Imaging evaluation of the hip after arthroscopic surgery for femoroacetabular impingement

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Abstract Arthroscopic surgery for femoroacetabular impingement (FAI) is increasingly frequently performed. Initial reports were that complications were very low, but as experience has increased, a number of long-term complications, in addition to factors related to poor clinical outcomes, have been identified. This review describes the normal and abnormal postoperative imaging appearance of the hip after arthroscopy for FAI. Abnormalities discussed include incomplete resection or over-resection of the impingement lesion, heterotopic ossification, cartilage damage, chondrolysis, instability and dislocation, recurrent labral tear, adhesions, psoas atrophy, infection, and avascular necrosis.

Keywords Femoroacetabular impingement · Hip arthroscopy complications · Hip instability · Psoas atrophy

Introduction

Femoroacetabular impingement (FAI) is a clinical syndrome of hip pain and limited motion that many hip specialists believe to be due to morphological abnormalities of the femoral head, acetabulum, or both. First described by Ganz and colleagues, FAI has been identified as a cause of pain, labral tears, juxtalabral cartilage damage, and premature osteoarthritis [1, 2].

Arthroscopy of the hip is increasingly performed for treatment of labral tears and FAI. Among privately insured patients between the ages of 18 and 64, the rate of surgery increased from 3.6 per 100,000 in 2005 to 16.7 per 100,000 in 2013 [3]. There are a number of known short-term and long-term complications of the surgery, including pain due to under-resection of the cam lesion, fracture, heterotopic ossification, cartilage damage, joint instability, adhesions, psoas abnormalities, neuropraxia, and osteoarthritis. This review is designed to familiarize radiologists with the normal and abnormal imaging appearance of the hip following arthroscopic surgery for FAI.

Imaging evaluation of impingement morphology

Radiographs, CT, and MRI with or without arthrography are all used to detect morphological abnormalities of the proximal femur (cam lesion) or of the acetabulum (pincer lesion) or both (mixed-type impingement). Radiographs include anteroposterior (AP), frog leg lateral, and false profile views. CT scan includes standard axial, sagittal, and coronal reformatted views. Three-dimensional CT images are often useful in characterizing the extent of morphological changes. It cannot be overemphasized that patients may have morphological findings associated with impingement without having the clinical syndrome [4, 5]. Radiologists must be careful in their reports to describe morphological findings only, rather than to imply that the clinical syndrome is present.

A cam lesion is a bony prominence anterolaterally or laterally at the junction of the femoral head and neck (Fig. 1). The prominence may be focal, or there may be decreased head–neck offset (pistol grip deformity). When the hip is flexed, adducted, and internally rotated, the bony prominence impinges on the rim of the acetabulum, shearing the labrum superiorly and causing labral tears and paralabral cartilage damage.

A pincer lesion refers to an acetabulum that limits hip flexion and adduction because it extends too far over the femoral
head. Femoral head overcoverage may occur owing to an acetabulum that is globally deep (coxa profunda), or there may be a bony prominence at the anterior–superior rim (Fig. 2). On the anteroposterior radiograph, the anterior rim of the acetabulum normally projects medial to the posterior rim. Superior rim retroversion may create a "crossover sign," where the anterior rim of the acetabulum projects lateral to the posterior rim (Fig. 3a). In either case, the labrum may be pinched between the femoral head and the prominence of the bony acetabulum.

Arthroscopic technique for FAI

Hip arthroscopy is technically demanding, and a precise surgical technique is key in preventing complications [6]. The hip joint is first distracted by a traction device. Access to the hip is gained via at least two of several standard arthroscopic portals (usually anterior and anterolateral). A vertical capsulotomy may be performed to improve access to the joint, in addition to a horizontal capsulotomy adjacent to the margin of the anterior acetabulum. Once access to the joint is obtained, fluoroscopy is used to locate the cam lesion. The area to be resected may be marked by cautery to allow accurate debridement. A burr is then used to remove the bony prominence. Acetabular labral tears may be repaired, or the labrum may be resected. The surgeon can treat mild pincer impingement by detaching the labrum, trimming the bone, and reattaching the labrum. This procedure is commonly known as a "rim trim." More severe femoral over-coverage is treated with periacetabular pelvic osteotomy, which lies outside the scope of this article. Chondral lesions may be treated with debridement or a variety of repair techniques [7].

Normal postoperative imaging appearance of the hip

Postoperative radiographs, computed tomography (CT), and magnetic resonance imaging (MR) after arthroscopic resection of a cam lesion show a sharply angled concave contour.
Fig. 2 Pincer lesion before and after surgery in a 32-year-old woman. 

**a** Preoperative false profile view shows prominent contour of the anterior acetabulum (arrow). **b** Postoperative false profile view shows subtle bone resection (arrow). **c** Coronal postoperative CT shows the bone resection (arrowhead) and a lucent track (arrow) where a bioabsorbable suture anchor was placed as part of labral repair. **d** 3D postoperative CT best shows the extent of bone resection (arrowheads). **e** Arthroscopy picture shows labral repair (arrows) after rim trim. A articular surface of the acetabulum, F femoral head. Arrowhead points to articular cartilage damage, probably related to the arthroscopic instruments.

Fig. 3 A 22-year-old man with persistent pain after surgery, and imaging suggesting inadequate resection of impingement lesions. **a** Anteroposterior (AP) radiograph shows “crossover sign” indicating persistent retroversion of the superior acetabular rim. White arrows show the anterior acetabular rim crossing over the posterior rim (black arrowhead). **b** Frog leg lateral radiograph shows a shallow indentation at the femoral head–neck junction representing the surgical resection (arrow). The head–neck junction remains prominent. There is also a small amount of heterotopic ossification (arrowhead).
Outcomes of hip arthroscopy

The literature shows a wide variation in reported outcomes of hip arthroscopy. A 2013 meta-analysis of 92 studies with more than 6,000 patients found that the reported rate of early major complications was 0.58% [10]. The reported rate among more than 6,000 patients found that the reported rate of hip arthroscopy. A 2013 meta-analysis of 92 studies showed a wide variation in reported outcomes.

Outcomes of hip arthroscopy (Fig. 1c, d) at the femoral head–neck junction [8, 9]. This angular contour change may be mistaken by an unwary for osteophyte formation. The acetabular “rim trim” may not be visible on radiographs, although a subtle change in contour is sometimes visible. It will be better visualized on CT (Fig. 2) and MRI.

Imaging findings of complications of FAI surgery

Many complications of FAI surgery can be seen on imaging studies: heterotopic ossification, incomplete resection or over-resection of the impingement lesion, cartilage damage, rapid osteoarthritis, instability, dislocation, recurrent labral tear, anchor displacement, adhesions, psoas atrophy, infection, and avascular necrosis. Infection and avascular necrosis are not included in this review, as their appearance in this setting is different than in other settings, and is commonly known.

At our institution, small field-of-view images of the affected hip are supplemented with large field-of-view images to evaluate the entire pelvis, to detect causes of hip pain that lie outside the area of surgery.

Incomplete resection of the impingement lesion

The radiographs and MRI should be scrutinized carefully for residual deformity (Fig. 3). Postoperative radiographs may show a persistent bone prominence, but the patient may still have a successful outcome. As correlation with symptoms is variable, the radiographic report should be descriptive rather than implying the cause of symptoms.

Over-resection of the impingement lesion

If the surgeon is overly aggressive in removing a cam lesion, the femoral neck may be at an increased risk for fracture.
However, there are no data on how much resection increases fracture risk. Risk of stress fracture of the femoral neck has been estimated at 0.07%, with an increased risk in patients who did not follow postoperative weight-bearing restrictions, and in women over the age of 50 [22]. If the pincer lesion is overly resected, the patient may develop anterior instability [23].

**Heterotopic ossification**

Hip arthroscopy carries a much higher risk of heterotopic ossification than arthroscopy of other joints, and is reported in 5–40% of patients, with a decreased rate after administration of indomethacin [24, 25]. Only about 1% of cases of heterotopic ossification require surgical resection. Heterotopic ossification may be asymptomatic, but may cause pain, impingement, and decreased range of motion. Radiographs and CT are used to make the diagnosis and define the extent of the ossification (Figs. 3, 4).

**Cartilage damage**

Arthroscopic instruments may cause focal damage to joint cartilage (Figs. 2e, 5). Cartilage changes seen on MRI may also reflect cartilage repair techniques. Correlation with the surgical report is important in reaching the correct diagnosis.

Occasionally, chondrolysis may occur. Chondrolysis refers to diffuse cartilage resorption due to mechanical, thermal or chemical causes. It has been reported to occur after arthroscopy [26]. On radiographs, it is characterized by rapid, diffuse joint space narrowing and the absence of osteophytes (Fig. 6). Infection must always be excluded, and if chondrolysis is suspected then joint aspiration is recommended.

**Labral abnormalities**

A torn labrum is usually repaired at the time of arthroscopy for FAI. A failed labral repair is commonly found at 2nd look arthroscopy, but may be difficult to distinguish on MRI from operative changes. On postoperative MRI, the labrum often appears small, with an irregular contour [27]. One study, which was performed without surgical correlation, found that abnormalities thought to represent recurrent tear at MR arthrography may be asymptomatic [28]. It should be remembered that labral tears in the general population may also be asymptomatic [29]. In the author’s experience, the best clues to recurrent tear, just as in recurrent tears of the meniscus of the knee, are separation of fragments, tear in a new location, and a paralabral cyst. Comparison with preoperative MRI is very useful (Figs. 7, 8).

Obliteration of the paralabral sulcus is very common in asymptomatic patients [28] and should be considered a normal postoperative finding.

Repair of a labral tear is usually performed with suture anchors and sutures. A displaced suture anchor can cause pain, and may be detected on MRI as a small focus of low-signal intensity (Fig. 9).

Absence of the labrum on MRI in a postoperative hip may indicate attrition of a repaired labrum, or a resected labrum. As labral resection is an accepted surgical option, it is prudent for the radiologist to review the surgical report in a postoperative patient. A small study with a 10-year follow-up found that patients with labral resection vs labral repair had no difference in pain with impingement maneuver [30]. In this study, revision arthroscopic surgery was performed in 24% of patients who had been treated with labral repairs, but in 54% of patients who had undergone labral resection. Rates of conversion to THA were equal in both groups.

**Instability**

The hip joint owes much of its anterior stability to the iliofemoral ligament (ligament of Bigelow). The iliofemoral ligament protects the hip against hyperextension, external rotation, and anterior displacement [31]. It arises from the inferior margin of the anterior inferior iliac
spine, immediately inferior to the straight head of the rectus femoris, and has two limbs that diverge in an inverted V shape to insert on the anterior intertrochanteric ridge, one medially and one laterally. Arthroscopic portals and capsulotomy may compromise the integrity of the iliofemoral ligament [32, 33]. Many arthroscopists close the capsule at the conclusion of the surgery to improve joint stability [34]. With or without capsule closure, the cartilage delamination. It is impossible to know on MRI whether this represents progression of disease or iatrogenic damage occurring at the time of arthroscopy. Arrowhead points to bone marrow edema in the femoral head, suggesting ongoing damage in this region as well. Edema due to surgery would be expected to resolve in 4–6 months.

Fig. 5 A 30-year-old woman with pain 1 year after arthroscopy. a Preoperative sagittal proton density-weighted fat-saturated (PDFS) MR arthrogram at 1.5 T shows homogeneous, intermediate gray articular cartilage (arrows) with a small amount of quantum mottle. b Postoperative sagittal PDFS MRI at 1.5 T shows fluid extending into acetabular cartilage defects (arrows), including a small region of cartilage delamination. It is impossible to know on MRI whether this represents progression of disease or iatrogenic damage occurring at the time of arthroscopy. Arrowhead points to bone marrow edema in the femoral head, suggesting ongoing damage in this region as well. Edema due to surgery would be expected to resolve in 4–6 months.

Fig. 6 Postsurgical chondrolysis. A 51-year-old woman with a labral tear. Preoperative radiographs were performed elsewhere, and were reportedly normal. She had severe, progressive pain following surgery that was not relieved by narcotic medication. Joint aspiration was negative for infection. a AP weight-bearing radiograph 4 months postoperatively shows mild joint space narrowing. b AP weight-bearing radiograph 8 months after arthroscopy shows progressive, uniform joint space narrowing (arrow), but no osteophytes. This radiographic finding is indicative of chondrolysis or infection or inflammatory arthritis.
iliofemoral ligament may be compromised, leading to anterior subluxation and sometimes to dislocation.

Signs and symptoms of anterior hip instability are nonspecific. Patients complain of anterior pain, and sometimes of a "popping" or a sensation of "giving way". They may show apprehension when the hip is extended.

Anteroposterior radiographs are usually normal except when frank dislocation occurs. The standing false profile view may show widening of the posterior joint space and uncovering of the anterior femoral head (Fig. 10).

Magnetic resonance imaging or MR arthrography shows a defect in the iliofemoral ligament (Fig. 10) that permits anterior subluxation. Some patients may have asymptomatic capsule defects [28].

Another possibility to consider is that unrecognized hip instability may have been present before hip arthroscopy. Hip instability in the absence of previous surgery was long considered to be rare, but is increasingly recognized [32, 35]. FAI has also been suggested as a cause of posterior hip instability [36, 37].
Hip dislocation

Most traumatic hip dislocations are posterior hip dislocations due to a posterior force on a flexed hip (“dashboard injury”). In contrast, hip dislocations after arthroscopy usually occur in the anterior direction. They are often due to minor trauma (Fig. 11) and are most likely related to iatrogenic instability. They have occurred despite surgical closure of the joint capsule, and have been associated with acetabular undercoverage (native or due to surgical resection), labral debridement, capsular insufficiency, or iliopsoas tenotomy (Fig. 12 [23]).

Progressive osteoarthritis

Osteoarthritis may be seen to progress rapidly after hip arthroscopy. This may have multiple causes. Direct trauma by arthroscopic instruments to the cartilage is one cause. Another cause of rapidly-developing osteoarthritis is iatrogenic instability, and a third is progression of previous osteoarthritis.

Psoas abnormalities

Arthroscopic release of the psoas tendon is a common procedure performed during arthroscopy to alleviate iliopsoas impingement [38]. The psoas tendon is readily visible on MRI at the level of the hip as a black, round structure lying posterior to the iliacus muscle. A recent study found that compared with patients who did not undergo release, patients who had undergone release had significant psoas atrophy on MRI evaluation, which corresponded to measurable muscle weakness [39].

Psoas atrophy after arthroscopic release may be profound, and may involve the iliacus muscle as well (Fig. 13). This finding may be seen on MRI of the lumbar spine, in which
case the history given to the radiologist often will not mention the history of hip arthroscopy. Because the psoas is innervated by multiple spinal levels, the finding of atrophy involving the entire psoas should raise consideration of psoas release as a more likely etiology for the atrophy than an abnormality in the lumbar spine.

Psoas weakness may occur, even when an arthroscopic release is not performed. A study of 8 patients who underwent arthroscopy without psoas release found that they had persistent psoas weakness 2.5 years after surgery [40]. The strength of other muscle groups was normal.

Adhesions

Adhesions may form between the joint capsule and the osteochondroplasty site, and present with groin pain and a sensation of “tightness.” They are visible on MRI or MR

Fig. 11 A 27-year-old woman complaining of ongoing pain and subjective instability after arthroscopy for FAI. a Preoperative sagittal PDFS MR arthrogram at 1.5 T shows intact iliofemoral ligament (arrows). b Postoperative sagittal PDFS MR arthrogram at 1.5 T at the same location as a shows the discontinuity of the iliofemoral ligament (arrow). The osteochondroplasty defect (arrowhead) appears unremarkable. c Postoperative axial PDFS MR arthrogram at 1.5 T shows the capsule defect (arrows) with contrast medium extending through the defect. Careful attention to the injection technique is needed to avoid extra-articular placement of contrast mimicking extravasation. Arrowhead points to osteochondroplasty site.

Fig. 12 A 50-year-old man had an atraumatic anterior hip dislocation following arthroscopy for FAI. He subsequently underwent total hip arthroplasty. a AP radiograph shows the femoral head perched on the rim of the acetabulum. b Cross table lateral radiograph confirms that the dislocation is anterior. The femoral head is perched on an anterior acetabular rim (arrow).
arthrography (Fig. 14) as irregular bands of fibrous tissue, usually adjacent to the osteochondroplasty site [41].

**Infection and avascular necrosis**

These complications are fortunately rare, but should always be on the radiologist’s checklist in evaluating any musculoskeletal imaging study.

**Failure due to incorrect initial diagnosis**

If a patient has persistent pain after surgery for FAI, the possibility that the initial pain was due to a different cause than FAI should be considered. Cam and pincer type morphology are very common and may be asymptomatic [4, 5]. Pain due to osteoarthritis, athletic pubalgia, muscle/tendon tears, ischiofemoral impingement, or iliopsoas impingement may be erroneously ascribed to FAI. A new problem may also emerge following successful arthroscopy. The radiologist interpreting a preoperative or postoperative study should be alert for other abnormalities which may cause hip pain.

**Conclusions**

The radiologist plays an important role in the evaluation of the hip after arthroscopy. A checklist of possible abnormalities is useful to ensure complete evaluation and accurate diagnosis.

**Fig. 14** A 30-year-old man with a sensation of tightness and pain when fully extending his hip. The pain had been gradually increasing in the 1.5 years since his arthroscopy for FAI. a Sagittal PDFS MR at 3 T shows that the iliofemoral ligament is thickened (arrowhead) and there appears to be a fibrous strand (arrow) extending to the osteochondroplasty site. The surgeon felt that this might be a spurious finding related to the lack of joint distention; thus, MRI arthrography was subsequently performed. b Sagittal PDFS MR arthrogram at 1.5 T. Contrast material slightly separates the thickened iliofemoral ligament (arrowhead) from the anterior margin of the femoral neck, and facilitates recognition of fine strands between the capsule and the femoral head. c Axial oblique T1FS MR arthrogram at 1.5 T best shows the fibrous adhesions (arrow)
Compliance with ethical standards

Conflicts of interest The author has no conflicts of interest to disclose.

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