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MRI Findings of Femoroacetabular Impingement

OBJECTIVE. The purpose of our study was to evaluate MRI in the identification of labral and articular cartilage lesions in patients with a clinical suspicion of femoroacetabular impingement.

MATERIALS AND METHODS. Preoperative MRI was performed in 46 consecutive patients (26 men, 20 women; age range, 21–45 years; mean age, 32.3 years) for whom femoroacetabular impingement was clinically suspected. Two musculoskeletal radiologists independently assessed the MR images for the presence and anatomic site of labral disorders, labral–chondral transitional zone disorders, femoral cartilage lesions, and acetabular cartilage lesions. Surgical correlation was obtained in all cases by two surgeons who were experienced in hip arthroscopy.

RESULTS. Seven patients showed labral tears on MRI that were confirmed surgically in all cases. Thirty-seven patients (97%) of the 38 surgically confirmed cases had lesions of the labral–chondral transitional zone on MRI. The sites of labral–chondral transitional zone abnormalities at arthroscopy were 50% anterosuperior, 36% anterosuperior and superolateral, 11% superolateral, and 3% superolateral and posterosuperior. The site was identified correctly in 92% (reviewer 1) and 95% (reviewer 2) of cases on MRI. Separate acetabular cartilage abnormality was surgically identified in 39% of cases, and femoral cartilage lesions were found in 20%. The acetabular chondral lesions were correctly identified in 89–94% of cases.

CONCLUSION. MRI provides a useful assessment of patients in whom a femoroacetabular impingement is clinically suspected. A high-resolution, nonarthrographic technique can provide pre-operative information regarding the presence and anatomic site of labral and cartilage abnormalities.

or some time, there has been significant interest in identifying the underlying cause of idiopathic osteoarthritis in young patients. A number of studies have identified abnormalities in the labrum early in the disease process of osteoarthritis [1–4]. The mechanism of osteoarthritis and labral degeneration in dysplastic hips has been attributed to chronic shear stresses caused by increased contact forces at the superolateral edge of the acetabulum [5–7], but less work has been performed on nondysplastic hips [5].

In recent years, the concept of femoroacetabular impingement has become increasingly recognized as a potential cause of early-onset osteoarthritis in the nondysplastic hip [1, 8]. In essence, this impingement consists of repetitive abutment between the femur and the acetabular rim during terminal hip motion secondary to reduced joint clearance. It has been postulated that this impingement process may be caused by either femoral or acetabular factors, although the exact cause of the spectrum of findings seen in patients with femoroacetabular impingement is not completely understood.

Our study aims to elucidate the MRI features of patients in whom femoroacetabular impingement is clinically suspected. Previous imaging studies have focused on the role of MR arthrography in the investigation of labral and chondral hip disorders [5, 9–14]; few studies have used unenhanced techniques [15, 16]. We attempted to discriminate labral tears from lesions confined to the acetabular rim (labral–chondral transitional zone), and we used a high-resolution nonarthrographic technique to do so. We then compared our imaging interpretations with arthroscopic findings.

Materials and Methods Patients

The study group was collected over a 2-year period and constituted 46 patients: 26 men (57%) and 20 women (43%). The mean patient age was 32.3 years (range, 21–45 years). There were 25 right hips (54%) and 21 left hips (46%). A history of chronic hip or groin pain and a clinical examination with findings

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Fig. 1—Sagittal oblique proton density-weighted fast spin-echo sequence (TR/TE, 4,000/34) in 28-year-old woman shows normal appearance of labral-chondral transitional zone. Intermediate-signal acetabular hyaline articular cartilage can be seen blending with low-signal fibrocartilage of acetabular labrum (*arrow*).

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Fig. 2—Sagittal oblique proton density-weighted fast spin-echo sequence (TR/TE, 4,000/34) in 29-year-old man shows grade 1 lesion of labral-chondral transitional zone. High-signal cleft (*black arrow*) is identified, and adjacent articular cartilage (*white arrow*) remains intact.



Fig. 3—Sagittal oblique proton density–weighted fast spin-echo sequence (TR/TE, 4,000/34) in 38-year-old man shows grade 2 lesion of labral–chondral transitional zone. Note thinning, hyperintensity, and fraying of cartilage at labral–chondral transitional zone and fissures extending to subchondral bone plate (*arrow*).

consistent with femoroacetabular impingement were present in all cases. The mean duration of symptoms was 16.8 months (range, 4–48 months). Patients with radiographic evidence of abnormal lateral coverage of the femoral head had previously been excluded, and all patients had a center edge Wiberg angle greater than 25° on preoperative radiographs. All patients referred with a clinical suspicion of femoroacetabular impingement underwent preoperative MRI to identify labral and chondral abnormalities and to exclude coexisting disorders such as stress fractures or osteonecrosis. None of the patient group had undergone previous hip surgery. Institutional review board approval was not required for the preoperative MRI and retrospective data analysis used in this study.

MRI Technique

A standardized high-resolution MRI protocol was used for all examinations in this series. MRI was performed using a 1.5-T superconducting unit (Signa LX, GE Healthcare). A phased-array surface coil (Shoulder Array, Medrad) was strapped over the hip and centered over the region of the femoral head. An axial localizing image was obtained and then the following sequences: axial and coronal proton density-weighted fast spin-echo imaging (TR/TE, 4,000/34); a sagittal oblique fast spin-echo sequence plotted from the axial images 10° oblique from the midline (4,000/34); and coronal STIR imaging (4,500/24). The fast spin-echo images used a field of view of 15-17 cm, a 512 × 384 matrix for the coronal and sagittal images, and a 512 × 256 matrix for the axial images, a 3-mm slice thickness with no interslice gap, echo-train length of 8-12, and 3 excitations (NEX). The inversion recovery sequence used a field of view of 15–17 cm, a 256 \times 256 matrix, echo-train length of 8–10, 2 NEX, a 3-mm slice thickness with no interslice gap, and an inversion time of 150 milliseconds. Bandwidth was 31 kHz for sagittal and coronal sequences and 20 kHz for the axial surface coil sequence.

MR Image Interpretation

Two musculoskeletal radiologists independently reviewed the MR images of all 46 patients in this series. The senior author preoperatively assessed the images as part of his routine clinical practice, and his report was available to the surgeon at the time of operation. A second musculoskeletal radiologist subsequently performed a further retrospective review of the MR images. Both radiologists were aware of the clinical suspicion of femoroacetabular impingement but did not have access to the surgical findings. Image interpretation was recorded using a standardized form in all cases. The presence and anatomic site of labral disorders, labral–chondral transitional zone disorders, femoral cartilage lesions, and acetabular cartilage lesions were recorded.

Labral tears were classified by site and type (radial or flap tear). Figure 1 shows the normal MRI appearance of the labral–chondral transitional zone. Labral–chondral transitional zone pathology was subdivided using the following classification: grade 1, labral separation, a distinct plane between the labrum and the acetabular cartilage, identified as a high-signal cleft between the low-signal fibrocartilage and the intermediate-signal hyaline articular cartilage (Fig. 2); grade 2, articular cartilage fraying, thinning, or separation immediately adjacent to the labral attachment (Fig. 3); and grade 3, full-thickness loss of articular cartilage leading to bare bone exposure immediately adjacent to the labral attachment (Fig. 4). Abnormality in the acetabular cartilage at the labral–chondral transitional zone was defined as occurring within 5 mm of the labral attachment on MR images.

The labral-chondral transitional zone was subdivided into three regions for descriptive purposes: anterosuperior, superolateral, and posterosuperior (Fig. 5). The presence of full-thickness acetabular articular cartilage lesions, separate from those within 5 mm of the labral-chondral transitional zone, was also noted (Fig. 6). The anatomic sites of acetabular chondral lesions were also subdivided into three regions for descriptive purposes: anterosuperior, superolateral, and posterosuperior (Fig. 5). The presence of full-thickness femoral head articular cartilage abnormalities was recorded (Fig. 7), with the femoral head being subdivided into four regions: anteromedial, anterolateral, posteromedial, and posterolateral (Fig. 5).

Involvement of the femoral and acetabular articular cartilage was further classified with respect to the size of the area involved. An estimate was made as to whether the cartilage abnormality was < 10%, 10-25%, or > 25% of the femoral head or acetabular area. No attempt was made to grade the cartilage abnormality. Furthermore, both radiologists recorded the presence of other MRI findings such as herniation pits, acetabular cyst formation, acetabular retroversion, os acetabuli, femoral waist deficiency, paralabral cyst formation, and acetabular protrusion that were thought to be of relevance in femoroacetabular impingement.





Fig. 4—32-year-old woman.

A, Coronal proton density-weighted fast spin-echo sequence (TR/TE, 4,000/34) shows grade 3 lesion of labral-chondral transitional zone. Full-thickness loss of articular cartilage (*white arrow*) is shown at labral-chondral transitional zone. Bone prominence (*black arrow*) is shown at femoral head and neck junction.
B, Sagittal oblique proton density-weighted fast spin-echo sequence (TR/TE, 4,000/34) shows grade 3 lesion of labral-chondral transitional zone. Full-thickness loss of articular cartilage (*white arrow*) is shown at femoral head and neck junction.



Fig. 6—Sagittal oblique proton density-weighted fast spin-echo sequence (TR/TE, 4,000/34) in 35-year-old man shows full-thickness loss of articular cartilage over anterosuperior acetabulum (*white arrow*). Lowsignal line of subchondral bone is visible, but no intermediate hyaline articular cartilage is present. Note associated subchondral cyst formation (*black arrow*) and bone marrow edema. Linear cleft of high signal at labral-chondral transitional zone (*arrowhead*) is again evident.

Arthroscopic Procedure

Two surgeons, both of whom had experience with more than 500 hip arthroscopies, performed the procedure in all patients. The mean time between MRI and surgical intervention was 25.2 days (range, 3–180 days). Arthroscopy was performed with the patient positioned in the dorsal decubitus position on a fracture table. Joint access was facilitated by the application of graduated distraction of the hip under fluoroscopic control. Arthroscopy was performed using a supratrochanteric lateral portal and an additional anterior portal to allow instrumentation. The operative findings were recorded using the same form on which the MR image interpretation was documented.

Data Collection

An author who was not involved in image interpretation or surgical evaluation performed data collection, analysis, and manuscript preparation.

Statistical Analysis

Interobserver reliability analysis using the kappa statistic was performed to assess the strength of agreement between the imaging and surgical findings in grading abnormalities at the labral–chondral transitional zone.



Fig. 5—Schematic drawing of hip joint. Labral–chondral transitional zone (gray) is divided into anterosuperior (AS), superolateral (SL), and posterosuperior (PS) areas. Acetabular articular cartilage is also divided using same divisions. Femoral articular cartilage is split into quadrants: anteromedial (AM), anterolateral (AL), posteromedial (PM), and posterolateral (PL).

Results

Acetabular Labrum

On arthroscopic evaluation, seven patients were identified as having labral tears: four flap tears and three radial tears (Figs. 8 and 9). The flap tears occurred in the anterosuperior region in all cases. Of the radial tears, one occurred in an anterosuperior site and two involved both the anterosuperior and the superolateral regions. Both radiologists correctly identified the presence and site in all seven cases. No further cases of labral tear were identified at surgery.

Labral-Chondral Transitional Zone

At the labral–chondral transitional zone, 38 cases were identified at surgery as being abnormal. On MRI, both reviewer 1 and reviewer 2 correctly identified 37 (97%) of the abnormal cases. Both reviewers reported the labral–chondral zone as being normal in the single case in which a discrepancy arose between MRI and arthroscopy. In that case, probing of the labral–chondral transitional zone at surgery revealed labral separation that was not initially evident on arthroscopic inspection.

At surgery, nine grade 1 lesions (24%), 15 grade 2 lesions (39%), and 14 grade 3 lesions

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Fig. 8—Sagittal oblique proton density–weighted fast spin-echo sequence (TR/TE, 4,000/34) in 23-year-old man shows radial tear of anterosuperior labrum and high-signal cleft (*white arrow*) extending into labral substance.



Fig. 9—Sagittal oblique proton density–weighted fast spin-echo sequence (TR/TE, 4,000/34) in 30-year-old woman shows flap tear (*white arrow*) of anterosuperior labrum. Note normal appearance of labral–chondral transitional zone (*black arrow*).

Fig. 7—Sagittal oblique proton density–weighted fast spin-echo sequence (TR/TE, 4,000/34) in 29-year-old man shows loss of articular cartilage (*arrow*) over femoral head. Note subchondral marrow edema (*arrowhead*) present in acetabulum.

(37%) were found. Reviewer 1 correctly graded 35 cases (92%) and intraobserver reliability showed good strength of agreement ($\kappa = 0.643$, SE = 0.085). In the three cases that were incorrectly graded, one was interpreted as normal and a grade 1 abnormality was identified at surgery. The two remaining cases were graded as grades 1 and 2 on MRI and surgery revealed grades 2 and 3 lesions, respectively. Reviewer 1 had a sensitivity of 89%, specificity of 75%, positive predictive value of 94%, and negative predictive value of 60%. Reviewer 2 correctly graded 33 (87%) cases and intraobserver reliability showed moderate strength of agreement ($\kappa = 0.522$, SE = 0.092). In the five cases that were incorrectly graded, one was interpreted as normal and a grade 1 abnormality was identified at surgery. Two cases were identified as grade 2 that surgically were grade 1, and two cases were given grade 3 but were shown to be grade 2. Reviewer 2 had a sensitivity of 89%, specificity of 63%, positive predictive value of 92%, and negative predictive value of 56%. Interobserver reliability analysis between radiologists showed good strength of agreement ($\kappa = 0.669$, SE = 0.085).

Arthroscopy revealed that the location of the labral-chondral transitional zone abnormality occurred in the anterosuperior region in 19 cases (50%), in the anterosuperior and superolateral regions in 14 (37%), in the superolateral region in four (11%), and in the superolateral and posterosuperior regions in one (3%). Reviewer 1 correctly identified the anatomic site in 35 cases (92%). As previously described, one case was not identified as being abnormal. The remaining two cases were identified on MRI as involving the superolateral region when at arthroscopy the lesion involved the anterosuperior and superolateral regions. Reviewer 2 identified the site correctly in 36 cases (95%). One case was not identified, and the other was described as superolateral when it involved both the anterosuperior and superolateral when it involved both the anterosuperior and superolateral when it involved both the anterosuperior and superolateral regions.

Articular Cartilage

Eighteen patients had focal acetabular cartilage lesions identified at surgery. Reviewer 1 identified 17 cases (94%) and reviewer 2, 16 cases (89%). Table 1 shows the amount of cartilage abnormality identified relative to the overall amount of acetabular cartilage cover. Overall, both reviewers underestimated the amount of involvement relative to the surgical findings. Table 2 shows the anatomic site of cartilage abnormality. Again, discrepancies existed in estimation of the extent of cartilage abnormality. Both reviewers described two cases as involving the anterosuperior region that actually involved both the anterosuperior and superolateral sites. Interestingly, of the patients with labral tears, only one patient had acetabular chondromalacia, and the remaining six patients showed no evidence of cartilage abnormality. All of the remaining 17 patients had associated abnormalities at the labral–chondral transitional zone (six having grade 2, 11 having grade 3).

Femoral articular cartilage lesions were surgically present in nine patients. Reviewer 1 identified all nine cases (100%) but misinterpreted two other cases that were normal at arthroscopy. Reviewer 2 also correctly identified all nine cases (100%). Reviewer 1 overestimated the extent of abnormality in one case and underestimated it in another case. Reviewer 2 underestimated involvement in two cases. Table 3 shows the extent of femoral articular cartilage lesions, and Table 4 identifies the anatomic sites of involvement. The extent of the anatomic area involved tended to be underestimated, with surgery identifying more diffuse involvement than was identified on MRI.

A number of other MRI findings were identified: Eighteen patients (39%) showed a bone prominence at the junction of the femoral head and neck (Figs. 4A and 10); 11 (24%) showed a cystic change of the femoral head and neck junction (Fig. 11); six (13%), acetabular cyst formation (Fig. 10); five (11%), acetabular retroversion; two (4%), os acetabuli; two (4%),

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Abnormality of Acetabular Area	Reviewer 1	Reviewer 2	Surgeon
None	29	30	28
< 10%	11	7	8
10–25%	4	6	7
> 25%	2	3	3

TABLE I: Presence and Extent of Acetabular Cartilage Abnormality

TABLE 2: Anatomic Sites of Involvement of Acetabular Cartilage Abnormality

Acetabular Site	Reviewer 1	Reviewer 2	Surgeon
Anterosuperior	5	5	3
Superolateral	4	4	4
Anterosuperior and superolateral	7	7	10
Posterosuperior	1	0	0
Superolateral and posterosuperior	0	0	1
None	29	30	28

TABLE 3: Presence and Extent of Femoral Head Cartilage Abnormality

Abnormality of Femoral Head Site	Reviewer 1	Reviewer 2	Surgeon
None	35	37	37
< 10%	7	5	4
10–25%	0	2	2
> 25%	4	2	3

TABLE 4: Anatomic Sites of Involvement of Femoral Head Articular Cartilage

Femoral Site	Reviewer 1	Reviewer 2	Surgeon
Anteromedial	1	0	0
Anterolateral	0	0	0
Posteromedial	2	0	1
Posterolateral	0	1	0
Anteromedial and anterolateral	4	5	2
Posteromedial and posterolateral	3	3	3
Anteromedial and anterolateral as well as posteromedial and posterolateral	1	0	2
Anteromedial and posteromedial as well as posterolateral	0	0	1
None	35	37	37

femoral waist deficiency; one (2%), paralabral cyst formation; one (2%), acetabular protrusion; and one (2%), gluteus medius tendinopathy. The bone prominence at the femoral head and neck junction was identified in four patients with grade 1, five patients with grade 2, and nine patients with grade 3 labral–chondral transitional zone lesions. Of the patients with herniation pits identified on MRI, one had grade 1, five had grade 2, and five had grade 3 labral–chondral transitional zone lesions. All

patients with acetabular cyst formations showed grade 3 abnormality at the labral-chondral transitional zone.

Discussion

Femoroacetabular impingement is a clinical condition that usually presents in physically active young adults with an age range of 30–40 years. The clinical presentation consists of intermittent hip or groin pain that may be exacerbated by physical activity. Hip examination

is directed toward showing clinical impingement. With the patient supine, the hip is internally rotated, flexed passively to 90°, and adducted. This test leads to abutment of the femoral neck against the acetabular rim, precipitating pain on forceful internal rotation if a labral or chondral lesion is present [17]. In the current study, patients with abnormal lateral coverage of the femoral head were excluded, including patients with both congruent and incongruent uncovering of the femoral head. These patients were excluded because this patient cohort frequently shows an abnormally elongated labrum with intrasubstance signal change that represents a different entity to that being examined in this study.

Two subgroups of femoroacetabular impingement have been described, the "cam" and the "pincer" types, although some overlap may exist between the two [8]. The cam type is more common in young athletic men and involves abutment of an abnormally shaped femoral head into the acetabular rim, particularly during hip flexion. This leads to chondral and labral injury secondary to the shearing forces produced. This conflict occurs in an "outside in" fashion, with tears occurring at the attachment of the labrum to the acetabular rim, leaving the body of the labrum substantially intact [5]. Widening of the femoral neck or reduced excursion of the femoral head and neck junction has been implicated in reducing femoral head clearance and thereby providing a potential source of femoroacetabular impingement [13, 18, 19]. An osseous prominence found at the anterolateral femoral head and neck junction might also be implicated in the pathogenesis of femoroacetabular impingement. An osseous prominence has been associated with several disorders, including chronic slipped capital femoral epiphysis, posttraumatic deformity, abnormalities resulting from prior surgical osteotomy, reduced antetorsion of the femoral head, and residual childhood diseases such as Perthes' (Legg-Calvé-Perthes) disease [13, 18, 20-22].

The pincer type, which is more common in middle-aged women, involves contact between the acetabular rim and the femoral head and neck junction [8]. In a similar fashion, an abnormal acetabulum may also reduce femoral head clearance and provide a potential source of impingement. Anterior acetabular overcoverage (acetabular retroversion) [23], protrusio acetabuli [6], and coxa profunda [6] have been implicated as causes of impingement. Both the cam and pincer types may contribute to the repetitive conflict between femur and acetabulum. Such conflict causes a shearing force to be





Fig. 10—Sagittal oblique proton density–weighted fast spin-echo sequence (TR/TE, 4,000/34) in 33-year-old woman shows small acetabular cyst (*white arrow*) beneath labral–chondral transitional zone. Note bone prominence (*black arrow*) at femoral head and neck junction.

Fig. 11—Coronal proton density—weighted fast spin-echo sequence (TR/TE, 4,000/34) in 32-year-old man shows MRI findings of cystic change (*white arrow*) at anterolateral femoral neck. High-signal cleft at labral–chondral transitional zone (*black arrow*) can again be identified.

applied to the acetabular labrum and adjacent acetabular hyaline articular cartilage, leading to degeneration and the subsequent development of hip osteoarthritis [8].

It has been suggested that the repetitive microtrauma between the femur and the acetabular rim causes tearing of the labral–chondral transitional zone, particularly in the anterosuperior region (Fig. 12). This may then predispose the adjacent articular cartilage to degeneration in the form of softening, fraying, and separation. Ultimately, articular cartilage detachment or fragmentation may occur, leading to exposure of bare bone and the subsequent development of osteoarthritis.

Using our standard high-resolution MRI protocol of the hip, we identified the presence and location of labral and chondral abnormalities in patients with a clinical suspicion of femoroacetabular impingement. Both reviewer 1 and reviewer 2 correctly detected all cases of flap and radial tears of the acetabular labrum. We believe that this group of patients may have a different entity than that seen in the remainder of cases. In patients with femoroacetabular impingement, lesions occur at the attachment of the labrum to the acetabulum, initially leaving the body of the labrum intact [24]. The repetitive shearing forces cause the high-signal cleft identified on MRI to occur at the labral-chondral transitional zone rather than in the body of the labrum itself. We believe that traumatic labral tears, characterized by a linear cleft of high signal extending into the body of the labrum, are a separate entity and are less frequently identified (Figs. 8 and 9). Ganz et al. [8] observed that solitary labral tears resulting from an acute traumatic event are rare and that labral tears without chondral injury are infrequently seen. In our series, only one (14%) of seven patients with a labral tear showed acetabular chondromalacia compared with 18 (47%) of 38 patients with abnormality at the labral–chondral transitional zone.

The evaluation of abnormalities at the labral-chondral transitional zone included an assessment of both separation of the labrum and adjacent cartilage abnormality. The assumption that the two are linked is based on work by Beck et al. [25] and Schmid et al. [26]. Those authors both noted that in patients with femoroacetabular impingement, adjacent acetabular cartilage abnormalities were found in all patients with labral abnormality. In a recent study by Kassarjian et al. [14], a triad of MR arthrographic findings was described. This triad was composed of abnormal head and neck morphology, anterosuperior cartilage abnormality, and anterosuperior labral abnormality, and was identified in 37 of 42 patients in their series. In our study, both reviewers detected 97% of abnormalities at the labral-chondral transitional zone. When the abnormality at this site was

graded, accuracy ranged from 87% to 92%. Reviewer 1 underestimated the degree of abnormality, and reviewer 2 overestimated the severity of involvement.

As in previous studies [14, 25–27], the predominant site of involvement was the anterosuperior labrum. In our series, 86% of patients had involvement at this site (50% anterosuperior and 36% anterosuperior and superolateral). Beck et al. [25] found involvement of the anterosuperior labrum occurred in all 19 patients in their series. It is important to be aware of the potential pitfall of the sublabral sulcus when interpreting MRI of the hip. The sublabral sulcus occurs as a normal variant in the posteroinferior position, and its location is distinct from most other labral abnormalities [28].

In our study, acetabular articular cartilage abnormality was correctly identified in 89-94% of cases and femoral articular cartilage in as many as 100% of cases. MRI of the hip is good at identifying high-grade, full-thickness chondral lesions when complete loss of the intermediate-signal layer of hyaline articular cartilage can be identified (Fig. 6). In such cases, the femoral articular cartilage may be seen abutting the subchondral bone plate. MRI also identifies discrete fissures or clefts as a high-signal line that can be seen traversing the intermediate-signal articular cartilage. However, identification of early chondromalacia is problematic. In our experience, it is impossible to appreciate early signal alteration in the femoral or acetabular cartilage, which can be identified in the patella cartilage, for example. This probably relates to the lower cartilage volume and apposition of the femoral and acetabular cartilage surfaces in the hip. It is difficult to draw conclusions about the accuracy of unenhanced MRI of the hip in identifying femoral cartilage lesions because of the small number of patients in this series.

An abnormal shape of the femoral head was identified in 39% of patients, and acetabular retroversion was present in 11%. The associated abnormality of acetabular cyst formation was found in patients with more advanced-grade lesions, and herniation pits and an abnormal bone prominence at the femoral head and neck junction are also more frequently found in advanced cases. Leunig et al. [29], in their series, found a prevalence of fibrocystic change at the anterosuperior femoral neck in 33% of patients with femoroacetabular impingement, compared with 24% in our series. In our series, only a single case

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Fig. 12—The labral chondral transitional zone in femoroacetabular impingement—schematic, MRI, and arthroscopic findings.

A, Schematic diagram of labral-chondral transitional zone shows cleft (*arrow*) that is apparent at this site in patients with femoroacetabular impingement.

B, Coronal proton density—weighted fast spin-echo sequence (TR/TE, 4,000/34) in 32-year-old man shows MR appearances illustrated in A. High-signal cleft can be seen at labral—chondral transitional zone and extending to subchondral bone plate (*black arrow*). Note also cystic change at anterosuperior femoral neck (*white arrow*).
C, In 32-year-old man, arthroscopic view of labral—chondral transitional zone shows full-thickness loss of articular cartilage in adjacent acetabulum (grade 3) (*black arrow*) and separation of labrum (*white arrow*) at its attachment, which has been lifted by arthroscopic probe.

(2%) of paralabral cyst formation was identified compared with 14% of cases identified in a previous article [14]. However, paralabral

cyst formation is less frequently identified in femoroacetabular impingement than in labral degeneration related to hip dysplasia [5].

Our study compared the MRI findings with the surgical findings at arthroscopy in patients with suspected femoroacetabular impingement. Hip arthroscopy is considered by some to be the gold standard in assessing intraarticular lesions of the hip joint [30, 31], and it facilitates proceeding to therapeutic intervention. Hip arthroscopy is an invasive and expensive technique, so in recent years there has been considerable interest in MRI of disorders of the hip. A number of authors have studied the accuracy of MR arthrography in identifying and evaluating labral and cartilage abnormalities of the hip joint [5, 9-12, 14]. Older studies showed limited success using unenhanced imaging to detect intraarticular disorders [16, 19]. Recently, Mintz et al. [15] reported 94% sensitivity in the detection of labral tears and 86-92% sensitivity in the detection of femoral and acetabular cartilage abnormalities.

Our MRI protocol uses a technique similar to that used by Mintz et al. [15] and provides an excellent method of assessing labral and articular cartilage abnormality. Our protocol provides good differential contrast between the low-signal labrum, the intermediate-signal hyaline articular cartilage, and the high-signal joint fluid. In our experience, labral and chondral abnormalities are best seen on sagittal oblique images, followed by coronal images. Once an abnormality has been identified on either sequence, confirmation should be sought of the extent of the lesion in alternative imaging planes.

We emphasize the importance of using a surface coil in routine hip imaging, which is neglected in some centers. In our opinion, the routine use of MR arthrography is not warranted for evaluating intraarticular abnormalities of the hip. MRI has the advantage of providing a noninvasive method of evaluating hip abnormalities. Preoperative imaging allows the surgeon to assess whether a resection osteoplasty of the anterior acetabular rim or of the femoral head and neck junction is required to relieve the impingement. Preoperative imaging is also of value in excluding occult disorders such as a stress fracture or osteonecrosis.

We acknowledge a number of limitations inherent in our study design. First, both radiologists were aware of the clinical suspicion of femoroacetabular impingement. Reviewer 1 (senior author) was aware of the clinical information in the original request, and reviewer 2 was aware of the purpose of the study, thus creating a potential bias. Second, the surgeon was aware of the MRI find-

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ings at the time of arthroscopy. It would not have been feasible to blind the surgeon to the MRI results because this information is of considerable use in preoperative planning. Third, no control group was included in our study because healthy individuals do not undergo hip arthroscopy. Therefore, whether these findings are present in asymptomatic patients of a similar age is not known. It has been postulated that abnormality of the labral-chondral transitional zone may be part of the degenerative process [1, 3]; however, our patient cohort was young (mean age, 32.3 years). Another inherent limitation of this study is the inability to detect early or partial-thickness loss of hyaline articular cartilage on MRI. Current techniques are not sufficiently sensitive to allow appreciation of milder grades of chondromalacia in the hip joint.

In conclusion, femoroacetabular impingement is an increasingly recognized entity that may predispose the individual to early-onset osteoarthritis. Recognizing this group of patients is important because early intervention may delay the natural history of this disease process. MRI is an excellent method of preoperative assessment and helps guide the surgeon as to the likely site of labral and chondral abnormalities. Furthermore, MRI may enable the referring surgeon to decide preoperatively which patients may require an arthroscopic versus an open surgical technique. In our experience, MR arthrography is not required to delineate the imaging findings in femoroacetabular impingement.

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