MRI of the Hip

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Take Home Points

• Joint effusion: does not collect dependently
• Imaging for FAI is unreliable
• Bone marrow edema:
  – Is not early osteonecrosis
  – Is likely from insufficiency fracture
• Insufficiency fracture: MRI is best
• Trochanteric bursitis is uncommon
Outline:

- Hip joint
- Labrum and FAI
- Osteonecrosis
- Fractures
- Trochanteric pain syndrome

Joint Pathology

- Effusion:
  - Reactive, infection, hemarthrosis
- Synovial hypertrophy:
  - Inflammatory: rheumatoid, atypical infection
  - Proliferative: PVNS, synovial chondromatosis
  - Characterized: enhancement
**Hip Joint: anatomy**

- Distal extent: to intertrochanteric line
- Recess: between labrum and capsule
- Does **not** collect dependently
  - Surrounds femoral neck\(^1\)
- Iliopsoas bursa:
  - Normal joint communication in 15 - 20%
- Obturator externus bursa: <10\(^2\)

\(^1\)Moss et al. Radiology 1998; 208:43
\(^2\)Robinson P et al. Radiology 2003; 118:230
Injection / Aspiration: fluoroscopy

- 75% direct anterior
- 24% oblique anterior
- 1% direct lateral

Shortt. Skeletal Radiol 2009; 38:377

Iliopsoas Bursa

Arthrogram
Iliopsoas Bursa: distention

Axial T1w post-gadolinium

Obturator Externus Bursa

Arthrogram
Hip: anterior recess

- Anterior and posterior layers
  - Fibrous tissue + minute layer of synovium
  - Hyperechoic
  - Each 2 - 4 mm thick

Radiology 1999; 210:499

Hip Joint: septic effusion

Long Axis
Joint: injection

- Anterior recess
- In plane
- Transducer:
  - Parallel to femoral neck
  - Consider curvilinear
- Needle: distal to proximal
- 97% accuracy


Joint Injection

- Femoral neck target
- Preferred over head
- High volumes
- Less extra-articular contrast

Pigmented Villonodular Synovitis

• Benign synovial proliferation
• Synovial hyperplasia
  – Multinucleated giant cells
  – Lipid-laden macrophages
  – Hemosiderin deposition
• Monoarticular: localized or diffuse

Lin et al. AJR 1999; 172:191
Synovial Chondromatosis

- Benign cartilaginous metaplasia
- Large joints: knee and hip
- May or may not ossify
- May detach: intra-articular bodies
Synovial Chondromatosis

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Synovial Chondromatosis

Total Hip Arthroplasty

- Metal-on-metal articulation
- Wear debris, hypersensitivity
  - Joint effusion synovitis
  - Bursa distention
- Pseudo-tumor:
  - Soft tissue: necrosis, inflammation
  - Ultrasound: 99% sensitive\(^1\)
  - MRI: effective\(^2\)

\(^2\)Garbuz DS Clin Orthop Relat Res 2014; 472:417
THA: iliopsoas bursal fluid

T1w Axial  T2w Axial

Metal-on-Metal: Pseudotumor
Metal-on-Metal: Pseudotumor

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Labral Tear: MR arthrography

- Abnormal contrast extension into labrum
- Improved sensitivity: 50% (MRI) to 81%\(^1\)
- Anterior: most common
- Classify:
  - Degeneration: gray signal
  - Partial tear, full-thickness tear
  - Detachment

\(^1\)Sutter R et al. AJR 2014; 202:160
Labrum: degeneration

Note hip osteophytes (white arrows)

Anterior Labrum: sagittal T1-w fat sat

Tear

Normal
Anterior Labrum: axial T1-w fat sat

Tear | Normal

Anterior Labrum: sagittal T1-w fat sat

Posterior | Anterior | Posterior | Anterior

Tear | Normal
Anterior Labrum: axial T1-w fat sat

Tear

Normal

Labrum Tear: full-thickness
Hip Labrum: normal variants

- Sublabral sulcus
- Posteroinferior groove
- Pectinofoveal fold
- Supra-acetabular fossa
Hip Joint: labrum

• Sublabral sulcus: controversial
  – Normal variant or asymptomatic tear\(^1\)
  – Any intralabral contrast: abnormal\(^2\)

\(^1\)Radiology 1996; 200:231
\(^2\)AJR 1999; 173:345

Hip Joint: sublabral sulcus

• Smooth contrast-filled cleft: <50%
• Junction of labrum and hyaline cartilage
• No labral detachment
• No labral abnormality

Saddik. AJR 2006; 187:W507
Sublabral Sulcus

Hip Joint: posteroinferior groove

- Normal variant: 22.4%
- Posteroinferior quadrant
- Near transverse ligament: inferior

Dinauer PA et al. AJR 2004; 183:1745
Posteroinferior Groove

Hip Joint: pectinofoveal fold

- Seen at MR arthrography: 95%
- Variable appearances
- Variable attachments
  - Usually inserts onto capsule
  - May insert onto femur

Blankenbaker D et al. AJR 2009; 192:93
Hip Joint: supra-acetabular fossa

- Pseudodefect of acetabular cartilage
  - Type 1: 1.6%
    - Bony fossa filled with contrast
  - Type 2: 8.9%
    - Bony fossa filled with cartilage

Dietrich TJ et al. Radiology 2012; 263:484

Supra-acetabular Fossa: Type 1

From Dietrich TJ et al. Radiology 2012; 263:484
Supra-acetabular Fossa: Type 2 (white arrow)

Note (black arrow): supra-acetabular roof notch (another normal variant)

From Dietrich TJ et al. Radiology 2012; 263:484

Paralabral Cyst

- Multilocular, fluid signal
- Associated with labral tear: detachment
- Fill with intra-articular contrast: 94%
- Extend extra-articular: 72%
- Remodel adjacent ilium: 50%

Magerkurth O et al. Skeletal Radiol 2012; 41:1279
Labral Tear + Paralabral Cyst

Ligamentum Mucosum

- Provides some stability
- Minimal head vascularity
- Torn in up to 15% having arthroscopy
- Major or minor trauma
- Tear: fluid signal
  - Partial: MRI is inaccurate

Blankenbaker DG et al.
AJR 2012; 199:1093
Labral Tear: location

- Anterior: iliopsoas tendon impingement
- Anterior or anterosuperior:
  - Associated with CAM-type femoroacetabular impingement
- Posterolateral tear:
  - Pincer-type femoroacetabular impingement
  - Leveraging effect

Aly AR et al. Skeletal Radiol 2013; 42:1245

Femoroacetabular Impingement

- CAM-type
- Pincer type
- Combination of both: most common

Brian P et al. Semin Roentgenol 2010; 2:230
**CAM-type FAI:**

- Extra bone:
  - Femoral head-neck junction
- Hip flexion / internal rotation:
  - Contact between extra bone and anterior labrum
- Labral tear, cartilage injury

**CAM** = a mechanical linkage that translates motion

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**FAI: pathology**

- Radiograph: femur
  - Pistol-grip deformity
  - Fibrocystic change
- MRI: **alpha angle** >50 degrees
- MR arthrography:
  - Improved sensitivity acetabular cartilage: 83% (MRI) to 92% 
  - No advantage: femoral cartilage defects

\(^1\text{Sutter R et al. AJR 2014; 202:160}\)
CAM-type FAI: Pistol-grip deformity

CAM-type FAI: alpha angle >50 degrees
Alpha Angle
Abnormal: >50 degrees

Pitfalls

• Pseudo-bump
  – Capsular reflection
  – Low signal
• Pseudo-labral tear
  – Adjacent iliopsoas tendon
  – Low signal
  – Simulates displaced labral tissue
Pincer-type FAI:

- Deep hip socket or retroverted acetabulum
- Abnormal contact between acetabular rim and labrum
- Radiograph: cross-over sign
- MRI: acetabular retroversion
Pincer-type FAI: Cross-over sign

Note: distance between sacrococcygeal junction and pubis should be between 3 and 4 cm

FAI: Cross-over sign and fibrocystic change
Pincer-type FAI: Otto Pelvis
(idiopathic acetabular protrusio)

Femoral head and acetabulum: medial to ilioischial line

FAI: imaging findings

• Radiography: inaccurate
  – Pistol-grip and fibrocystic change
  – Cross-over sign

• Alpha angle measurements:
  – Unacceptable intra- and inter-observer variability
  – Does not correlate with physical exam findings
  – Osseous bump: not always anterior
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- Osteonecrosis
- Fractures
- Trochanteric pain syndrome
Osteonecrosis: terminology

• Involving end of a bone:
  – Avascular necrosis
  – Aseptic necrosis

• Diaphysis or metaphysis:
  – Bone infarct

Osteonecrosis: etiology

• Anemia (sickle cell)
• Steroids
• Etoh
• Pancreatitis
• Trauma
• Idiopathic
• Caisson disease or Chronic renal failure (children)
Osteonecrosis: MRI classification

• Mitchell
  – MRI-based
  – Describes the central signal intensity
  – Not used
• A: fat
• B: blood
• C: fluid (cyst)
• D: fibrosis (dense)

Osteonecrosis: classification

• Modified Ficat
• 1: symptoms but normal radiographs
  – 1A: abnormal MRI; 1B: abnormal bone scan
• 2: radiograph positive- mixed lucent sclerotic
• 3: subchondral lucency (crescent sign)
  – 3A: without collapse; 3B: with collapse
• 4: osteoarthrosis

Osteonecrosis

Osteonecrosis

Note early flattening or collapse
Osteonecrosis: MRI findings

- Serpiginous, geographic low signal
  - Represents interface, not necessarily calcified
  - Bone marrow edema **NOT** early osteonecrosis¹
  - Weight-bearing aspect of femoral head
- Internal signal: variable
- Double line sign: pathognomonic
  - High signal (T2w) inside low signal line²

¹Kim YM et al. JBJS 2010; 82B:837
²Apostolos HK et al. Sem Musculoskelet Radiol 2011; 15:281

Note: double line sign
Osteonecrosis: MRI findings

- Symptoms correlate with:
  - Bone marrow edema and volume of necrosis
- Secondary osteoarthrosis:
  - Seen in end-stage osteonecrosis
  - Findings should asymmetrically involve the femur > acetabulum
  - Unlike isolated OA: similar imaging findings across joint and marked femoral head findings
**Isolated Bone Marrow Edema**

- In the past, was called:
  - Transient osteoporosis of the hip
  - Transient bone marrow edema syndrome
- Now: due to insufficiency fracture
  - Look for discontinuous linear low signal
  - Subcortical, parallel to cortex
  - Subtle collapse, little femoral head abnormality
- Is NOT a early finding of osteonecrosis


**Insufficiency Fracture**
Osteopenia

Bone Marrow Edema: Insufficiency fracture
Normal Bone Density Returns

3 months later

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**Fractures: femur**

- MRI findings:
  - Bone marrow edema
  - T1w and PDw: linear low signal fracture line
  - T2w: low or high signal fracture line
- MRI is much better than CT¹
  - Sensitivity (insufficiency): MRI 99%, CT 69%
- MRI most accurately shows extent of fracture

¹Cabarrus MC et al. AJR 2008; 191:995
Proximal Femur Fracture: MRI

Femur Fracture: negative radiograph and CT
Garden Classification

1. Incomplete, valgus impacted
2. Complete, non-displaced
3. Displaced, angulated
4. Displaced

Garden 3 or 4 = hip replacement because of osteonecrosis risk

Femoral Neck: radiographs

- Internal rotation radiograph essential
- Goal: diagnose non-displaced femoral neck fracture
- Garden Classification: 1 – 4
  - 1 & 2: non-displaced → percutaneous pins
  - 3 & 4: displaced → arthroplasty (risk of AVN)
- With osteopenia, MRI necessary
Femoral Neck Fracture: now displaced
Femoral Neck Fracture

Greater Trochanter Fracture

T1w MRI  T2w MRI
Intertrochanteric Fracture

Fracture: bisphosphonate

- To treat osteoporosis: *i.e. Fosamax*
  - Inhibits osteoclasts, may slow bone turnover
- Increased risk of fracture:
  - Average treatment at fracture: 6 years
  - Femur: subtrochanteric, diaphyseal, lateral cortex
- Early sign: periosteal reaction
  - 2% are asymptomatic at early stage
  - Black line: fracture likely progresses

Chen SS et al. AJR 2010; 194:1581
Insufficiency Fracture: bisphosphonate

Femur: fatigue-type stress fracture

T1w  T2w  Later
Femur Fracture: pathologic

- Lesser trochanteric avulsion
  - Adult: pathologic fracture until proven otherwise
  - Cortical metastasis: lung cancer

Lesser Trochanteric Avulsion: metastasis

Coronal T1w  |  Coronal T2w  |  Axial post-gado
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Trochanteric Pain Syndrome:

- Trochanteric bursitis: uncommon\(^1\)
  - Up to 20% of subjects\(^2\)
  - Not actually inflamed\(^3\)
  - Not associated with pain\(^4\)
- Gluteus tendinosis: 50%\(^1\)

\(^{1}\)Kong A et al. Eur Rad 2007; 17:1772.  
\(^{2}\)Long SS et al. AJR 2013; 201:1083  
\(^{3}\)Silva F et al. Clin Rheumatol 2008; 14:82  
\(^{4}\)Blankenbaker et al. Skeletal Radiol 2008; 37:903

Greater Trochanter: gluteal tendons

Anterior  Lateral  Posterior

Gluteus medius (red)  Gluteus minimus (blue)
Greater Trochanter

Pfirrmann et al. Radiology 2001; 221:469

Axial MRI

Yellow arrow = gluteus medius
White arrow = gluteus minimus
Greater Trochanter

Yellow arrow = gluteus medius
White arrow = gluteus minimus

AF: anterior facet
LF: lateral facet
PF: posterior facet
Trochanteric Bursa Distention

Gluteus Medius Tendinosis and Subgluteus Medius Bursitis
Peritrochanteric Fluid Signal

- Tendon:
  - Gray: tendinosis; Fluid signal: tear
  - Calcific tendinosis
- Bursa
- Diffuse soft tissue: common finding
  - Doesn’t correlate with symptoms
  - Likely irrelevant if symmetric

1Blankenbaker DG et al. Skeletal Radiol 2008; 37:903
Morel-Lavallée Lesion

Note location of fluid between subcutaneous fat and muscle or aponeurosis fascia
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