Radiology Corner

Femoroacetabular Impingement

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Note: This is the full text version of the radiology corner question published in the March 2008 issue, with the abbreviated answer in the April 2008 issue.

Introduction

Femoroacetabular impingement (FAI) is a relatively recently described but important cause of hip pain which frequently affects young and otherwise healthy patients. FAI results from an abnormal contact between the acetabulum and the femur secondary to a variety of morphologic abnormalities of the hip. There are two types of FAI, termed cam impingement and pincer impingement, which have distinct imaging findings. Early diagnosis of FAI is crucial as these patients will frequently develop early osteoarthritis of the hip without timely surgical intervention.

History

A 32 year old male active duty Air Force Captain presents to the Family Medicine clinic with a two month history of left hip and groin pain as well as left hip stiffness. There is no history of trauma, though the patient does report a recent increase in his physical activity.

Based on the patient's clinical data, multiple etiologies for his hip pain should be considered. One possibility is internal derangement such as chondral injury or labral tear, possibly related to femoroacetabular impingement (FAI) as in this case. Other considerations include femoral neck stress fracture (especially given the recent increase in physical activity,) osteonecrosis of the femoral head, infection (unlikely without associated fever or leukocytosis,) referred pain from the lumbar spine, or very rarely a bone tumor such as an osteoid osteoma or osteosarcoma. An inflammatory arthropathy was also considered in this patient, but a rheumatologic work-up was unremarkable to include a normal ANA and negative HLA-B27. (1) Given this clinical differential diagnosis, routine plain films followed by MRI of the hip would be the most appropriate initial imaging work-up.

Summary of Imaging Findings

The AP pelvis and frog leg lateral left hip radiographs (Figs. 1A, 1B, and 2) demonstrate the abnormal morphology of the femoral head indicative of FAI. Prominent osteophyte formation can be seen bilaterally at the femoral head-neck junction. The abnormal convexity of the anterolateral femoral head-neck junction, which should normally appear concave, is best visualized on the frog leg lateral view of the hip (Fig. 2). This is the key radiologic finding that suggests the diagnosis of FAI in this patient. (2)

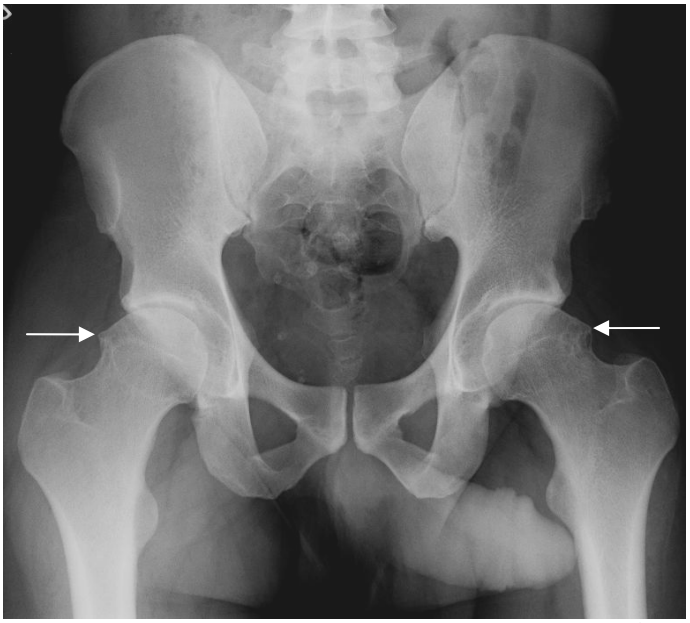

Fig. 1 (A). AP Pelvis radiograph demonstrates an abnormal focal protuberance at the level of the femoral head-neck junction bilaterally (white arrows) sometimes referred to as a femoral neck "bump." There are ostoearthritic changes of both hips, worse on the left than right.

Significant osteoarthritic changes of both hip joints, left greater than right, are also demonstrated on the radiographs. Though fine detail is not well seen on the AP pelvis radiograph, bilateral joint space loss can be appreciated (Fig. 1A). The magnified AP view and frog leg lateral view more readily demonstrate the marked joint space loss of the left hip which predominantly involves the superolateral aspect of the joint (Figs. 1B and 2). Subchondral sclerosis, especially of the superior acetabulum, is best seen as periarticular increased density on conventional radiographs (Figs. 1B and 2) and is also supportive of osteoarthritis.

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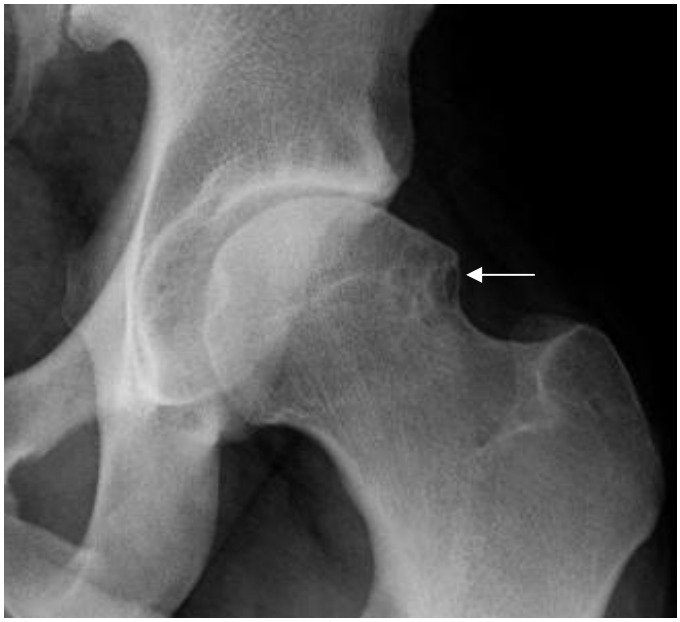

Fig. 1 (B). Close up view of the left hip from Fig. 1A. Superolateral joint space loss, subchondral sclerosis, cystic changes of the anterolateral femoral head-neck junction and subcapital region (white arrow), and subchondral cystic changes of the superior acetabulum are better visualized.

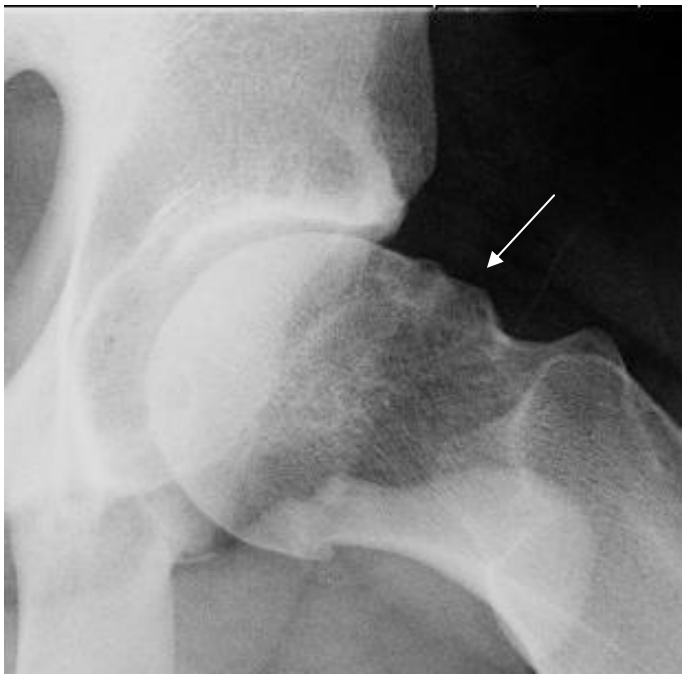

Fig. 2. Frog leg lateral left hip radiograph nicely shows the abnormal convexity of the anterolateral femoral head-neck junction (white arrow). Subchondral sclerosis and joint space loss are well seen on this view. Also note the cystic changes at the femoral head-neck junction.

Subchondral cystic changes involving the superolateral acetabulum are faintly seen (Fig. 1B). Cystic changes of the anterolateral femoral head-neck junction and subcapital region are more readily apparent (Figs. 1B and 2). This pattern of cystic changes correlates to the areas of abnormal contact, or impingement, of the anterior/superior femoral head-neck junction with the lateral acetabular rim. In combination, the findings of joint space loss, subchondral sclerosis, and subchondral cystic change are consistent with moderate degenerative arthritis of the hip.

MR images also demonstrate the convexity of the femoral head-neck junction with the associated osteophyte (Figs. 3 and 4). While loss of joint space can be seen on conventional radiographs, on MR the thinned articular cartilage can be directly visualized. In addition to thinning, the decreased signal of the involved cartilage indicates chondral injury (Fig. 3). Cystic changes of the lateral femoral head-neck junction and subcapital region along with the superior acetabulum are more conspicuous on MR than conventional radiographs. (Figs. 5, 6A, 6B, and 7). The cysts are especially prominent on fluid sensitive sequences (Fig. 6A). Another important finding seen only on the MR images is a complete tear of the anterior superior acetabular labrum (Fig. 7). Though labral tears are more conspicuous with MR arthrography, routine hip MRI will often sufficiently demonstrate significant tears such as the one in this patient.

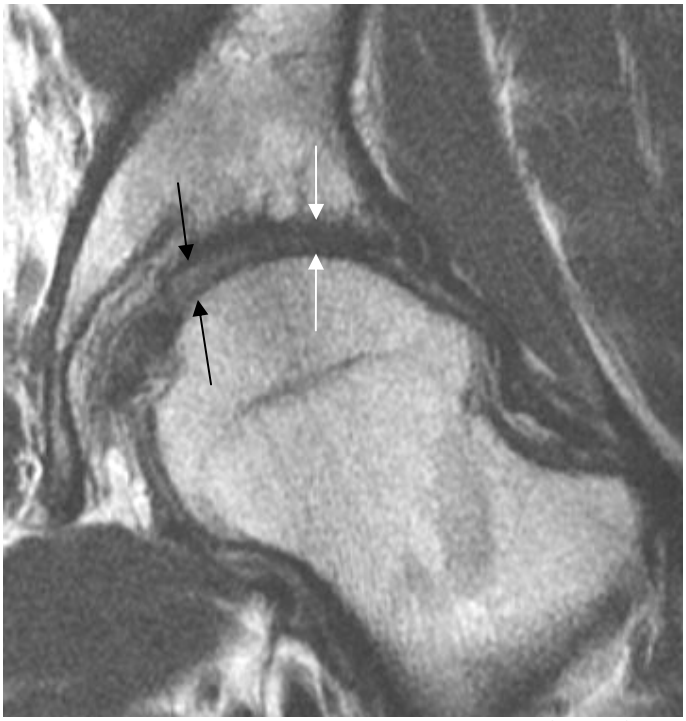

Fig. 3. Coronal Fast Spin Echo (FSE) MR image of the left hip demonstrates convexity of the lateral femoral head-neck junction. There is significant thinning and loss of signal of the articular cartilage overlying the superolateral femoral head (white arrows). Compare this to the normal thickness, intermediate signal cartilage along the superomedial femoral head (black arrows).

Patient Discussion

The patient's clinical presentation along with the findings on the subsequently obtained hip radiographs and magnetic resonance imaging (MRI) study are classic for FAI. The patient's symptoms of pain and stiffness are likely in large part due to the early onset degenerative arthritis of the hip and the anterior labral tear that have developed secondary to the chronic stress injury caused by FAI.

The most common age for presentation is in the third through fifth decades with young men particularly affected by cam type FAI (discussed below), as is seen in this patient. (2,3) The presentation of unilateral hip or groin pain, even with apparent evidence of bilateral hip involvement, is also typical. (4) The radiologic findings of convexity of the femoral head-neck junction, an osseous prominence of the femoral head-neck junction, an anterosuperior labral tear, and early onset degenerative arthritis of the hip are all supportive of a diagnosis of FAI. (2,3,4,5) While there are specific surgical therapies for the treatment of FAI (discussed below,) they are generally aimed at preventing the development of early osteoarthritis of the hip. This patient was referred to orthopedic surgery for evaluation, and it was felt that the degree of his osteoarthritis precluded any specific surgical therapies to correct his FAI. His plan of treatment includes conservative medical management for his hip pain with the expectation that he will eventually require a total hip replacement.

Discussion

FAI results from abnormal contact between the acetabulum and the femur secondary to several different morphologic abnormalities of the hip. There are two types of FAI, termed cam impingement and pincer impingement. Though each type has distinctive radiographic features, in reality most patients have some combination of both types. (3) Cam impingement is predominantly due to asphericity of the femoral head resulting from a flattening or convexity of the normally concave femoral head-neck junction. This abnormal osseous prominence results in repetitive stress injury along the femoral head-neck junction and the acetabular rim. Pincer impingement also results in abnormal contact between the acetabulum and femoral head, but the underlying abnormality is overcoverage of the acetabulum. (2,3) In general, cam impingement may be thought of as resulting from femoral morphologic abnormalities while pincer impingement is a result of a deep acetabulum. (3)

Demographically, FAI is most common in the 20's-40's age range. Cam impingement characteristically affects younger men while pincer impingement has been more strongly associated with middle aged women. The overall prevalence of FAI is 10-15% making it very common, though likely under-recognized, problem. (3)

The clinical presentation of both types of FAI is similar. Patients typically complain of unilateral anterior hip/groin pain which is exacerbated with physical activity, sitting for prolonged periods, and climbing stairs. (4) On physical exam, patients with FAI will have pain with placement of the hip in 90° of flexion, adduction, and internal rotation. External rotation of the femur with the hip in maximum abduction will frequently produce a grinding or popping sensation.

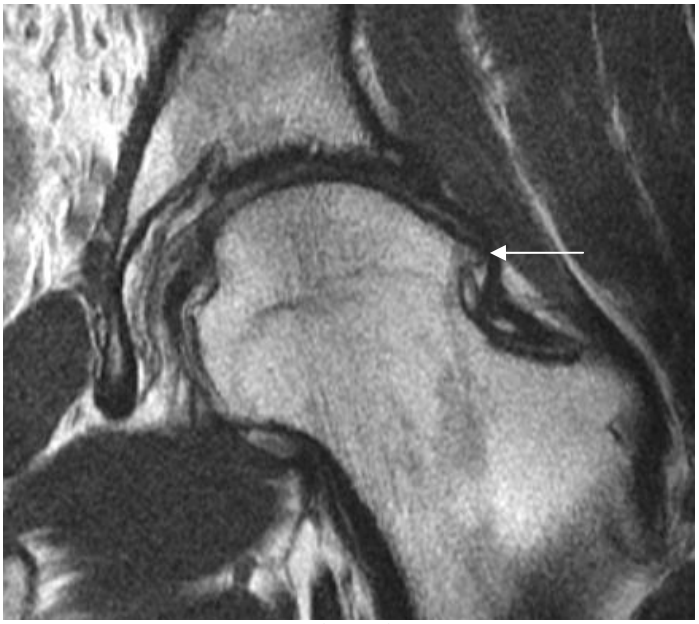

Fig. 4. Coronal FSE MR image of the left hip shows a triangular shaped osteophyte (white arrow) at the lateral femoral head-neck junction as a result of chronic impaction injury.

Additionally, patients may have loss of internal rotation with otherwise preserved range of motion of the hip. This finding helps distinguish the abnormalities of FAI from those of typical hip osteoarthritis which is usually characterized by universal range of motion loss. (2)

The radiologic workup of FAI begins with conventional radiographs of the hip which will demonstrate many of the morphologic abnormalities of the acetabulum and femur seen in this disorder. The frequently associated degenerative changes of the hip joint can also be effectively assessed with radiographs. MRI is helpful to evaluate for chondral damage and labral tears. Direct MR arthrography, which entails direct intraarticular injection of dilute gadolinium contrast into the hip joint, increases the conspicuity of labral tears. MR can also be used to assess the alpha angle, a quantitative measurement of the sphericity of the femoral head (discussed below). The oblique axial imaging plane used to measure the alpha angle is not usually a part of routine hip MRI protocols, but it can be easily added if there is clinical concern for FAI. Computed Tomography (CT) can also be useful in obtaining the alpha angle and for assessing the osseous abnormalities of FAI, though poor visualization of articular cartilage and the acetabular labrum limits the utility of CT. (2)

There is ongoing research into the underlying etiologies of FAI with multiple proposed mechanisms currently being considered. Entities that have been associated with the development of FAI include subclinical slipped capital femoral epiphysis, congenital acetabular retroversion, developmental dysplasia of the hip, avascular necrosis of the femoral head, prior trauma, coxa magna, and abnormal growth of the capital femoral epiphysis. (2,3)

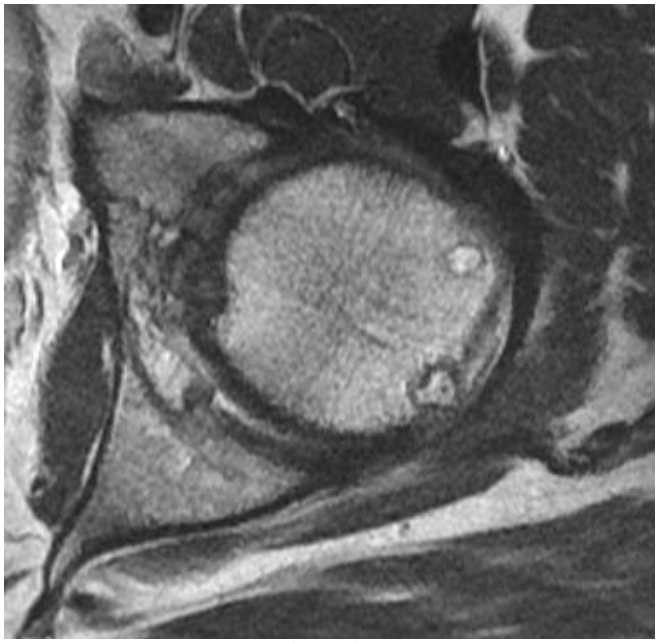

Fig. 5. Axial FSE MR image of the left hip shows cystic changes along the lateral aspect of the femoral head. Cysts along the anterolateral aspect of the femoral head-neck junction and subcapital region are also known as synovial herniation pits.

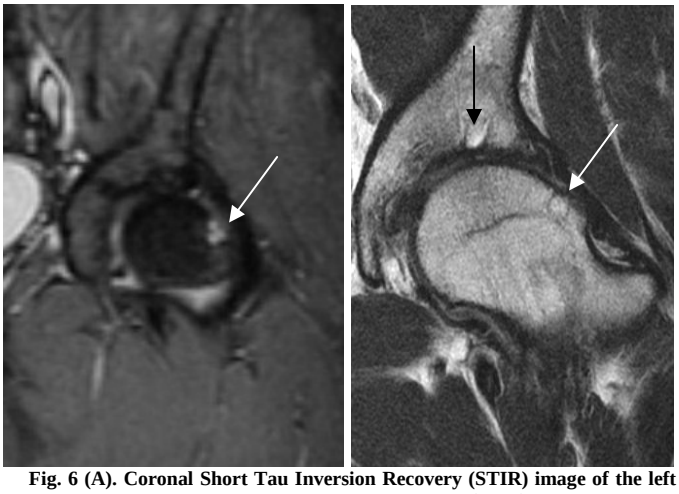

Fig. 6 (A). Coronal Short Tau Inversion Recovery (STIR) image of the left hip demonstrates cystic changes at the lateral aspect of the femoral head-neck junction (white arrow). Fluid, including these cysts, demonstrates high signal intensity on this imaging sequence making this finding particularly conspicuous.

Fig. 6 (B). Coronal FSE image of the left hip also shows the cystic changes at the lateral aspect of the femoral head-neck junction (white arrow). A subchondral cyst of the acetabular dome is also present (black arrow). Fluid, including these cysts, demonstrates intermediate signal intensity on this imaging sequence in contrast to the STIR image.

The radiographic findings of FAI are usually classified as relating to either cam type or pincer type impingement. On conventional radiographs, prominence of the anterolateral femoral head-neck junction, a "pistol grip deformity," and findings of early degenerative arthritis are suggestive of cam impingement. Prominence of the anterolateral head-neck junction is also described as a decreased femoral head-neck offset. The femoral head-neck offset is defined as the difference in size between the largest diameter of the femoral head and the diameter of the most prominent part of the femoral neck. A "pistol grip deformity" is the descriptor for a tubular shaped femoral head and neck resulting from a flattened head-neck junction. (2)

The alpha angle can be obtained on an oblique axial image obtained in a plane parallel to the femoral neck. Vectors are drawn from the center of the femoral head parallel to the femoral neck and to a point at the anterior femoral head-neck junction. (See Fig.12 in reference 2) An alpha angle of >50-55° has been shown to be associated with cam type FAI. (2,5) Labral tears have been convincingly associated with both cam and pincer FAI. (5) On MR arthrography, a characteristic triad of findings has been described as being present in up to 90% of patients with cam type FAI. The triad consists of an abnormally increased alpha angle, an abnormality of the anterosuperior aspect of the acetabular cartilage, and an anterosuperior labral tear. (6)

Pincer impingement can be suggested if acetabular retroversion is noted on conventional radiographs. The appearance of acetabular retroversion on AP hip radiographs is often termed a "figure of 8" configuration. This occurs when the anterior wall of the acetabulum, which normally remains medial, is visualized lateral to the posterior wall. On the AP projection, the anterior wall appears to cross over the posterior wall to become more lateral, hence the figure of 8 analogy. (See Fig. 5 in reference 2) Evidence of impaction injury of the femoral head or acetabulum, early onset degenerative arthritis, as well as any abnormality resulting in acetabular overcoverage to include coxa magna, coxa vara, and ossification of the acetabular rim may be indicative of pincer impingement. On MRI, anterosuperior labral tears are frequently seen. (5) The chondral abnormalities resulting from pincer impingement tend to be more focal, which is in contradistinction to the more extensive chondral injury seen with cam type FAI. The alpha angle in pincer impingement is normal.

Synovial herniation pits, which are cystic changes of the femoral head and subcapital region, especially anterolaterally, were historically thought to be incidental findings. More recently, however, some studies have shown an association between both cam and pincer impingement and synovial herniation pits. (2,6) This has led some authors to list these cystic changes as a secondary sign of FAI. (3)

Identification of patients with FAI is important due to the serious and sometimes debilitating sequelae for which these patients are at risk. As noted above, tears of the acetabular labrum are strongly linked to FAI and can be a cause of chronic hip pain. (5) Early onset degenerative arthritis of the hip is a known sequela of FAI, and FAI is now thought to be the cause of the majority of early onset hip osteoarthritis in non-dysplastic hips. (7) The irreversible chondral injury which can develop over time in patients with FAI may cause chronic pain which will not abate even after surgical intervention to correct the anatomic abnormities causing the impingement. It is for this reason that early diagnosis, before this irreversible injury occurs, is important in the management this disease.

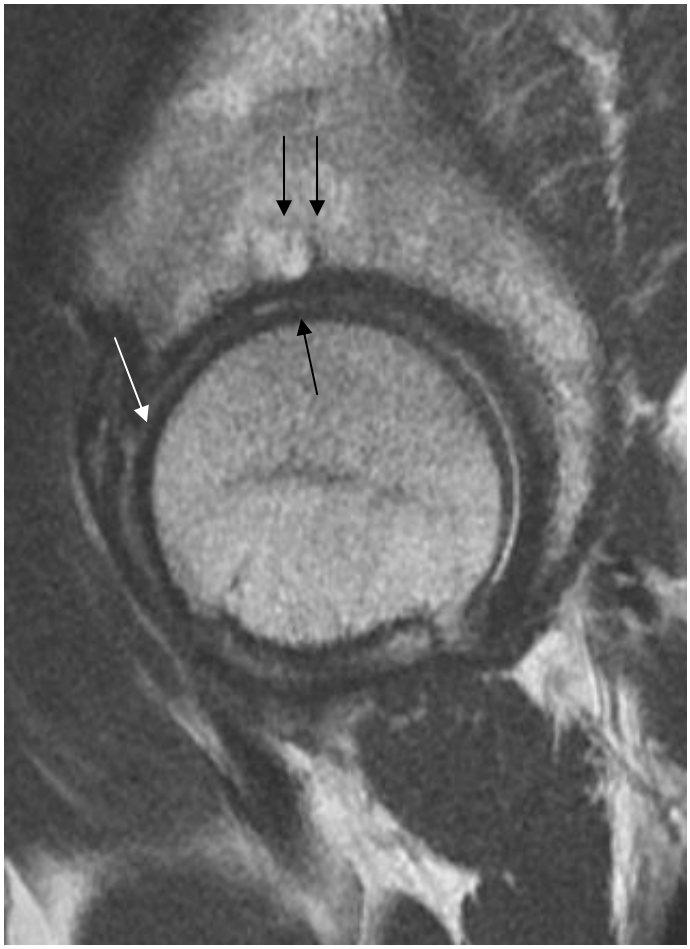

Fig 7: Sagittal FSE image of the left hip (anterior is to the left) demonstrates a full thickness tear of the anterior superior acetabular labrum (white arrow) as demonstrated by an increased signal linear defect traversing the triangular shaped fibrocartilage of the anterior labrum. Also notice the focally thinned articular cartilage over the acetabular dome (black arrow) and superior acetabular subchondral cyst (double black arrows).

Treatment of FAI often begins with conservative therapy to include non-steroidal anti-inflammatory drugs (NSAIDs) and physical therapy. (4) However, as described above, early surgical intervention is important to prevent or minimize the development of degenerative arthritis. Both arthroscopic and open procedures have been described in the treatment of FAI. The most commonly performed procedures entail reduction of the osseous prominence at the femoral head junction and resection of any acetabular overcoverage. Though good short term post-surgical results have been reported, long-term studies are still pending. (2,4) For patients who have already developed significant hip osteoarthritis, therapies to correct the morphologic abnormalities of the hip are not helpful and hip replacement may be required.

Femoroacetabular impingement is an important cause of hip pain in young adults which has only recently gained widespread recognition. A diagnosis of FAI can usually be established based on typical symptoms, physical exam findings, and characteristic findings on conventional radiography and MRI. The diagnosis and treatment of FAI is aimed at minimizing the long term sequelae of this disorder, especially early onset degenerative arthritis of the hip.

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