Meniscus: anatomy & mechanics

- Fibrocartilage (type I collagen)
- Shock Absorption / low friction
- Peripheral articular congruity
- Circumferential fibers
  - hoop strength
- Vascularity
  - outer portion (pink zone) >> inner (white zone)

Medial Meniscus: anatomy

- MM larger than LM
- Greater radius of curvature
- Firmly adherent to central tibia
  - Anterior & posterior roots
  - Strong capsular ligaments
Lateral Meniscus: anatomy

- Posterolateral:
  - Popliteus tendon posterior to LM
- Meniscofemoral ligaments
  - From LM → femur
  - Humphrey 1/3 (ant to PCL)
  - Wrisberg 1/3 (post to PCL)
  - 3%: both present

DIAGNOSIS OF INJURY

Menisci: Pulse Sequences

- CSE is standard
  - PD: best SNR
- FSE
  - Watch out for “blur” artifact on low TE images!
  - Use PD, not T1 FSE – use TE about 30
  - Keep echo train length low – use 4 ETL
Meniscal Tear

T1, PD weighted
Highly sensitive

T2 weighted
Highly specific

Meniscal Degeneration

T1

PD

T2

9 Month F/U
Now with flap tear

Is a degenerated meniscus
More prone to tear?
Why not use T1 for Menisci?

- Degeneration is quite bright
- Hard to tell degeneration from tear
- Nearly impossible to tell extent of tear
- Open MRI: better T1 contrast than high field
  - Fluid as dark as meniscus
  - Can miss tears
- Why do we use T1 at all??
  - Marrow fat (fx, tumor, IA bodies)
  - Soft tissue fat (synovium, SQ)

The Trouble with T1

Discoid Meniscus with Tear? NO!!

Low signal of fluid is difficult to differentiate from meniscus

Intra-meniscal Fluid: Assume Tear

Even if it doesn’t reach surface
Meniscal Tear - Criteria

1) Intrameniscal signal unequivocally extending to inferior or superior surface
   2 sections: 90% accuracy
   1 section: (55% MM; 30% LM)
2) Abnormal Morphology
   – Amputation / truncation

Meniscal Tears

- Diminutive meniscus DDx:
  – Post-op partial meniscectomy
  – Tear with flipped fragment (e.g., bucket-handle)
  – Chronic degenerative tear

Diminutive Meniscus

- Step 1: Look for H/O arthroscopy or “scope scar”
  – If +, meniscal finding may be due to partial meniscectomy
- Step 2: Look for flipped fragments
  – Common places:
    • Notch
    • Anterior, posterior recesses
    • Meniscotibial recess
- Caution: scope scar and flipped fragment can co-exist
Scope Scar

Each side of patellar tendon: rounded low signal

Diminutive Meniscus
anteriorly flipped fragment

“Ghost Sign”
Initially Looks Like Meniscectomy  
But no scope scar!

Anterior and superior flip

Fragment Flipped into Meniscotibial Recess  
AKA “Boomerang”

Pitfalls of Meniscal Tear
Menisci: Pitfalls
Normal Anatomy

- Prominent recesses
  - esp. laterally

- Fascicles may separate
  - at tibial spines
  - at takeoff of meniscofemoral lig
  - at transverse lig

- Crossing structures
  - popliteus post-lat

Pitfall:
Paired geniculate vessels ALWAYS next to lateral meniscal body

- Expect them there!
- Follow on serial coronal images to confirm

Anterior Horn of the Lateral Meniscus

- the “Alligator”

- Fascicles may separate
  - at tibial spines
  - at takeoff of meniscofemoral lig
  - at transverse ligament
Anterior Horn Lateral Meniscus

*How to tell if there is a tear*

- Step 1: look for parameniscal cyst
- Step 2: does signal extend toward body?

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Iliotibial Band Friction Syndrome

- Runners
- Friction: iliotibial band, lateral femoral condyle
- Edema, pain
- Simulates lateral meniscal tear

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Humphry / Wrisberg

Simulating tear of PHLM
Menisci: Pitfalls

Physiology

Intrameniscal signal
- young: vascular
- old: degeneration
PHMM most common

Meniscal Flounce

Artifact

Motion artifact
Series repeated with less motion
MRI Diagnosis of Meniscal Tear

<table>
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<tr>
<th>Technique</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>PPV (%)</th>
<th>NPV (%)</th>
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Summary of results from prospective studies containing greater than 200 cases with surgical correlation

Clinical Experience

- Most (approximately 80%) of meniscal tears are large and obvious
- Approximately 20% are borderline by standard criteria
  - Therefore, overall accuracy of 90% is not very impressive
  - In borderline cases, other findings ('secondary signs') could potentially increase accuracy

Baker’s Cyst

Synovial cyst – forms at weak point of capsule
Extends through interval between semimembranosus and medial head of gastrocnemius
Presence suggests chronic or recurrent effusion
What Can Be Done to Improve Our Odds??

Secondary Signs of meniscal tear

Results: N=140
2 readers – separate sessions
Compared with Arthroscopy


Parameniscal Soft Tissue Edema

- Analogous to joint line tenderness
- Sensitivity: 14/32%
- Specificity: 95/21%
- PPV: 67/50%
- K= 0.38

Parameniscal Cyst

- Sensitivity: 14/32%
- Specificity: 100/21%
- PPV: 100/100%
- K= 0.92
Meniscal Extrusion >3mm
- Sensitivity: 3/14%
- Specificity: 88/97%
- PPV: 17/80%
- K = 0.31

Subchondral Bone Marrow Edema
- Linear
- Sensitivity: 89/88%
- Specificity: 98/100%
- PPV: 89/88%
- K = 0.6

Subchondral Bone Marrow Edema
- Any edema adjacent to a meniscus
- Sensitivity: 43/43%
- Specificity: 98/100%
- PPV: 92/100%
- K = 0.65
Perivascular Edema Adjacent To Meniscus

- Sensitivity: 10/7%
- Specificity: 89/100%
- PPV: 97/100%
- K = 0.8

Focal Cartilage Loss Directly Adjacent To Meniscus

- Sensitivity: 32/14%
- Specificity: 85/97%
- PPV: 56/80%
- K = 0.27

PATTERN PREDICTION OF PATHOLOGY

- Mechanism = type of meniscal tear
ACL tear: Prediction of Meniscal Pathology

“Pivot-shift” mechanism
Lateral meniscal tear: impaction of posterior horn 
+/- valgus stress: MCL, medial meniscal injury

Post-op ACL
Bucket-handle tear can be a cause of new sx

“Bucket Handle” Tear
- 95%: medial meniscus
- Abnormal meniscal size
- Truncation
- Blunt, irregular margins
- Flip into intercondylar notch
  - “Double PCL” sign
- Mimicked by
  - torn ACL
  - MFL
  - loose body

Vertical circumferential tear, flipped fragment
Bucket Handle Tear

Double PCL – only with medial bucket-handle tears (ACL blocks lateral fragment – can’t get under PCL)

Bucket-handle Tear

*Lateral blocked by ACL – no ‘double PCL’*

Blocked by ACL

Flipped Meniscus

*Posterior to anterior: relatively common flip - looks like a double anterior horn*
Atypical Flaps & Flips

“Boomerang Sign”

Superior

Under MCL – into meniscotibial recess
-surgeon must look 'under' meniscus to retrieve

Meniscal Extrusion

“Hoop strength” of meniscus altered
• Meniscus expands centripetally
• Use tibia, not femur as guide

DDx
• Post-op
• Degeneration (microtears in internal fibers)
• Tear

> 3mm extrusion (look for radial tear, esp at root)

Meniscal Root Injury

Radial tear at meniscal root
-Causes body to extrude
Root Tear
ALWAYS inspect your roots

Presenting w calf pain
Ruptured Baker’s extending inferioy
Cause: Meniscal root tear / extrusion
SONK also!

Parameniscal Cyst
- Lobulated
- Direct connection with a meniscal tear
- 7% incidence in presence of meniscal tear (medial or lateral)
**Parameniscal Cyst**

- Can extend far from origin
- Ligaments (esp MCL) deform

**Rim enhancement**

- Gd not usually needed for “R/O mass” at knee
- Most are cysts

**Lobulated Cyst in Hoffa’s Fat**

**DDx:**
- Parameniscal cyst from AH
- Ganglion off joint capsule
- ACL Ganglion

Open MRI
Lateral – large recesses... most likely just from effusion (look for capsular attachments)

SIGNIFICANCE OF INJURY

- Type of tear can determine prognosis

Meniscocapsular Separation

- Not treated surgically
- Important to differentiate from peripheral meniscal tear
Peripheral Meniscal Tear

Peripheral tears
- Potential for healing (pink zone)
- Easy to miss; look at T2s

Peripheral Meniscal Tear
Pro Basketball Player

Meniscal Tears: Nomenclature

• Type:
  – Longitudinal (parallel to circumference)
    – Horizontal
    – Oblique
      – Vertical (bucket-handle)
  – Radial (perpendicular to circumference)
    – Straight
    – Curved (parrot-beak)
  – Complex (combination of above)
Longitudinal Tear

Parallel to circumference
- Horizontal
- Oblique
- Vertical (bucket-handle)
  - Looks similar on adjacent images

Longitudinal Tear
Horizontal

Horizontal Tear MM

- A degenerative tear
- Shear stresses in underlying degenerated meniscus
- Relatively stable

Longitudinal Tear
Oblique

Oblique Undersurface Tear MM

- Undersurface part can flap under
Radial Tear

Perpendicular to circumference
• Straight
• Curved (parrot-beak)

Sag, cor: nonvisualized or focal defect
Axial: best plane
"PARROT-BEAK" - Oblique radial tear

Large Radial Tear

Importance of Axials

RADIAL TEAR
COMPlex TEAR
Complex Tear

Combination of tear types
TIP: if there is an unstable component to a complex tear, describe!
- Radial / parrot beak
- Flap
- Root

Summary

- Be descriptive
- Be aware of pitfalls
- Encourage feedback from clinicians

Joint “Mouse”
Thank You!

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