Imaging of the acetabular labrum: a review

FL Carty¹, I Crosbie¹, J Ryan¹, JP Cashman²*

Abstract

Introduction
The acetabular labrum is a critical structure within the hip joint. Abnormality of the acetabular labrum is a significant cause of pain, and it plays an integral role in the development of osteoarthritis. This article reviews the normal anatomy and anatomical variants of the acetabular labrum and describes the technique for performing magnetic resonance arthrography. This article also reviews the diagnostic criteria and classification of tears of the acetabular labrum.

Conclusion
Magnetic resonance arthrography offers the best imaging of the acetabular labrum. The acetabular labrum has little anatomical variation. Irregularity of the labrum and fluid is associated with labral tear. Magnetic resonance arthrography is specific to the diagnosis of the acetabular labrum.

Introduction
Hip magnetic resonance (MR) arthrography has a high accuracy in the detection of labral tears¹–³ 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 tears⁴–⁵. There are reports of successful assessment of the labrum without joint distention⁶; however, in a study by Czerny et al. the sensitivity and accuracy of MR imaging (MRI) for non-distended joints was 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 contrast⁷. The aim is to review the imaging of the acetabular labrum.

Discussion

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. The intra-articular needle position is confirmed by injection of iodinated contrast material. Joint distention is achieved by injection of a dilute solution of gadolinium⁸. The standard dilution of gadolinium for joint distention is 2.5 mM of gadopentetate dimeglumine⁹. 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 capacity of the hip joint is 8–20 mL. 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 14–16 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 coronal images that include the symphysis pubis and the sacrum, increasing the field of view to 36–40 cm (Figure 1).

Anatomy
The acetabular labrum is a fibrocartilaginous structure, which rims the acetabulum anteriorly, superiorly and posteriorly, and which evolves into the fibrous transverse ligament inferiorly¹⁰. 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 images¹¹. 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 posterosuperiorly and has 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, superiorly the capsule inserts several millimetres above the labral attachment. Inferiorly, the capsule blends with the transverse ligament¹² (Figure 2).

Figure 1: Arthrogram of the right hip showing needle tip placement along the lateral aspect of the femoral neck (arrow).

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* Corresponding author
Email: james.cashman@gmail.com

¹ Department of Radiology, Mater Misericordiae University Hospital, Eccles Street, Dublin 7, Ireland
² Department of Orthopaedics, Mater Misericordiae University Hospital, Eccles Street, Dublin 7, Ireland

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. This sulcus should be known as the labroligamentous sulcus. Another sulcus is located at the posteroinferior position of the joint, and it represents a physiological cleft at the junction of the articular cartilage. The cleft may be partial or complete. Histological 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] 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, reported 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 = 72–84 years), Czerny et al.[15] did not identify any sublabral sulci. Dinauer et al.[16] and Petersilge et al.[17] 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[18] 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 2–5 mm in width and 8–20 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%–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 (Figure 3).

A defect in the capsule between the pubofemoral and iliofemoral ligaments may lead to communication between the joint and the iliofemoral bursa, and in contrast may occasionally fill this structure.[1] The bursa should not be confused with an extra-articular cyst or ganglion. The bursa typically lies lateral to the iliofemoral tendon, whereas extra-articular cysts are medial and usually adjacent to the acetabulum.[17]

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.[13] 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.[18]

Criteria for identification of torn labra at MR arthrography include labra with intra-substance contrast material, and labra with irregular margins with and without labral

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Figure 2: Axial (a) and coronal (b) MR arthrogram of the left hip showing a normal triangular appearance to the anterior and posterior labrum (arrows).

Figure 3: Sagittal MR arthrogram of the hip showing an anterior paralabral recess (arrow) at the transverse ligament attachment.
Competition interests: none declared. Conflict of Interests: none declared. All authors contributed to the conception, design, acquisition, analysis, and interpretation of the data, and all authors have given final approval of the version to be published. All authors abide by the Association for Medical Ethics (AME) ethical rules of disclosure.

Review


Detachment. Labral detachment is identified by contrast material interposed at the acetabular–labral interface with or without displacement of the labrum. A high percentage of tears reported in the literature are in the form of detachments rather than intra-substance tears (Figure 4).

Cysts
Cystic lesions near the joints may represent either ganglion cysts or synovial cysts. 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. 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 acetabulum, resulting in a para-acetabular cyst. Labral cysts may also be associated with intraosseous acetabular cysts in association with osteoarthritis. Synovial fluid under pressure may extend into the bone through erosion and permeation of the articular cartilage with resultant cyst formation. 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 (Figure 5).

Cartilage
Apart from the symptomatic complaints due to 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 the 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.

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 (sub-chondral sclerosis, sub-chondral cysts and osteophytes). 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%. Furthermore, the sensitivity for detecting cartilage delamination in patients with femoroacetabular impingement is as low as 22% (Figure 6).
Ossification rim and Os acetabularia

Distinct pathological changes occur in the labrum and acetabular rim in association with developmental dysplasia of the hip, and the term ‘acetabular rim syndrome’ has been used by Klaue et al. to describe these changes. These investigators recognise two types of anatomical abnormalities with different pathological changes within the rim. In type I changes, the acetabulum is shallow and vertical, and the femoral head and acetabulum are incongruent. In this situation, the labrum is subject to chronic shear stress because of the increased weight-bearing role. This stress leads to labral hypertrophy and subsequent separation from the acetabular margin. Soft tissue para-acetabular cysts may form. Identification of periarticular cysts should suggest the possibility of underlying labral tear or detachment. Although these cysts are more commonly seen in patients with developmental dysplasia, they are not unique to that patient population. With type II changes, the acetabulum and femoral head are congruent and the acetabular roof is short. The acetabular rim is stressed and eventually may fail with a fatigue fracture and os acetabuli formation. Intraosseous cysts may form. McCarty et al. hypothesised that with disruption of the chondrolabral interface, joint fluid is driven into the subchondral bone. This fluid leads to undermining of the articular cartilage and creates cartilage flaps, continued subchondral injury and subchondral cyst formation (Figure 7).

Classification of labral tears

Lage et al. described four basic aetiological and four basic morphological patterns of acetabular labral tear based on arthroscopic findings. Morphologically, a type 1 tear or radial flap was diagnosed if a discrete contrast cleft was seen extending either partially or all the way through the labral substance creating a flap. A type 2 tear, radial fibrillated, was diagnosed if there was irregularity of the labral outline, but no discrete cleft within the labrum. A type 3 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 4 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.

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

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, 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 centre-edge angle of <25° and/or a Tonnis angle of >10°.

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

Figure 7: Radiograph (a) of the left hip. Coronal (b) and axial (c) images from an MR arthrogram of the hip showing an os acetabuli (arrows).
degenerative changes present in the joint. Stage I degenerative tears are localised to one segment of an anatomical region (anterior or posterior) whereas Stage II tears can involve an entire anatomical region, and Stage III tears are diffuse and involve greater than one anatomical region. Higher stage tears are associated with more pronounced degenerative changes in the acetabulum and femoral head.

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 patients) had an osseous dysmorphosis consistent with femoroacetabular impingement. It would, therefore, be more appropriate to rename the so-called idiopathic group femoroacetabular impingement (Figure 8).

The Čzerny classification assesses labral morphology, intralabral signal, presence of tear or labral detachment and the presence or absence of an adjacent perilabral recess on MRI 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 centre 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.

**Conclusion**

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 anatomical 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 has a high association with labral tear. MR arthrography is both sensitive and specific in the diagnosis of tears of the acetabular labrum.

**Abbreviations list**

MR, magnetic resonance; MRI, MR imaging.

**References**


