauma, fall to patella
  - Distraction – fragments pulled apart
- **Femur**
  - Condyle fracture – rare
  - Supra/Intra-condyle fx – more common
  - Osteochondral defect – fairly common
- **Tibia Plateau**
  - MVA – Very Common

**Bipartite Patella**

- Normal variant
- 2% of population
  - 9x more common boys
- Bilateral 43%
- Asymptomatic 98%
  - Usually superolateral

**Patella Fractures (Uncommon)**

- Direct Trauma (Fall onto knee)
- Comminuted, stellate pattern
- Typically not distracted

**Patella Fractures (Uncommon)**

- Indirect distracting injury
- Unexpectedly rapid knee flexion against contracted quadriceps
- Distraction upper/lower poles

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Knee Imaging

Femur Fracture

- Bones
- Radiographs
- Fluid
- Fractures
  - Patella
  - Femur
  - OCD
  - Tibia
  - Occult Fxs
  - Ligaments
  - Menisci

Condyle fractures: rare
- Supra-condylar
- Inter-condylar

More common
- Anterior View
- Posterior View
- Lateral View

Femoral Supra/Inter Condylar Fractures

- More common
  - From axial loading
    - Fracturing between condyles
    - Fracturing above condyles
  - Increasingly common
    - Older females (low energy)
    - Younger males (high energy)

Femoral Condyle Fracture

- Uncommon Fx
  - Results from shearing of condyle as femur is dislocated across tibia

Osteochondral Defect (OCD)

- Fairly common
  - Fx of bone "osteo" & cartilage "chondral"
  - Adults: traumatic
  - Children: idiopathic "osteocondritis dissecans"
  - Femoral condyles
    - Medial 4x > Lateral

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Imaging Osteochondral Defects

Start with radiographs...
- CT shows corticated margin
- MR shows "stability"

These should be ordered by orthopedic surgeon

- MR: Coronal T1
- CT: Coronal Reformat

MRI of the knee shows a defect in the patella.

M, A 24yo M

Bones
Radiographs
Fluid
Fractures
Patella
Femur
OCD
Tibia
Occult Fxs
Ligaments
Menisci

Imaging Osteochondral Defects: MR

Coronal T1
Post-op Coronal T2fs
Sagittal T2fs
Arthroscopy
Arthroscopy

MRI of the knee shows a defect in the tibia.

G, L 46yo M

Bones
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Tibial Plateau Fractures

Very Common
- 80% MVA (the rest from falls, sports)*
- 60% involve lateral plateau**
- CT used for surgical planning
- Schatzker classification system*

** http://www.wheelessonline.com/ortho/tibial_plateau_fractures

Surgical planning for tibial plateau fracture.

G, L 46yo M

Bones
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Post-operative imaging of tibial plateau fracture.

G, L 46yo M

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Occult Fxs
Ligaments
Menisci
Non-displaced (Occult) Fractures

The way we diagnose fractures on radiographs is to see displaced fragments. Non-displaced Fx can be radiographically occult. So how do we detect occult knee fractures?

- CT often doesn’t help.
- MR doesn’t miss non-displaced Fxs.

Can’t send every ER patient with knee pain to MR.

There is a trick!

- Look for lipohemarthrosis on cross-table lateral!

Radiographic Views: In ER

Shot with patient lying on a cart.
- AP view
- Vertical X-ray beam

Shot with patient lying on a cart.
- Cross Table Lateral view
- Horizontal X-ray beam
- Perpendicular to gravity

Types of Joint Effusions

- Synovial fluid
  - From inflamed synovium
  - Arthritis
- Blood: “Hemarthrosis”
  - From torn vascularized structure
  - Anterior Cruciate Ligament tear
- Fat + Blood: “Lipohemarthrosis”
  - Fat comes from fatty yellow bone marrow
  - Indicates presence of intra-articular fracture
Thought Experiment

**Lipo-arthrosis on X-Table Lateral**

- Bones
- Radiographs
- Fluid
- Fractures
- Patella
- Femur
- OCD
- Tibia
- Occult Fxs
- Ligaments
- Menisci

**Impacted Tibial Plateau Fracture (SIII)**

- Bones
- Radiographs
- Fluid
- Fractures
- Patella
- Femur
- OCD
- Tibia
- Occult Fxs
- Ligaments
- Menisci

**Occult Fracture**

- Bones
- Radiographs
- Fluid
- Fractures
- Patella
- Femur
- OCD
- Tibia
- Occult Fxs
- Ligaments
- Menisci

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Knee Imaging

MR Doesn’t Miss Fractures

Bones
Radiographs
Fluid
Fractures
Patella
Femur
OCD
Tibia
Occlus. Fract.
Ligaments
Menisci

MR: Coronal T2fs
AP View
CT: Coronal Reformat
MR: Coronal T1
MR: Coronal T2fs
Bone Marrow Edema

Ligaments & Tendons

Bones
Radiographs
Fluid
Fractures
Ligaments
Quadriceps
Collaterals
Cruciates
ACL Tears
Menisci

Tendons
Connect muscles to bone
★ Quadriceps Tendon
Ligaments
Connect bone to bone
★ Patella Ligament
★ Anterior Cruciate Ligament (ACL)
★ Medial Collateral Ligament (MCL)

Quadriceps Tendon Rupture

Most commonly rupture >50yo
★ Men 8x > Women
Transversely, patella insertion
Exam:
★ Patella freely mobile
★ Inability to actively extend knee
★ Active flexion preserved
Radiographs:
★ May show low patella
★ “patella baja”

Patella Ligament Avulsion

Most commonly rupture <40yo
★ More common in African descent
Transversely, patella origin
Exam:
★ Inability to actively extend knee
Radiographs:
★ May show high patella
★ “patella alta”

Patella alta:
Patella ligament
>20% longer
Patella length.
Normally patella length = patella lig. length (+/- 20%)
Knee Imaging

Patella Ligament Avulsion
- Bones
- Radiographs
- Fluid
- Fractures
- Ligaments: Quadriceps, Collaterals, Cruciates, ACL Tears, Menisci

Medial Collateral Ligament (MCL)
- Bones
- Radiographs
- Fluid
- Fractures
- Ligaments: Quadriceps, Collaterals, Cruciates, ACL Tears, Menisci

Lateral Collateral Complex
- 3 Structures: Iliotibial Band, Biceps Femoris Tendon, Fibular Collateral Ligament

Cruciate Ligaments
- Cruciate: [L] "cross"
- Anterior Cruciate Ligament crosses anterior to the Posterior Cruciate Ligament

Cruciate Ligament Tears
- PCL infrequently tears
- Surgical reconstruction of the PCL is controversial
- ACL frequently tears
- Requires surgical reconstruction
- Sports related twisting injury
- Torn ACL allows anterior displacement of the tibia relative to the femur
- Anterior Draw Sign
Knee Imaging

Anterior Draw Sign = ACL Tear

Bones
Radiographs
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Ligaments
Quadriceps
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Cruciates
ACL Tears
Menisci

Not usually seen on radiographs but...
More common on MR

Kissing Contusions = ACL Tear

Bones
Radiographs
Fluid
Fractures
Ligaments
Quadriceps
Collaterals
Cruciates
ACL Tears
Menisci

Back of tibial plateau impacts upon front of femoral condyle
Bone marrow contusions/edema

Impaction Fractures from ACL Tear

Bones
Radiographs
Fluid
Fractures
Ligaments
Quadriceps
Collaterals
Cruciates
ACL Tears
Menisci

Back of tibial plateau impacts upon front of femoral condyle
- Bone marrow contusions/edema
- Impaction fractures
- Anterior lateral femoral condyle
- Posterior lateral corner tibial plateau
- Radial tear

ACL Tears on MRI

Direct sign:
- Non-visualization of intact fibers
Indirect signs:
- Anterior draw
- Kissing contusions

Menisci: Function

Looking at the menisci is the primary indication for ordering MRI of the knee
- To assess for fractures, arthritis
- Surgical planning fracture repair
- To assess for ACL tear
- To assess for meniscal tear
- Radiographs, PE not helpful
- Order MRI!

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Looking at the menisci is the primary indication for ordering MRI of the knee
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Menisci: C-shaped

- Normal Anatomy
- Horizontal Tear
- Radial Tear

Meniscal Tears

- Articular surfaces:
  - Superior
  - Inferior

Articular surfaces:

- Superior
- Inferior

Vertical tear
- Separates meniscus into inner/outer

Horizontal Tear
- "Cleavage tear"
- Leaves the meniscus into upper/lower

Radial Tear
- Radiates from free edge outward
- Separates meniscus into anterior/posterior

Flipped Meniscal Fragment
- Meniscus portion displaced within knee joint
- Can cause locking
- Decreased motion

Meniscal Tears are seen on MR as increased signal that extends to an articular surface on at least 2 slices.

1 slice only touches called “possible tear”

50% of these are torn at arthroscopy.

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Bucket Handle Tear

Longitudinal tear where inner portion flips into the intercondylar notch, under PCL

Bucket Handle Tear

Longitudinal tear where inner portion flips into the intercondylar notch, under PCL

Knee: What to Order When (WOW)

Always start with radiographs!

- Diagnose arthritis, assess progression
  - Joint space narrowing, osteophytes
- Diagnose fractures, assess healing
  - Fracture displacement, articular involvement
- Look for loose bodies
  - See if bodies move over time
- Screen for unexpected findings
  - Tumors
  - Metal foreign bodies

MRI: Frequently ordered for knee pain

- Internal derangement
  - Meniscal tears
- Ligament tears (ACL, MCL)
- Cartilage defects
- Occult/non-displaced fractures
- MRI does not miss fractures

BEST IF ORDERED BY KNEE SPECIALIST!

- They may prefer certain sequences
- They may prefer certain MR scanners
CT: Infrequently ordered for knee pain
- Primary use is in the ER to assess the alignment of fracture fragments (shown on radiographs) to aid in surgical planning
  - Should be ordered by the surgical team
- Occasionally, for patients who are not MR compatible, we will do an Arthrogram-CT to assess for internal derangement
  - Should be ordered by the knee specialist