Imaging of Femoroacetabular Impingement (FAI)

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Introduction

• Femoroacetabular impingement (FAI) is a common cause of hip pain in young adults.

• It is a pathologic condition in which hip morphology results in excessive contact between the proximal femur and the acetabulum.

• FAI can be caused by a morphologically abnormal proximal femur, acetabulum, or both.

• Results in damage to the labrum, labral-chondral junction, and acetabular cartilage and is believed to lead to early osteoarthritis.
Introduction

• Patients typically present between the second and fourth decades of life with complaints of groin pain following prolonged sitting or during athletic activities.

• Physical examination reveals decreased hip motion, particularly in internal rotation, as well as pain with hip flexion, internal rotation and adduction – the so called “impingement test.”
Cam type FAI

- Aspherical head articulating with spherical acetabulum
- Leads to chondral damage of anterosuperior acetabular cartilage
- Eventually results in labral tear, often at the labral-chondral junction
- More common in males
Pincer type FAI

• Caused by acetabular over-coverage

• Wear pattern is more circumferential and narrower

• Labral myxoid degeneration and tearing

• Underlying cartilage damage and dystrophic ossification predominantly at the superoanterior joint, although large contrecoup lesions are often seen in the posterioroinferior joint

• More common in middle-aged females
Mixed type FAI

- Most cases of femoroacetabular impingement are a combination of cam-type and pincer-type pathology, with cam-type typically being most prominent.

- In mixed type FAI, both the cam bump and the overhanging acetabulum contribute to progressive enlargement of the osseous bump and formation of cystic changes at the anterosuperior femoral head-neck junction.

- If there is superimposed osteoarthritis, osteophyte formation, ossification within the damaged labrum and osseous remodeling at the femoral head junction may create an aspherical femoral head.
Diagnostic modalities

• History & physical exam

• Radiographs to assess skeletal morphology

• Magnetic resonance allows detailed assessment of femoral head and neck as well as condition of labrum and articular cartilage
Initial work-up: Frontal Radiographs
Initial work-up: Dunn and False Profile Radiographs
Radiographic Findings in FAI

Frontal and lateral views of the right hip demonstrate an osseous excrescence, or “cam bump” at the anterosuperior femoral head neck junction (blue arrow), seen best on the lateral view.
Frontal view of the right hip demonstrates a cam bump (arrow) and crossover sign (interrupted blue line), seen when the anterior and posterior acetabular walls cross over as a result of femoroacetabular retroversion.
Radiographic Findings in FAI

Frontal view of the pelvis hip and magnified view of the right hip demonstrate osteoarthrosis of the right hip characterized by joint space narrowing, subchondral sclerosis and osteophyte formation on both sides of the joint. Osteoarthrosis may result from longstanding FAI.
MRI

• Arthrogram technique

• Assess:
  • Bone morphology
  • Bone marrow edema
  • Labral morphology and presence of a tear
  • Cartilage
  • Ligamentum teres and transverse ligament
  • Surrounding muscles and tendon attachments.
  • Intra-pelvic structures
Arthrogram

Fluoroscopic spot image obtained during intraarticular injection of dilute gadolinium in preparation for MR imaging.

MR arthrogram is preferred over conventional MRI for more detailed evaluation of the labrum.
MRI arthrogram- T1 vs. T2

Coronal fat-saturated T1 (A) and fat-saturated T2 (B) weighted images from MR arthrogram. Note some hyperintense signal in the pelvis and within the insertional gluteal tendons in the fat-saturated T2 weighted image, while the only hyperintense signal in the fat-saturated T1 image is the intraarticular contrast.
Sagittal and Axial planes

Sagittal (A) and axial (B) proton density images of the hip following the intraarticular injection of contrast. A small osseous excrescence, or cam bump, is seen on the both images (blue arrows). These sequences are also helpful for evaluating the labrum and the articular cartilage in the setting of FAI.
Acetabular Labral Assessment
Labral morphology and assessment for tears in FAI

- Labral tears and associated cartilage lesions in FAI occur most commonly in the anterosuperior quadrant of the hip, and may be partial or full thickness with occasional extension into other quadrants.

- Concurrent labral tears at multiple sites are seen relatively infrequently, and have been reported only 7% of the time.

Courtesy RadSource: [http://radsource.us/acetabular-labral-tear/](http://radsource.us/acetabular-labral-tear/)
Labral morphology and assessment for tears

- Contrast that spans the entire labral base or extends into the substance of the labrum on MR arthrogram should be considered abnormal.

- Labral tears occur most commonly at the chondrolabral junction and are often described as labral detachments (B).

- Tears confined to the substance of the labrum, occurring along the course of the circumferentially oriented fibers, are less common (E).
Case 1 - MRI of FAI

Two sequential sagittal proton density images of the hip following the intraarticular injection of contrast demonstrate fluid signal intensity within the anterosuperior labrum (circle) and an osseous excrescence, or cam bump (arrow), at the anterosuperior femoral head-neck junction in a patient with femoroacetabular impingement.
Case 1 (cont.)- MRI of FAI

Axial fat saturated T1 image from an MR arthrogram demonstrates contrast tracking between the labrum and underlying acetabulum (circle) and within the labrum itself compatible with complex anterosuperior labral tear.

The cam bump identified on sagittal images is less well visualized on axial images.
Case 2 – MRI of FAI

• Axial proton density image from MR arthrogram demonstrates a full-thickness labral tear at the chondrolabral junction (arrow) in the setting of FAI.

• Note the prominent osseous excrescence, or cam bump, at the femoral head-neck junction (outlined by interrupted blue line).
Case 2 (cont.)- MRI of FAI

- Sagittal proton density MR image from MR arthrogram in the same patient again demonstrates a prominent osseous excrescence of the femoral head-neck junction (between arrows).
Case 3 - Partial thickness labral tear on MRI

Axial T2 fat-saturated arthrogram image demonstrating a small partial defect at the chondrolabral junction (arrow).

Illustration of chondrolabral junction tear (blue arrow) which corresponds with MR image.

Illustration by Leah Davis, Medical University of South Carolina, Charleston, SC
Labral morphology and assessment for tears in the posttraumatic setting

• Classically, labral tears in the setting of trauma have been described with posterior hip dislocations.

• The most common movement associated with acute labral tears is hyperextension with concurrent external rotation.

• More commonly, labral tears occur in the setting of repetitive micro-trauma at extremes of motion in certain athletes.

• Soccer, hockey, golf, martial arts and ballet involve extremes of abduction, extension, flexion and external rotation, and have been associated with labral tears.
Cartilage Assessment
Cartilage on MRI

• Cartilage damage in the hip occurs initially along the acetabular surface, whereas the femoral cartilage is typically preserved until late in degeneration.

• Since the acetabular cartilage is thinner than in other joints of the body, detection of pathology can be challenging.
Cartilage on MRI

- The normal articular cartilage in the hip demonstrates homogeneous intermediate signal, with the acetabular and femoral surfaces separated by a thin band of high signal intensity on MR arthrogram images, representing joint fluid or gadolinium.

- Pathology in the cartilage manifests as inhomogeneity of signal, diffuse thinning and irregular morphology, most commonly in the anterosuperior quadrant.
Early cartilage damage, flap

Coronal fat saturated T1 and sagittal proton density images from an MR arthrogram of the hip demonstrate a chondral flap (between arrows) along the anterosuperior acetabulum.
Progression of Disease in FAI

• Tears of the acetabular labrum can be associated with the development of cartilage loss, leading to progressive cartilage damage and subsequent development of osteoarthrosis.

• Likewise, cartilage damage can occur first, as a precursor to labral tears, which can be associated with progressive cartilage and labral damage and subsequent development of osteoarthrosis.

• Regardless of which pathology occurs first, the process is initiated by shear forces or impingement within the hip which causes excessive loading of the anterosuperior joint and labrum.
Progression of Disease in FAI

- Initial shear forces or impingement may then result in fraying of the acetabular labrum along its articular margin, progressing to labral tearing at the chondrolabral junction.

- Delamination of the articular cartilage may then occur, resulting in cartilage flaps at the level of the labral abnormality, leading to further progression of labral and chondral degeneration, and eventually, osteoarthritis.

- Inciting pathology includes acetabular dysplasia or morphology associated with FAI.
Advanced OA

Coronal fat saturated T1 and sagittal proton density images from an MR arthrogram demonstrate advanced osteoarthritis characterized by joint space narrowing, most pronounced in the anterosuperior hip, with areas of full thickness cartilage loss, subchondral cyst formation (arrow) and osteophyte formation at the femoral head-neck junction (circles).
Ligamentum Teres and transverse ligament
Surrounding muscles and tendon attachments

- Gluteal muscles, gluteus medius and minimus insertions
- Common hamstring origin on the ischial tuberosity
- Portions of the adductors and obturators
- Portions of the hip flexors
- Iliopsoas insertion on the lesser trochanter
- Rectus femoris origin from the AIIS
- Intra-pelvic contents and neurovascular bundles
Normal Variants: Perilabral recess

- Axial proton density MR arthrogram image demonstrates a normal variant, perilabral recess (circle).

- This recess occurs between the labrum and the overlying joint capsule and may be more conspicuous when the joint becomes distended with contrast material.

- This should not be mistaken for a labral tear given its location superficial to the chondrolabral junction.
Normal Variants: Sublabral sulcus

• Axial proton density MR arthrogram image demonstrating a normal variant, posterior sublabral sulcus (circle).

• The anterior labrum in this patient demonstrates intermediate signal abnormality with a linear area of contrast at the chondrolabral junction, compatible with a concomitant anterosuperior labral tear (arrow).
Normal Variants: Normal notch in superior acetabulum

• Sagittal proton density image demonstrating a normal variant, supraacetabular fossa which is devoid of cartilage (circle).

• This should not be mistaken for focal cartilage defect and is characterized by smooth cortical irregularity in the superior acetabular fossa.
Normal Variants: Air from the injection

- Sagittal proton density image from an MR arthrogram demonstrating rounded areas of hypointensity in the non-dependent joint space (circle), compatible with intraarticular gas.

- This is an iatrogenic finding and should not be mistaken for intraarticular debris or synovial proliferation.
Conclusion

• Provided an overview of pathomechanics and discussed different types of femoroacetabular impingement

• Emphasized the importance of clinical signs of impingement for the diagnosis of FAI

• Reviewed imaging work up
  • Starts with X-rays to assess osseous morphology
  • Proceed to cross sectional studies with intraarticular contrast to assess labrum

• Discussed imaging pitfalls and discussed ways to avoid them
References


