INTRODUCTION

Hip magnetic resonance (MR) arthrography has a high accuracy in the detection of labral tears (1–3) and is the imaging modality of choice in patients in whom there is a strong suspicion of labral lesions. Abnormalities of the acetabular labrum include partial tears, complete tears, and labral detachment, with detachments being more common than tears (4,5). There are reports of the successful assessment of the labrum without joint distention (6), however in a study by Czerny et al. the sensitivity and accuracy of MRI for nondistended joints were 30% and 36%, respectively, when compared with surgical findings. Sensitivity and accuracy of MRI increased to 90% and 91%, respectively, after joint distention with gadolinium contrast (7).

In a small group of eight patients, Sundberg et al. showed MR arthrography at 1.5 T and conventional MRI at 3 T, both identified seven out of eight labral tears. In one patient in whom the interpretations from the two examinations disagreed, the labrum demonstrated a marked increase in intrasubstance signal intensity indicative of a tear at 3 T MR imaging, whereas a normal labrum was shown at 1.5 T MR arthrography. At arthroscopy, the labrum was found to be torn (8).

ANATOMY

The acetabular labrum is a fibrocartilaginous structure which rims the acetabulum anteriorly, superiorly, and posteriorly, and which evolves into the fibrous transverse ligament inferiorly (9). The labrum may be separated from the transverse ligament by a defect that is filled with articular cartilage. This defect may be confused with a tear on MR and MR arthrographic images (10). The labrum serves to deepen the acetabulum; however, its role in maintaining stability is probably less critical than that of the glenoid labrum. On MR arthrography, the normal labrum is triangular in appearance with sharply defined margins. The labrum is thinnest anteroinferiorly and thickest posteroinferiorly and is typically low signal intensity on all imaging sequences. The capsule of the hip joint inserts directly at the base of the labrum anteriorly and posteriorly and superiorly, the capsule inserts several millimeters above the labral attachment. Inferiorly, the capsule blends with the transverse ligament (11) (Fig. 15.1).

MR ARTHROGRAPHY TECHNIQUE

MR arthrography of the hip is performed as a two-stage procedure. The first step is performed under fluoroscopic guidance. The preferred approach for hip arthrography is a direct anterior approach, targeting the lateral femoral neck or the lateral femoral head (Fig. 15.2). The intra-articular needle position is confirmed by injection of iodinated contrast material. Joint distention is achieved by injection of a dilute solution of gadolinium (12). The standard dilution of gadolinium for joint distention is 2.5 mm of gadopentetate dimeglumine (9). For a single hip this dilution may be achieved by mixing 0.1 mL of gadopentetate dimeglumine in 20 mL of normal saline, however, different gadolinium products may contain different gadolinium concentrations. The joint capacity is 8 to 20 mL. Intra-articular lidocaine injection also may be useful. Pain relief with intra-articular lidocaine further supports an intra-articular source. Failure to produce pain relief, however, does not exclude an intra-articular source. With the use of intra-articular gadolinium, axial, coronal, and sagittal T1-weighted fat suppressed images are acquired through the hip joint using a surface coil and field of view of 14 to 16 cm. It is important to use at least three imaging planes to ensure that all portions of the labrum are adequately assessed. An assessment of the entire pelvis is performed with T1 and short tau inversion recovery (STIR) coronal images that include the symphysis pubis and the sacrum, increasing the field of view to 36 to 40 cm.

Standard imaging planes sufficiently demonstrate all acetabular labral tears. Imaging in the axial oblique plane has the highest rate of detection of acetabular labral tears (10). Addition of radial imaging has not been found to reveal additional labral tears (11).

ANATOMICAL VARIANTS

One pitfall in the interpretation of MR arthrography of the hip is the question about the presence of a normal sulcus or recess at the anterosuperior aspect of the joint. To date, no conclusive data are available about whether such a sulcus may exist normally. The perilabral recesses are located at the labrocapsular junction on the capsular surface of the labrum. A sulcus created by the junction of the transverse ligament and the labrum is also a normal finding (Fig. 15.3). This sulcus should be known as the labroligamentous sulcus.
Another sulcus is located at the posteroinferior aspect of the joint, and it represents a physiologic cleft at the junction of the articular cartilage. The cleft may be partial or complete. Histologic studies have concluded that the articular cartilage and the labrum blend together seamlessly, which suggests that a separation between the articular cartilage and labrum would be abnormal (2,13,14). Cashin et al. studied the prenatal development of the human acetabular labral–chondral complex in 11 fetal hips, aged from 8 weeks of gestation to term. Morphologically, the anterior acetabular labral–chondral complex had a somewhat marginal attachment to the acetabular cartilage and seemed to cap its anterior part. There was an intra-articular labral projection which formed a recess between the articular surface of the acetabulum and the labrum. The posterior labrum differed in that it was directly attached to and continuous with the acetabular cartilage. It lacked a labral projection into the articular space. Under higher magnification, the attachment site of the labrum to the acetabulum anteriorly demonstrated a sharp, abrupt transition at the junction of the cartilaginous acetabulum and the labrum. Anteriorly, the collagen fibers at the junction of the acetabular cartilage ran parallel to the labral–cartilage junction, but posteriorly they were perpendicular to this junction when examined under polarized light (15).

Figure 15.1. Axial (A), coronal (B), and sagittal (C) MR arthrogram of the left hip showing a normal triangular appearance to the anterior and posterior labrum (white arrows).
Chapter 15  ■ Imaging of the Acetabular Labrum

Hodler et al. (2) examined 12 cadaver hips from elderly individuals to make their observations. The conclusions of Seldes et al. (13) and Tan et al. (14) are drawn from studies of 67 cadaveric specimens. Seldes and Tan, however, report tears at the anterosuperior margin in 74% of hips, and 89% of these tears were detachments. In their study, few normal anterosuperior labral margins were examined. The average age of their specimens was 78 years. The finding is of significance in the younger population but not the older population. In their study of six cadaveric hips (age range: 72 to 84 years), Czerny et al. (16) did not identify any sublabral sulci. Dinauer et al. (17) and Petersilge et al. (3) in their studies of 23 and 24 hips, respectively, were unable to confirm the presence of a sulcus at the anterosuperior portion of joint. In an arthroscopic study of 56 hips, Fitzgerald (5) found 41 tears with separation of the articular cartilage and labrum. Most tears were in the anterior aspect of the hip. Based on visual inspection, they reported that evidence of attempted healing of the defect was usually seen but a residual sulcus could be identified. The sulcus measured 2 to 5 mm in width and 8 to 20 mm in length, which would suggest that the sulcus is abnormal. The literature suggests that a normal cleft is located between the margin of the articular cartilage and the labrum and that this normal variant has an incidence of 5% to 6%. The margins of the cartilage edge and the border of the labrum are sharp. In contrast, any extension of contrast into the acetabular (osseous) labrum junction should be considered abnormal. Any irregularity of the margins of the cartilage edge or the adjacent labrum would indicate that the separation between labrum and cartilage is abnormal.

A defect in the capsule between the pubofemoral and iliofemoral ligaments may lead to communication between the joint and the iliopsoas bursa, and contrast may occasionally fill this structure (3). The bursa should not be confused with an extra-articular cyst or ganglion. The bursa typically lies lateral to the iliopsoas tendon, whereas extra-articular cysts are medial and usually adjacent to the acetabulum (18).

DIAGNOSTIC CRITERIA

The majority of acetabular labral tears reported in the MR arthrography and arthroscopy literature have occurred in the anterior or anterosuperior portion of the labrum (1,3). Isolated posterior labral tears are seen most frequently after a posterior hip dislocation or with dysplasia but are not commonly seen in other populations having hip arthroscopy. Lateral labral tears are encountered infrequently in arthroscopic evaluation. When lateral tears occur, they invariably are associated with additional labral and acetabular lesions (19). Leuing et al. (20) found in femoroacetabular impingement only undersurface tears were seen, whereas there was labral degeneration and volume increase in patients with dysplasia, although transitions from undersurface tears to complete avulsions from the acetabular rim were seen suggesting decompensation of the disease process.

Criteria for identification of torn labra at MR arthrography include labra with intrasubstance contrast material, and labra with irregular margins with and without labral detachment. Labral detachment is identified by contrast material interposed at the acetabular–labral interface with or without displacement of the labrum (1,3). A high percentage of tears reported in the literature are in the form of detachments rather than intrasubstance tears (1,3,5) (Fig. 15.4).

Cysts

Cystic lesions near the joints may represent either ganglion cysts or synovial cysts (21,22). Ganglia are cystic structures
lined by flat, spindle-shaped cells that contain mucin, they may arise from the joint capsule, tendon sheath, bursa, or subchondral bone (22). Synovial cysts are fluid-containing masses with synovial lining. The term paralabral cyst for the hip joint is preferred, because it describes the cystic lesion seen adjacent to the labrum, which can represent either a ganglion or a synovial cyst. Once a labral tear is present, the loss of congruency between the femoral head and the acetabulum may lead to elevated intra-articular pressure and joint effusion. The elevated pressure forces synovial fluid through the labral tear into the adjacent soft tissues, resulting in a para-acetabular cyst (23) (Fig. 15.5). Labral cysts may also be associated with intraosseous acetabular cysts in association with osteoarthritis. Synovial fluid under pressure may extend into bone through erosion and permeation of the articular cartilage with resultant cyst formation (22). The osseous lesion may then break out into the surrounding soft tissues in the form of a ganglion or synovial cyst because of continued pressure.

**CARTILAGE**

Aside from the symptomatic complaints because of labral tears, the importance of the pathology is its association with degenerative changes. McCarthy et al. found that 73% of 436 patients with fraying or tearing of the acetabular labrum at arthroscopy had chondral damage and that this chondral damage was more severe in patients with labral lesions. They also found that in 94% of these patients, the articular damage occurred in the same zone of the acetabulum as the labral lesions. They suggested that the relative risk of significant chondral erosion approximately doubles in the presence of a labral lesion. An isolated labral tear was found more often in younger patients, whereas a labral tear in conjunction with chondral lesions was found more often in older patients, indicating that a labral tear may precede and possibly lead to articular changes (24).

Criteria for the diagnosis of cartilage lesions on MR arthrography include a contrast material-filled defect, an area of cartilage signal intensity alteration, and secondary signs of osteoarthritis (subchondral sclerosis, subchondral cysts, and osteophytes) (25). MR arthrography has relatively...
Low diagnostic performance for evaluating the articular cartilage of the hip joint. The sensitivity of MR arthrography for detecting surgically confirmed cartilage lesions ranges between 41% and 79%, with specificity values ranging between 77% and 100% (25,26). Furthermore, the sensitivity for detecting surgically confirmed cartilage lesions ranges between 77% and 100% (27) (Fig. 15.6).

**Classification of labral tears**

Lage et al. described four basic etiologic and four basic morphologic patterns of acetabular labral tear based on arthroscopic findings. Morphologically, a type I tear or radial flap, was diagnosed on MR arthrography if a discrete contrast cleft was seen extending either partially or all the way through the labral substance creating a flap. A type II tear, radial fibrillated, was diagnosed if there was irregularity of the labral outline, but no discrete cleft within the labrum. A type III tear, longitudinal peripheral, was diagnosed when there was contrast extending through the labrum either very near to or at the junction between the labrum and the acetabulum. A type IV unstable tear was diagnosed if the labrum had a thickened, distorted appearance. These criteria have their limitations as an unstable labrum often becomes thickened and distorted when it is unstable, but not all unstable tears are thickened (32) (Fig. 15.8).

Lage et al. described four categories of labral tears based on etiology.

1. Traumatic, based on a clear history of hip injury and subsequent onset of symptoms. More recently, a traction injury of the labrum by the iliopsoas tendon has been reported in some cases (8), with the intra-articular portion of the iliopsoas tendon noted to be attached to the labrum in those cases.

2. Congenital, based on the presence of acetabular dysplasia, defined as a center-edge angle of <25 degrees and/or a Tönnis angle of >10 degrees (33).

3. Degenerative, based on radiographic evidence of arthritic changes, such as joint space narrowing or osteophytes, or the identification of severe chondral damage at the time of operative intervention. Degenerative tears also can be seen in association with inflammatory arthropathies. The extent of the tear is related to the degree of degenerative changes present in the joint. Stage I degenerative tears are localized to one segment of an anatomic region (anterior or posterior) whereas stage II tears can involve an entire anatomic region, and stage III tears are diffuse and involve greater than one anatomic region. Higher stage tears are associated with more pronounced degenerative changes in the acetabulum and femoral head (19).

4. Idiopathic, based on the absence of any other findings. However, three recent studies in which the presence of osseous abnormalities was retrospectively examined in patients with a labral tear demonstrated that the majority (49% of 78, 79% of 99, and 87% of 31) had an osseous dysmorphism consistent with femoroacetabular impingement (34–36). It would therefore be more appropriate to rename the so-called idiopathic group femoroacetabular impingement (Fig. 15.9).

The Czerny classification, assesses labral morphology, intralabral signal, presence of tear or labral detachment and...
the presence or absence of an adjacent perilabral recess on MRI (1) and has been reported to have an excellent correlation with arthroscopic findings. In this classification system, the labrum is graded as: stage 0 = normal labrum, stage 1A = increased signal intensity within the center of the labrum that does not extend to the surface and triangular shape with perilabral recess, stage 1B = similar to 1A but with a thickened labrum without a perilabral recess, stage 2A = extension of the contrast material into the labrum without detachment with a perilabral recess and a triangular shape, stage 2B = same as 2A except the labrum is thickened without perilabral recess, stage 3A = detachment of the labrum from the acetabulum and triangular shaped, and stage 3B = labral detachment with a thickened labrum. Only stages 2A and B and 3A and B are considered to represent labral tears.

ASSOCIATIONS

FEMOROACETABULAR IMPINGEMENT

In cam-type impingement, the anterior-superior femoral head–neck junction, which normally has a concave

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**Figure 15.7.** Radiograph (A) of the hip coronal (B), and axial (C) images from an MR arthrogram of the right hip showing an os acetabuli (arrows).
configuration, becomes either flattened or convex. Because of this morphologic abnormality, the femoral head may become aspherical. The exact etiology of this abnormal femoral head–neck morphology is not clear. Although some have suggested that it may be due to a subclinical slipped capital femoral epiphysis, there is other evidence that suggests that the abnormal morphology is due to abnormal separation of the common physis of the femoral head and the greater trochanter during development (37). As the hip is placed in flexion and internal rotation, because of the loss of the normal concavity in this region, the femur abnormally touches the acetabular rim. This abnormal contact results in damage to acetabular labrum and acetabular cartilage. A triad of MR arthrographic findings has been described in patients with cam-type femoroacetabular impingement (38). The triad consists of an abnormal alpha angle, an anterior-superior acetabular cartilage lesion, and an anterior-superior acetabular labral tear. In that study, 90% of patients with clinical impingement had the triad of MR arthrographic findings (Fig. 15.10).

In pincer-type impingement, the cartilage lesions are often seen along the posterior aspect of the acetabulum because of a contrecoup type of injury as the femur abnormally touches the acetabular rim. The associated labral degeneration and tears are most common in the anterosuperior labrum. The exact association between the so-called synovial herniation pits of the femoral neck and femoroacetabular impingement is not entirely clear (39). A recent study suggests that there is a high prevalence of these cysts in patients with femoroacetabular impingement (40). However, another study, which focused on patients with cam-type femoroacetabular impingement, demonstrated that only 5% had these cysts (38). Thus, it is possible that these cysts are more common in patients with pincer-type impingement than in those with cam-type impingement.

Tears caused by the pincer-type mechanism extend perpendicular to the surface of the labrum and, in more severe cases, to the subchondral bone, in which case the labrum may become calcified. Endochondral ossification within the labrum is also typically seen. Tears caused by the cam-type mechanism occur at the transition zone between the

**Figure 15.8.** Sagittal (A) and axial oblique (B) images from an MR arthrogram of the hip showing a tear of the anterosuperior labrum which is detached at the base (arrows).

**Figure 15.9.** Axial image from an MR arthrogram of the right hip showing a tear of the posterior labrum (arrow).
fibrocartilaginous labrum and the articular hyaline cartilage and are perpendicular to the articular surface (41).

In pincer-type impingement, repeated contact between the femoral neck and the prominent anterior aspect of the acetabular rim leads to initial damage of the labrum (42,43) and often a contrecoup lesion leading to premature wear of the posterior articular surface.

DYSPLASIA

With a shallow acetabulum the labrum is exposed to increased load resulting in degeneration and/or detachment from the rim. The superior labrum assumes a portion of the weight-bearing load as a result of the poor bony coverage of the femoral head by the dysplastic acetabulum (28,44). This increased stress eventually leads to degeneration and tearing of the labrum. Once a tear is present the femoral head lacks its peripheral cover and eventually there is migration out of the joint. Labral detachment predisposes to extraosseous ganglia in soft tissues and splits in the labrum or acetabular cartilage (45) allowing the penetration of synovial fluid into subchondral bone, predisposing to intraosseous ganglia. These morphologic and structural alterations of the cartilage and bone lead to degenerative arthritis (28,44) (Fig. 15.11).

ACETABULAR RETROVERSION

The alignment of the mouth of the acetabulum does not face the normal anterolateral direction, but inclines more posterolaterally. As a result of retroversion, anterolateral cover for the femoral head is more extensive than normal. It is possible that during flexion of the hip the edge of the anterior wall and the anterosuperior roof of a retroverted acetabulum are vulnerable to impingement because they tend to lie directly in the path of the femoral neck. As this progresses, there is fragmentation at the bony acetabular edge and signs of degenerative change of varying degrees (46).

MR arthrography offers the best imaging of the acetabular labrum. Imaging is best achieved using a high field strength magnet with a small field of view for optimum image quality. Unlike the glenoid labrum, there is little anatomic variation in the appearance of the acetabular labrum. Irregularity of the labrum and fluid extending into or through the labrum can be considered highly specific for labral tear. Furthermore, the presence of paralabral cysts have a high association with labral tear. MR arthrography is both sensitive and specific in the diagnosis of tears of the acetabular labrum.

REFERENCES

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