From the RSNA Refresher Courses

Chronic Adult Hip Pain: MR Arthrography of the Hip[1]

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This article describes the technique for performance and interpretation of magnetic resonance arthrography of the hip. A description of normal anatomy of the hip is presented, and the appearance of the abnormal labrum is discussed. Labral detachments and tears are the most common clinically significant abnormalities to be identified. These abnormalities are recognized on the basis of the presence of contrast material at the acetabular-labral interface or within the substance of the labrum. Many varied appearances of the labrum have been identified within the asymptomatic population, and the correlation of these appearances is contrasted with those of the abnormal labrum in symptomatic patients. To date, it is difficult to draw conclusions regarding the significance of an absent labrum or of a sulcus at the acetabular-labral junction. Experience suggests that an absent labrum in a symptomatic individual is pathologic and that a sulcus at the anterosuperior acetabular-labral junction may be a normal variant.

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Introduction

Evaluation of the patient with chronic mechanical hip pain has remained a diagnostic dilemma for physicians. The differential diagnosis is diverse including common entities such as osteoarthritis, fracture, and avascular necrosis, as well as less common entities including pigmented villonodular synovitis, synovial osteochondromatosis, snapping hip syndrome, and hemorrhage into the ligamentum teres (1,2). Similar to findings in the knee and shoulder, radiographs appear normal in the vast majority of patients with internal derangement as a cause for hip symptoms (2). In one study, labral lesions were identified at arthroscopy in 55% of patients with intractable hip pain (2). Owing to the previous lack of a reliable imaging examination, diagnosis was often delayed. In another study, patients averaged 25 months of symptoms before the cause was established (3).

Although lesions are easily identified at arthroscopy, this technique is not widely available. An invasive procedure, hip arthroscopy is not without risk. As with other joints in the body, magnetic resonance (MR) arthrography of the hip has emerged as a technique for diagnosis of internal derangement of the hip (4–9). In addition to depicting labral lesions, MR arthrography may also depict intraarticular loose bodies, osteochondral abnormalities, and abnormalities of the supporting soft-tissue structures.

In this article, the normal anatomy of the hip and the technique for MR arthrography are presented, as well as the appearance of normal and abnormal labra at MR arthrography and the clinical aspects of pathologic labral conditions, detachment or tears.

Normal Anatomy

The hip is a ball-and-socket joint, which exhibits a wide range of motion in all directions. The spherical acetabular socket covers the femoral head nearly completely except for its inferior medial aspect, known as the acetabular notch, where the socket is deficient (Figs 1, 2). The transverse acetabular ligament spans this deficient portion of the acetabulum. The relationship between acetabulum and femur, with the acetabular cup oriented anteriorly and laterally relative to the pelvis and the femoral neck directed posteriorly, contributes to the overall stability of the joint.

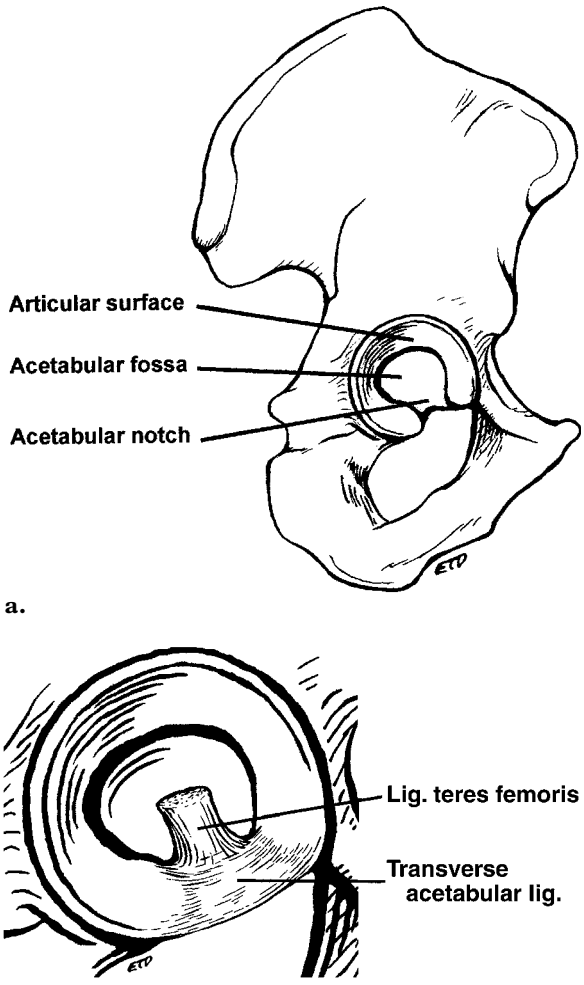


Figure 1. Normal hip anatomy. **(a)** Drawing depicts the acetabulum, the spherical socket of the ball-and-socket hip joint. The socket is deficient anteroinferiorly, as is the lunate-shaped articular surface. This opening is known as the acetabular notch. The central cartilage-devoid depression is known as the acetabular fossa. **(b)** Detailed view of the acetabulum demonstrates the transverse acetabular ligament spanning the acetabular notch and the insertion of the ligamentum teres femoris onto the transverse ligament.

The lunate, a horseshoe-shaped articular cartilage, lines the acetabulum. The cartilage-devoid central region of the acetabulum, the acetabular fossa, is filled with fibrofatty tissue and is lined with synovium. The entire femoral head is covered with articular cartilage except for the region of the fovea capitus. The fovea is a depression along the central surface of the femoral head. The ligamentum teres femoris arises from this depression and courses inferiorly within the joint to insert onto the transverse ligament. Its function is unknown.

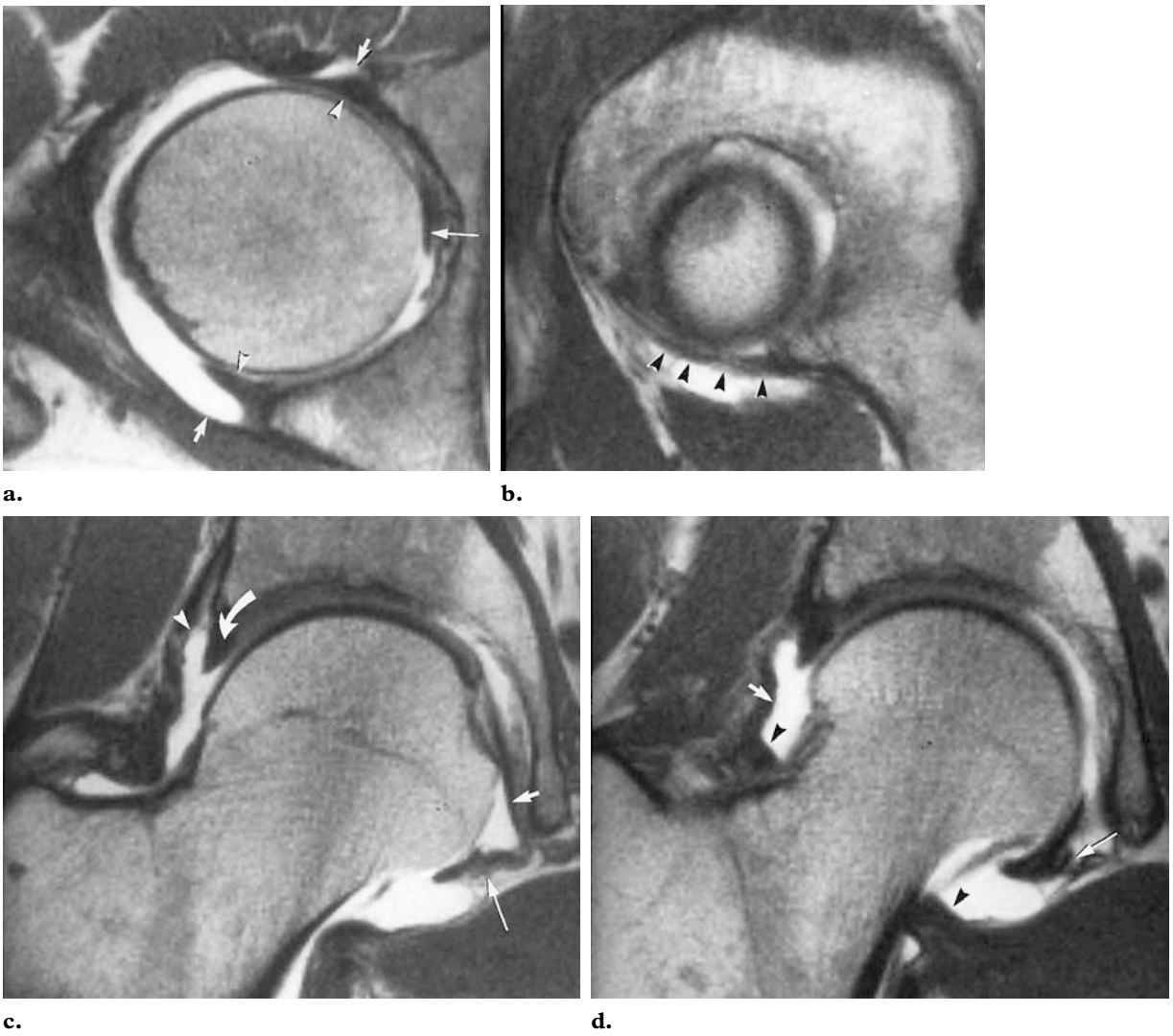
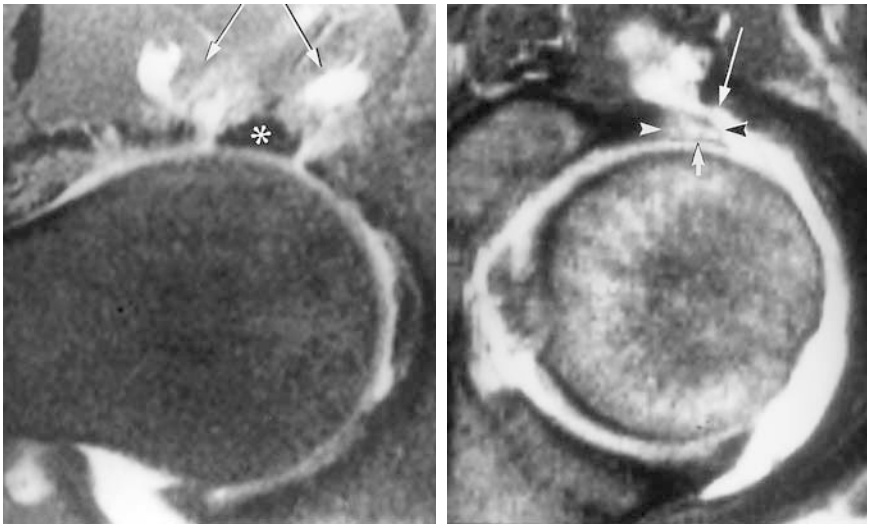


Figure 2. Normal anatomy in a 43-year-old man with chronic hip pain is depicted on T1-weighted (repetition time msec/echo time msec = 600/17) MR images obtained with intraarticular contrast material. **(a)** Axial MR image demonstrates the normal triangular cross section of the anterior and posterior labrum (arrowheads), small perilabral sulci (short arrows), and cross section of ligamentum teres (long arrow). **(b)** Sagittal MR image along the medial joint includes the transverse ligament (arrowheads). **(c)** Midline coronal MR image shows the long axis of the ligamentum teres (short arrow) and its insertion onto the transverse ligament (long arrow). A normal superior labrum (curved arrow) and the larger superior perilabral recess (arrowhead) are seen. **(d)** On a more posterior coronal MR image, the circular fibers of the zona orbicularis (arrowheads) are evident, as are the longitudinal fibers of the iliofemoral ligament (short arrow). A cleft is seen where the transverse ligament and labrum start to merge (long arrow).

The fibrocartilaginous labrum rims the acetabulum and is triangular in cross section. The labrum is thicker posterosuperiorly and thinner anteroinferiorly (5,9–11). This fibrocartilage lacks the highly organized structure seen within the fibrocartilaginous meniscus of the knee (7). The labrum is attached directly to the osseous rim of the acetabulum. It blends with the transverse ligament at the margins of the acetabular notch. A cleft is created where the ligament and labrum join, and this cleft should not be confused with a labral tear (Fig 2) (6). Unlike the glenoid labrum, the function of the acetabular labrum is unknown (12).

The joint capsule inserts onto the acetabular rim. Along the anterior and posterior joint margins, the capsule inserts directly at the base of the labrum; thus, a small perilabral recess is created between the labrum and joint capsule (10,13).



3. 4.

Figures 3, 4. **(3)** Hip pain of unknown cause in a 45-year-old active man. Fat-suppressed T1-weighted (735/17) axial MR image obtained with intraarticular contrast material demonstrates filling of the iliopsoas bursa (arrows) both medial and lateral to the tendon (*). **(4)** Extensive labral tear in a 38-year-old woman who is an avid runner. T1-weighted (600/17) axial MR image depicts contrast material throughout the labral substance. The labrum is enlarged and maintains its triangular shape (arrowheads). An extensive linear intralabral collection of contrast material is present (short arrow). Communication between the joint and the iliopsoas bursa is evident (long arrow).

Superiorly, the capsule inserts several millimeters above the labrum, creating a much larger perilabral recess. The capsule has several thickenings, which serve to reinforce the joint (13). These thickenings include the pubofemoral, iliofemoral, and ischiofemoral ligaments, which are composed of superficial longitudinally oriented fibers. A deep layer of circularly oriented fibers known as the zona orbicularis encircles the capsule at the base of the femoral neck. The iliopsoas tendon is intimately related to the anterior aspect of the hip joint. In 10%–15% of individuals, a direct communication exists between the joint capsule and bursa of the iliopsoas tendon (Figs 3, 4) (13).

Technique for MR Arthrography

MR arthrography of the hip, like MR arthrography elsewhere, is a two-step procedure. Joint injection is performed in the fluoroscopic suite, followed by MR imaging in the MR imaging suite. With the development of MR interventional techniques, this procedure may eventually be performed entirely in the MR imager (14). For hip puncture, the patient is placed on the fluoroscopic table with a bolster under the knees and with both feet taped together to maintain internal rotation of the hip. A direct anterior or anterolateral approach to the hip is used. A small amount of iodinated contrast material is injected to document intraarticular needle position. Once the intraarticular position is confirmed, a dilute solution (0.2 mmol/L) of gadopentetate dimeglumine (Magnevist; Berlex Laboratories, Wayne, NJ) is injected. To obtain this dilution, 0.1 mL of gadopentetate dimeglumine is diluted in 20 mL of normal saline solution. Joint capacity of the hip ranges from 8 to 20 mL (5,9). Lidocaine may be injected at this time. Pain relief after injection is a positive indicator of an intraarticular source of hip pain (1). Unfortunately, the converse, that a lack of response to injection excludes an intraarticular source, is not true (1). Once injection is complete, the patient is transferred to the MR imager.

A surface coil or phased-array coil should be used to obtain optimal signal-to-noise ratio. Imaging parameters should include a field of view of 14–16 cm, section thickness of 3–5 mm for spin-echo sequences or 1.5 mm for gradient-echo sequences, and matrix of 192–256 × 256. Because of the spherical nature of the hip joint, images must be obtained in three orthogonal planes. The

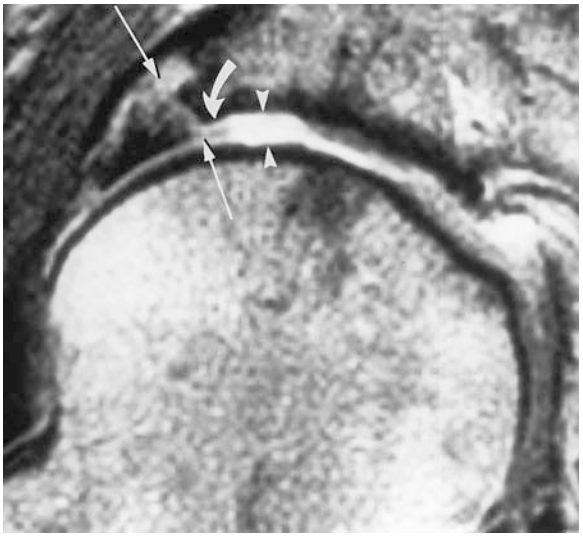


Figure 5. Developmental dysplasia of the hip in a 62-year-old man. T1-weighted (630/17) coronal MR image obtained with intraarticular contrast material depicts uncovering of the lateral aspect of the femoral head. The labrum is enlarged with irregular margins and an abnormal interface with the acetabular rim (straight arrows). Multiple sites of articular cartilage loss are evident (arrowheads). A tiny fragment of cartilage or labral tissue is adjacent to the site of detachment (curved arrow).

traditional axial, sagittal, and coronal planes may be used. Oblique axial (also known as oblique sagittal) and oblique coronal planes have been described (4). The orientation of these planes is more perpendicular to the orientation of the labrum, thus optimizing demonstration of these structures (4). With a coronal (scout) view, the oblique axial (oblique sagittal) plane is oriented along the long axis of the femoral neck. With a true sagittal image, the oblique coronal plane is directed along the long axis of the ilium.

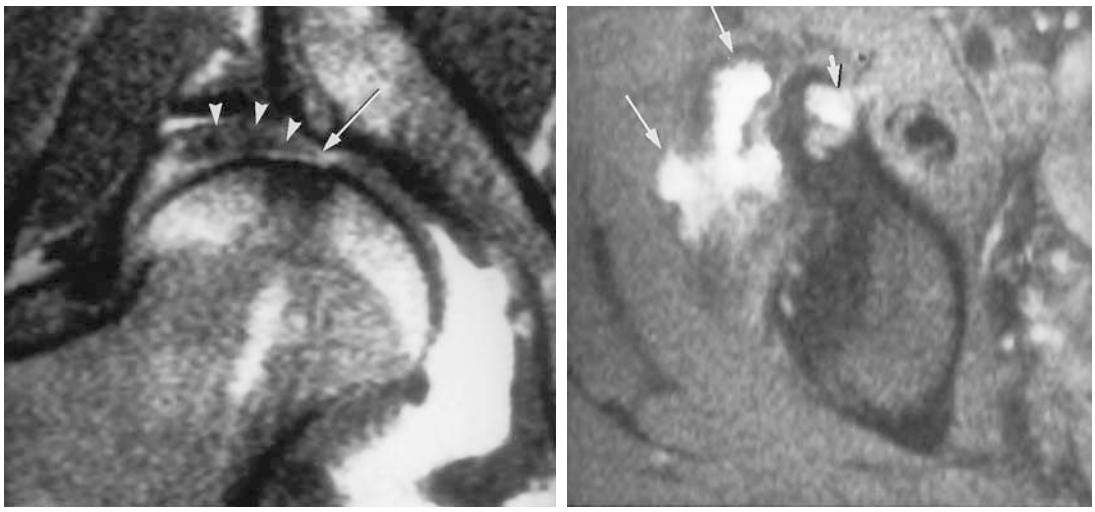
T1-weighted imaging is used to visualize the high signal of the intraarticular gadopentetate dimeglumine solution. Fat saturation increases contrast between the intraarticular gadopentetate dimeglumine and the adjacent soft tissues. T1-weighted gradient-echo sequences may also be used (4). These sequences have the advantage of allowing use of very thin sections that eliminate partial volume averaging artifacts and increase detection of small tears (4). Additional imaging with a short inversion time inversion-recovery (STIR) sequence or fat-suppressed T2-weighted sequence, usually in the coronal plane, allows detection of an unsuspected pathologic condition in the surrounding soft tissues and adjacent osseous structures.

Clinical Aspects of Pathologic Labral Conditions

Labral lesions have a strong correlation with anterior inguinal pain, painful clicking, transient locking, and giving way of the hip (2,3,15,16). Pain may be reproduced with flexion and internal rotation of the hip (17,18). An audible click may also be present. The patient history usually does not reveal significant trauma (6). The onset of pain may be related to sports and may involve a mild twisting or slipping injury (17,18). Major trauma such as dislocation may result in labral tear, and the labral fragment may prevent anatomic reduction (19–22). Radiographs in patients with labral tears are typically unremarkable. If early osteoarthritic disease is present, the pain is out of proportion to the radiographic changes.

Treatment of a pathologic labral condition includes resection or repair of a tear (1,2,15,18,23,24). Arthroscopic techniques are preferred to open arthrotomy, although arthroscopy of the hip is still not widely practiced. Treatment is aimed at pain relief and the prevention of secondary osteoarthritis (15). Although it was initially feared that resection of the labrum may predispose to osteoarthritis, similar to acceleration of arthritis after meniscectomy, that fear has not been substantiated (12). Patients without radiographic evidence of osteoarthritic disease have more successful outcomes after treatment of their labral tear than do patients who have already developed radiographic evidence of osteoarthritis (3).

Patients with developmental dysplasia of the hip are at increased risk for labral tears. This risk results from the weight-bearing role of the labrum owing to the deficient acetabular coverage of the femoral head (Fig 5) (17). In patients with developmental dysplasia, the acetabular rim and the labrum are placed under increased stress. In developmental dysplasia of the hip where the acetabulum and femoral head are congruent, essentially the acetabular roof is short, and the osseous rim is stressed (25). This situation results in rim fragmentation and intraosseous cyst formation. In developmental dysplasia of the hip where the femoral head and acetabulum are incongruent, the acetabulum is vertical and the acetabular radius is greater than the femoral head radius; thus, abnormal shearing forces placed on the labrum



a. b.

Figure 6. Marked developmental dysplasia of the hip in a 35-year-old woman. **(a)** T1-weighted (640/17) coronal MR image depicts a short acetabular roof. The labrum is markedly abnormal, having lost its triangular shape, and it has diffuse intermediate signal intensity (arrowheads). Its normal attachment to the acetabular rim has been disrupted (arrow). **(b)** Fat-suppressed T1-weighted (605/15) axial MR image through the acetabular roof depicts a contrast-enhanced cyst within the soft tissues (long arrows), as well as its intraosseous extension into the anteroinferior iliac spine (short arrow).

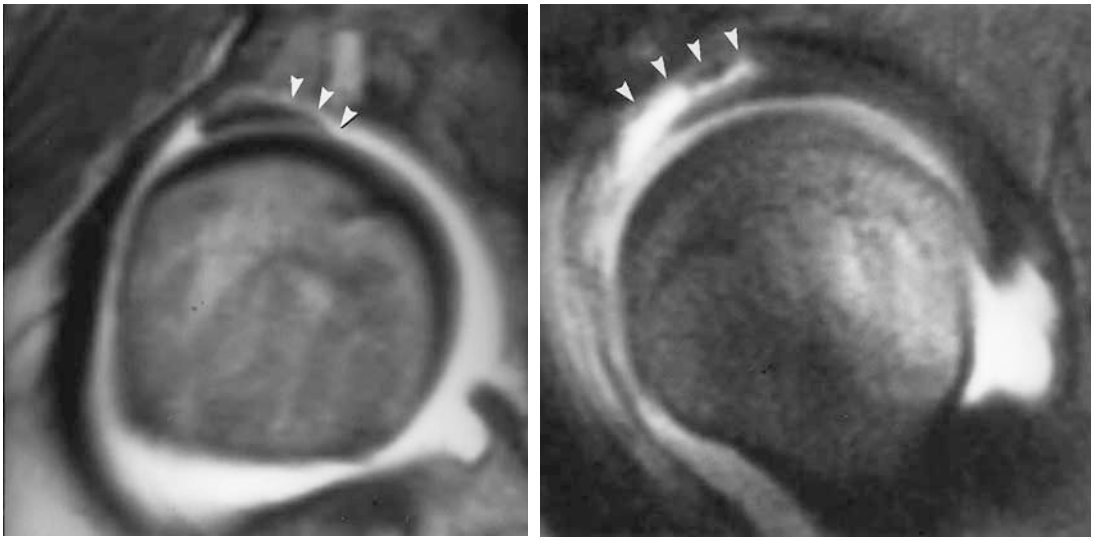
lead to labral hypertrophy and detachment (Fig 6) (25). Perilabral cysts accompany this form of developmental dysplasia of the hip. The possibility of a pathologic labral condition should be considered in individuals with developmental dysplasia of the hip in whom the pain is disproportionate to the radiographic changes, as well as in patients who have not experienced significant improvement after osteotomy. The fact that a detached labrum increases the risk of failure of treatment has been recognized (26).

MR Imaging Appearance of Normal and Abnormal Labra

The normal labrum has uniform low signal intensity on T1-weighted images, with slightly higher signal intensity on gradient-echo images (8,9). The edge of the labrum may overlap the periphery of the articular cartilage, creating the appearance of cartilage undercutting the labrum (9,10). Internal intermediate signal intensity may be present, particularly at the junction of the labrum and articular cartilage (5,7). Intermediate or high intralabral signal intensity on T1- and proton-density–weighted images has been described in 58% of asymptomatic labra studied without the benefit of articular distention (Fig 7) (11). On T2-weighted images, 37% of labra had internal intermediate signal intensity, and 87% of these signal intensity abnormalities were located within the superior labrum (11). These signal intensity

Figure 7. Hip pain and no history of trauma in a 41-year-old woman. T1-weighted (640/17) coronal MR image obtained with intraarticular contrast material shows diffuse intermediate signal intensity throughout the superior labrum (arrow). Normal morphology is maintained. On the basis of the current literature, the clinical significance and cause of this appearance are not known.

changes were most commonly linear or curvilinear and often extended to the labral margin (11). On T2-weighted images, globular foci of increased signal intensity without labral distortion have been attributed to cystic or mucoid degeneration (11). One study of cadaveric labra at histologic examination reveals that the internal intermediate signal intensity does not correlate with the presence



a. **b.**

Figure 8. Bucket handle labral detachment in a 17-year-old girl with developmental dysplasia whose pain was out of proportion to radiographic changes. **(a)** T1-weighted (450/17) coronal MR image obtained with intraarticular contrast material demonstrates contrast material interposed along the entire superior acetabular-labral interface (arrowheads). **(b)** Fat-suppressed T1-weighted (980/14) sagittal MR image obtained with intraarticular contrast material shows that the detachment involves the anterior and anterosuperior labrum (arrowheads).

Figure 9. Onset of pain during a golf game in a 66-year-old man who is an avid golfer. Fat-suppressed T1-weighted (500/17) coronal MR image obtained with intraarticular contrast material depicts osteoarthritic disease, with joint space narrowing and osteophyte formation. The labrum is detached from the acetabulum, with contrast material at the acetabular-labral interface (short arrow). The labrum is abnormal, with loss of its triangular shape and diffuse intermediate signal intensity (arrowhead). A small cyst is developing in the adjacent soft tissues (long arrow).

of degenerative disease (7). The internal signal intensity was attributed to fibrovascular structures within the labral substance (7). The significance of intermediate signal intensity that extends to the margin of the labrum is not yet known. The finding that intrasubstance signal intensity changes on T1-weighted images increased with age suggests some relationship with degeneration (27). Increased labral volume has also been attributed to degeneration (8,9). Irregularity of the margins may reflect degeneration or small tears and also has increasing frequency with increasing age (9,11).

Use of intraarticular contrast material is necessary to differentiate torn and detached labra from other forms of pathologic labral conditions (4,7,9). This includes separating internal signal intensity abnormalities secondary to tears from those due to other causes, as well as separating the normal signal intensity at the labral-acetabular junction from that secondary to detachment. The sensitivity and accuracy of MR arthrography for detection of labral tears and detachments is 90% and 91%, respectively, versus 30% and 36% for nonarthrographic MR images (4).

Detachments are the most common form of pathologic labral conditions (1,8). Detachments are identified on the basis of the presence of contrast material interposed at the acetabular-labral junction with or without accompanying displacement of the labrum (Figs 8, 9). This signal intensity has been ascribed to cartilage degeneration, fissures, partial detachment, and irregular insertion of fibrocartilage onto subchondral bone.

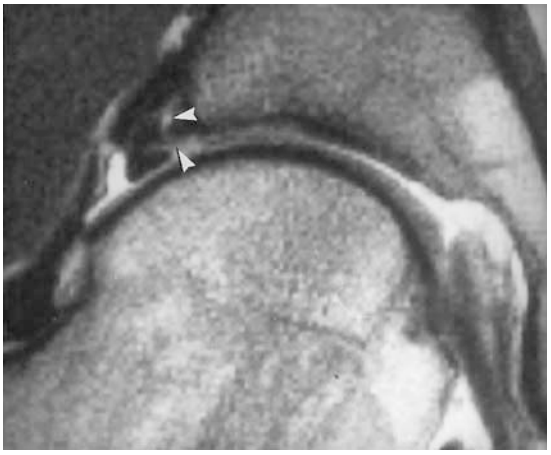


Figure 10. Hip pain after hip trauma in a 31-year-old man. T1-weighted (630/17) coronal MR image obtained with intraarticular contrast material depicts a complex tear (arrowheads) within the superior labrum.

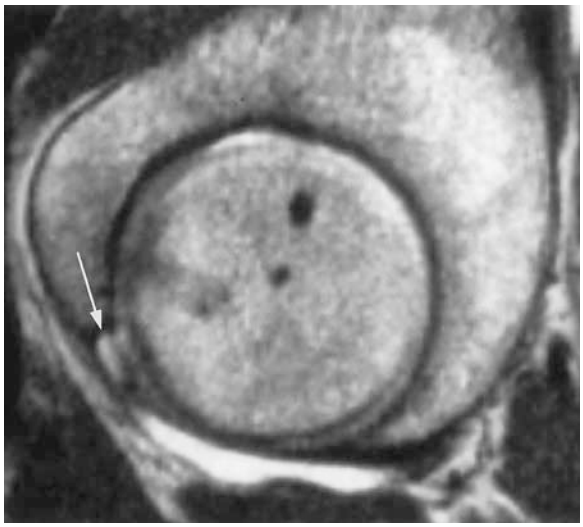


Figure 11. Hip pain for 19 months after a motor vehicle accident in a 29-year-old woman. T1-weighted (600/17) sagittal MR image obtained with intraarticular contrast material reveals an absent anterior labrum (arrow).

Most labral tears occur in the anterior through superior regions of the labrum (1,3–5,8,9,17). Tears of the posterior and posterosuperior labra have been identified in younger patients (18,24, 28). Tears are recognized on the basis of the presence of intrasubstance contrast material (Figs 4, 10). Chondral defects accompany approximately 30% of labral tears and detachments (1).

The significance of morphologic changes in the labrum is uncertain. Typically triangular in cross section, rounded and flattened labra have been identified in 11% and 9% of nonarthrographic MR images, respectively (27). The frequency of nontriangular cross section increased with age. At MR arthrography, blunting of the normally sharp inner margin would suggest abnormality of this region. Deformation and distortion of the labrum indicate abnormality (5). Any loss of the perilabral recess also indicates an abnormal labrum (6). The significance of absence of a segment of the labrum remains unknown at this time (Fig 11). Two studies of labra in asymptomatic individuals have reported that a portion of the labrum is absent in 10%–14% of this population (11,27). It is likely that some of these cases are false-positive for absent labral segments and are related to close apposition between the labrum and capsule, creating the appearance of no labrum. The inability to separate labrum and capsule on nonarthrographic MR images has been demonstrated in cadavers (7). Joint distention aids in separating these structures. In other cases, the segment of the labrum was truly absent. In these cases, the absent labral segment was always located anterosuperiorly, with a small superior remnant (11). This consistent pattern suggests that this appearance may be a normal variant (11). There is currently no scientific evidence to determine whether these absent labral segments represent anatomic variants or asymptomatic lesions. In a patient with symptoms suggesting a pathologic labral condition, the presence of an absent labral segment at MR arthrography should be considered abnormal.

Perilabral cysts may accompany a pathologic labral condition, especially detachment (5). The cysts seem to have a predilection for hips with developmental dysplasia (9,29). These cysts are typically extraarticular in location and may erode into the adjacent bone. They may or may not fill with contrast material at the time of MR arthrography. Identification of a cyst around the hip joint should raise the possibility of an underlying acetabular-labral tear (5,16,30).

Controversy remains regarding the reality of a sublabral sulcus of the anterosuperior aspect of the labrum (Fig 12). Such a sulcus has been described in histologic specimens from fetal hips, and the possibility that its existence was artifactual due to fixation techniques was raised (31). No sublabral sulci were identified in two separate studies of six and 12 cadaveric hips; thus, these authors believe that the presence of such a sulcus should always be considered abnormal (5,7). In one study of asymptomatic hips, increased signal intensity on T2-weighted images was seen at the acetabular-labral junction with or without accompanying labral displacement (11). A groove

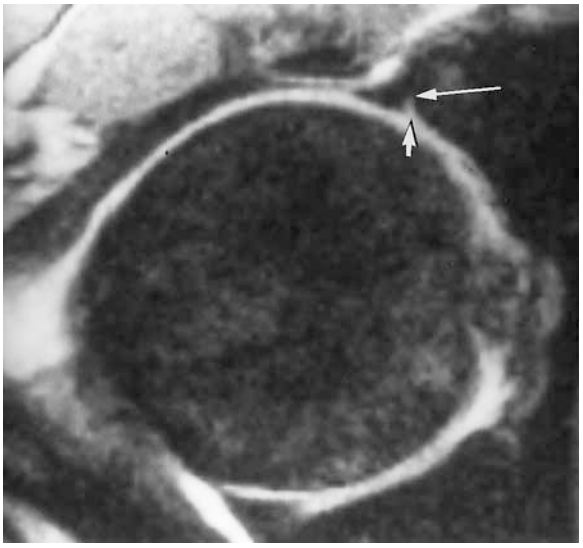


Figure 12. Hip pain for 1 year after a twisting injury in a 35-year-old man. Normal sulcus versus partial detachment? Fat-suppressed T1-weighted (500/17) axial MR image obtained with intraarticular contrast material shows a cleft with well-defined margins (short arrow) at the anterosuperior aspect of the joint. The acetabular-labral interface appears normal (long arrow). The labrum is not displaced.

between the cartilage and labrum has been described at MR arthroscopy (10). In my experience, this sulcus is a common finding on MR arthrographic images, and it is consistently located at the anterosuperior aspect of the joint. The consistent location of this finding and the well-defined margins of the sulcus as well as the presence of a well-defined insertion onto the subchondral bone have led me to believe that this appearance is likely an anatomic variant.

Summary

A pathologic labral condition, detachment or tear, is a common cause of chronic hip pain, and MR arthrography of the hip is the imaging procedure of choice for identifying an abnormal labrum. Detachments are more common than tears and are identified on the basis of the presence of contrast material interposed at the acetabular-labral junction. Tears are recognized on the basis of extension of contrast material into the labral substance, which may or may not be accompanied by changes in labral shape. The clinical implications of an absent labrum and of a sulcus between the labrum and acetabulum anterosuperiorly are not known.

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