MR: Post-operative Knee Assessment

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Has There Been Surgery?

- Linear area of low signal intensity in Hoffa’s fat pad
- Represents footprint of the arthroscopic cannula
- Susceptibility artifact from metallic hardware or microscopic metallic fragments

Scope Scar

Each side of patellar tendon: rounded low signal
Initially Looks Like Meniscectomy
*But no scope scar!*

![Anterior and superior flip](image)

**Question**

If you see a small meniscus the differential includes:
1) Post-op partial meniscectomy
2) Tear with flipped fragment
3) Chronic degenerative tear
4) All of the above

**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

Fragment Flipped into Meniscotibial Recess
AKA “Boomerang”
Criteria for Detecting Meniscal Tears

- Surfacing (Grade III) signal diagnostic of tear in the non-operated meniscus
- Grade III signal in post-op meniscus
- Stable intrasubstance signal
- Granulation tissue
- Persistent tear/ retear

Meniscal Surgery: Resection, Repair, Replacement
Meniscal Preservation is the goal

- Medial meniscectomy increases contact stress 100%; lateral meniscectomy increases contact stress 200-300%
- Meniscectomy decreases the shock absorbing capacity of the normal knee by 20%

NOT ALL MENISCAL TEARS WARRANT SURGERY!!

Non-operative conservative therapy appropriate:

< 1 cm
Partial thickness
Peripheral aspect of the meniscus
Stable type tears (e.g., horizontal)
Partial Meniscectomy

Goals:
- Obtain a stable meniscus with smooth contours
- Remove displaced meniscal fragments preserving as much meniscal tissue as possible

Stress on weight bearing joint surface following meniscectomy directly proportional to amount of meniscal tissue resected

Partial Meniscectomy

Pre-operative

Altered biomechanical stress on underlying cartilage

1 year post-op

Accelerated cartilage loss following partial meniscal resection - 1 yr follow-up

Meniscal truncation

Question

What is your protocol for evaluation of the post-op knee?
1) Noncontrast MRI
2) Direct MR arthrography (into joint)
3) Indirect MR arthrography (intravenous)
4) CT arthrography
5) Depends on type of surgery
Conventional MR

May be appropriate if less than 25% of meniscus resected (use criteria for tear in virgin meniscus)

Direct MRA

Sicualli et al compared arthrography, conventional MR, MR arthrography with iodinated contrast, & MRA - MRA most accurate 92%

Advantages of gadolinium

- Lower viscosity of gad compared to synovial fluid allowing imbibition into small clefts
- Utilization of T1 pulse sequences with favorable signal to noise
- Intra-articular distention allowing separation of otherwise apposed torn meniscal edges

Indirect MR arthrography

Enhancement of joint fluid will create greater conspicuity of re-tear

Q: WILL NORMAL GRANULATION TISSUE ENHANCE?
CT arthrography

CTA vs 2nd look arthroscopy
93% sensitivity
89% specificity

Conventional MRI
Partial Meniscectomy
Normal MR Appearance

- Small truncated meniscus
- No grade III signal

Conventional MRI
Partial Meniscectomy
Criteria for a Retear

1. Grade III signal
   - Fluid within the line on T2
2. Displaced meniscal fragment
3. Tear in a new location

Conventional MRI
Partial Meniscectomy
Criteria for a Retear

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• Conventional MR
  • Accuracy: 65-82%
  • Sensitivity: 60-86%
  • Accuracy improved if
    • <25% meniscus resected

Conventional MRI
Partial Meniscectomy
Criteria for a Retear

1. Grade III signal
   - Fluid within the line on T2
2. Displaced meniscal fragment
3. Tear in a new location

Conventional MR
Pitfall

• Grade III signal: T1-weighted or PD sequence only
• Indeterminate
Routine MRI indeterminate for tear

- Grade 3 signal on T1 image - conventional MR
- Follow-up direct MR arthrogram
- No contrast enters meniscus
- No evidence of tear

MR Arthrography Partial Meniscectomy

- Surfacing gadolinium signal = tear
- Direct and Indirect MRA similar accuracy

Meniscal Repair

Minority of tears are amenable to repair

- Traumatic lesions within the vascular zone (within 3 mm of the meniscosynovial junction) generally greater than 8 mm with minimal damage to the meniscal body
Meniscal Repair

Success rates variable

- Tear length
- Acute or chronic
- Lateral or medial
- ACL injury

Meniscal Repair

All inside
Inside-out
Outside-in

Meniscal Suturing
Meniscal Repair

The Big Pitfall

• Prior to repair
• Following repair

Repair of Peripheral Tear

Meniscal Suturing

Pitfall: Granulation tissue may resemble tear

Recurrent medial joint line pain following earlier meniscal repair

- Direct MR arthrogram
- Contrast enters meniscus: demonstrating a retear
Meniscal Repair: Recurrent Tear

- Fluid enters area of repair on T2
  - Irregular margins
  - Displacement, widening
  - Increasing parameniscal cyst size

- Contrast enters area of repair
  - During the first year granulation tissue may enhance with indirect MR arthrography

Meniscal Arrow

- Recurrent meniscal tear
- Displaced meniscal arrow resulting in linear chondral defect

Meniscal Transplantation

- Free graft with separate bone plugs
- "Keyhole" technique
  - Native meniscal rim-repair techniques to suture to meniscal transplant
Meniscal Transplantation

- Pre-operative imaging mandatory
  - Wt bearing 45 degree flexion PA view
  - Jt space narrowing, significant OA
- Long-leg alignment radiographs
- MRI
  - Cartilage integrity

Meniscal graft sizing via radiographs, MR, or CT

Meniscal transplant sizing via CT

Assessed at the level of the articular tibial plateau, with “A” bisecting the tibial spines

Meniscal Transplantation

- <40yo
- Pain, swelling
- Unresponsive to conventional treatment
- Minimal OA

Normal dark signal within the transplant meniscus
MR Evaluation of the Meniscal Transplant

FOLLOW-UP: LOOK FOR
- Tear (Grade 3 signal, morphology, fragment)
- Change in position
- Shrinkage
- Arthrofibrosis
- Articular cartilage damage

Rath, et al: 36% of transplanted menisci torn at 5 years

Meniscal Transplantation

Arthroscopically proven meniscal transplant re-tear

Meniscal Transplantation

-Malpositioned (extruded) meniscal transplant
MRI of the Painful Knee Following Meniscal Surgery

- Post-meniscectomy (recurrent pain)
  - Residual tear/ retear of meniscus
  - Articular cartilage damage
  - Osteoarthritis
  - Intraarticular bodies
  - Spontaneous osteonecrosis

Question

Which cause is most common?
1) Articular cartilage damage
2) Osteoarthritis
3) Intraarticular bodies
4) Spontaneous osteonecrosis

Articular cartilage damage overlying meniscal repair site

- Most common source of recurrent pain
- Occurs in up to 40% of patients
- Altered weight-bearing following meniscal resection/ repair
Articular Cartilage Evaluation:
Direct Versus Indirect MR Arthrography

Direct Arthrography
Indirect Arthrography

Osteoarthritis
-Related to the amount of meniscus resected
-40% incidence following total meniscectomy
-Joint space narrowing
-Cartilage thinning
-Osteophyte formation
-Subchondral marrow change

Intraarticular Bodies
-Fragmentation of articular cartilage
-Begin as cartilagenous bodies
-Subtle on MR imaging
Question

Spontaneous osteonecrosis represents
1) True osteonecrosis – all of the time
2) Subchondral insufficiency fracture that may progress to osteonecrosis
3) A complication related to prolonged tourniquet time during surgery

“Spontaneous Osteonecrosis”

-Medial femoral condyle; subchondral insufficiency fracture
-Osteopenic patients
-Acute onset of pain/ 2-18 months; 50% heal; 50% collapse

67 y.o. male- golfing injury

-Medial meniscal tear

-6 months post-op
-Acute onset medial joint line pain
Hyaline Cartilage Surgery

Current Therapies

Cartilage Repair
- OATS
- Microfracture
- Cartilage transplantation
- Proteoglycans

Or 'masking' symptoms
- NSAIDS
- Synvisc

Autologous Osteochondral Transplantation (AOT)

Generally indicated for chondral lesions
1.5 – 3 cm

Autologous bone with overlying cartilage cored from non-weightbearing areas of the joint and transferred into the cartilage defect

MosaicPlasty
OATS (Osteochondral Autograft Transplant Surgery)
SDS (Soft Delivery System)
COR

Disadvantages- donor site morbidity, limited supply of grafts, long rehab
Osteochondral Autograft Transplant Surgery (OATS)

**DONOR SITE**

- Eventually fills in with bone

**MR Appearance of Harvest Site**

- Defect in supratrochlear region (initially fluid filled)
- Fills in with fibrocartilage during the first year
- Dark on T1- and T2-weighted images

**OATS IMPLANT SITE**

- Congruity of the articular surface is necessary
- "Cobblestone" normal
OATS

Typical Appearance

“COBBLESTONE” PATTERN:
NORMAL AS LONG AS OVERALL SURFACE IS CONGRUENT
Revascularization of Osteochondral Graft

- First two weeks
  - Avascular graft
  - No enhancement of "plug"

- Four to six weeks
  - Plug revascularizes
  - Enhancement of "plug"

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OATS

Persistent subchondral bone marrow edema

Osteous incorporation between 6-14 wks subchondral marrow edema can be present initially and should resolve as graft incorporates; when solid maturation occurs, normal fatty marrow is seen within and around the plugs

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OATS

Poor graft incorporation

Subchondral cysts

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Osteochondral Allograft (OCA)

- Osteochondral segment harvested from cadaver and transplanted to cartilage defect
- Potential risks of immunologic rejection of the allograft and disease transmission from donor to recipient

Microfracture

- Perforations (microfractures) in subchondral bone plate
- Stem cell migration
- Fibrin clot
- Disorganized hyaline/fibrocartilage

Advantages - cost effective, technically feasible, supportive clinical data
Disadvantages - does not reproduce hyaline cartilage

Microfracture – NBA Player

Medial compartment symptoms prevent play
4 MONTHS LATER
REMAINS SYMPTOMATIC

S/P MICROFRACTURE
7 MONTH FOLLOW-UP

13 MONTHS LATER

Playing without symptoms

Recurrent symptoms
Microfracture
(Abrasion Chondroplasty)

Cartilage Healing
without surgery

Autologous Chondrocyte Implantation

Cells harvested from healthy non-weightbearing area of the joint are cultured and then re-injected at site of cartilage injury

Advantage- potential restoration of hyaline cartilage
Disadvantage- 2 invasive procedures, highly technique dependent requiring lab support, unpredictable results

NOT indicated in OA
ACI- MR Appearance

Complete fill of cartilage defect with repair tissue that restores contour of articular surface, as early as 3 weeks post-op; signal intensity of the graft variable and often differs from native cartilage- subchondral edema acceptable early, should resolve over time

Interface between ACI and native cartilage may be indiscernable or appear as a sharp bright line

Complications: hypertrophy of the peristomeum post-operative adhesions (may be attached to ACI graft- infrapatellar fat pad, suprapatellar, & infrapatellar recesses)

OCD Repair

Unstable OCD lesion

Displaced fragment post-op

Ligament Reconstruction and Repair
Anterior Cruciate Ligament Graft

Types of ACL Graft
1. Bone-Patellar Tendon-Bone (BTB)
2. Hamstring (Semitendinosus and Gracilis Autograft)

MR Appearance of BTB ACL Graft

0 to 3 months
- Graft is avascular
- MR signal characteristics are identical to native patellar tendon
- Dark on T1- and T2-weighted images

4 to 8 months
- Graft revascularization
- Increased T1- and T2-signal
- Normal graft should not have fluid signal within graft on T2-weighted images
MR Appearance of BTB ACL Graft

>12 months
- Ligamentization occurs
- MR appearance similar to native ACL appearance
- Dark on T1- and T2-weighted images; may have intermediate stranding in distal fibers

MR Appearance of Hamstring ACL Graft

- Hamstring graft progresses through the same stages as a BTB graft.
- Fluid present between separate strands of graft

MRI of the ACL Graft

- Lax Knee
  - Graft disruption
  - Stretched graft
- Lack of Full Extension
  - Graft impingement
  - Loose bodies
  - Arthrofibrosis
- Recurrent Trauma
  - Internal derangement
Lax Knee: Disrupted ACL Graft
- Discontinuity of fibers
- Consider age of graft

Lax Knee: Stretched Graft
- Knee lax on physical exam
- Graft intact with posterior bowing of fibers noted on MR imaging

ACL Graft Impingement
- Tibial Tunnel placed anterior
- Graft impacts roof of intercondylar notch during extension of knee
- MRI Findings
  - Anteriorly placed tibial tunnel
  - Increased signal in graft
  - Kinking of graft
Decreased ROM: Graft Impingement
- Anterior placement of tibial tunnel
- Kinking of ACL graft
- Increased signal within graft fibers

Graft Impingement
- Graft fibers intact
- Increased signal in fibers
- Fibers kinking and rubbing against roof of intercondylar notch

Decreased ROM: Arthrofibrosis
- Diffuse scarring in the anterior fat pad
- Can be painful and limit motion of the knee
Decreased ROM: Arthrofibrosis

- Cyclops lesion (limits full extension of knee, anterior knee pain)
- Focal nodule of scar tissue just anterior to ACL graft
- Dark on P.D. and T2-weighted images

Decreased ROM: Loose Bodies

- Loss of full extension, decreased range of motion, locking
- Loose bodies can be subtle on MR imaging
- Can be cartilaginous or osseous

Decreased ROM: Foreign Body

- Locking and pain 6 weeks following ACL repair
Decreased Range of Motion

- Basketball injury following ACL reconstruction

MRI of the ACL Graft

- ACL Reconstruction
  - Lax Knee
    - Stretched graft
    - Disrupted graft
  - Lack of Full Extension
    - Graft impingement
    - Loose bodies
    - Arthrofibrosis
  - Following Trauma
    - Internal derangement

Ganglion Cyst

- Associated with degeneration or partial tear of graft
- Usually involves the tibial tunnel (presents as mass or with pain)
- More common in hamstring graft
**Fluid in Tunnel of Hamstring Graft**

- Normal finding during first year
- Does not lead to ganglion formation

**Patellar Tendon Harvest Site**

- BTB graft harvested from the middle 1/3 of the patellar tendon
- Defect seen in tendon and bone on MR imaging
- Defect fills in with tendon-like material during the first year

**Harvest Site Complications**

- Anterior Knee pain - common
- Patellar tendonitis
- >10mm thick after one year
Harvest Site Complications
- Anterior Knee pain
- Patellar fracture

Hamstring Tendon Harvest Site
- Immediate post-op: Fluid seen within harvest track

Hamstring Tendon Harvest Site
- Tendon regenerates from proximal to distal
- Tendon appears normal within 8 months; 80% original strength
Posterior Cruciate Ligament

- PCL twice as strong as ACL
- PCL less commonly injured (usually only partially torn)
- Conservative therapy usually adequate
- PCL reconstruction
  - Indicated in high performance athletes
  - Indicated if significant instability/multiple ligamentous injuries

PCL Reconstruction

- MR appearance of PCL graft
  - Initially thickened with increased signal on T1- and T2-
  - Fibers become better defined by the end of the first year
  - Extensive arthrofibrosis is commonly seen

- By one year; fibers are well defined and dark on all pulse sequences
Collateral Ligament Injuries

- Grade I/II sprains treated conservatively
- Grade III sprains / disruptions - when combined with other injuries
  - treated with stapling or suturing

Medial Collateral Ligament Repair

- MR appearance
  - Metallic artifact at repair site
  - Persistent thickening of repaired ligament

Posterolateral Corner Reconstruction

- MR appearance
  - Metallic artifact at repair site
  - Persistent thickening of repaired ligament
THANK YOU!