MR Arthrography of the Adult Acetabular Capsular–Labral Complex: Correlation with Surgery and Anatomy

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OBJECTIVE. Our purpose was to describe the appearance of the acetabular capsular–labral complex on MR arthrography and to correlate this appearance with surgical findings in adult patients and with gross anatomic findings in cadavers.

SUBJECTS AND METHODS. MR arthrography of the hip joint was performed in 40 patients and six cadavers. All patients underwent subsequent arthrotomy of the hip. MR arthrography consisted of a T1-weighted three-dimensional gradient-echo sequence in both the coronal oblique and sagittal oblique planes after intraarticular injection of a 2 mmol/l solution of gadopentetate dimeglumine. The normal and pathologic appearance of the capsular–labral complex was assessed, and the labra were evaluated on the basis of morphology, signal intensity, presence of a tear, and attachment to the acetabulum. MR arthrography findings were correlated with the surgical results in all patients and with the anatomic sections of the cadaveric hip joint specimens.

RESULTS. MR arthrography images of the T1-weighted three-dimensional gradient-echo sequences allowed visualization of the anatomic structures. The normal labrum was triangular, without any sublabral sulcus, and of homogeneous low signal intensity. A recess between the labrum and the joint capsule could be identified in instances in which no thickened labrum was present. Labral lesions included labral degeneration, a tear, or a detached labrum either with or without thickening of the labrum. The sensitivity for detection and correct staging of labral lesions with MR arthrography in the patient study was 91%; the specificity, 71%; and the accuracy, 88%.

CONCLUSION. MR arthrography with T1-weighted three-dimensional gradient-echo sequences allows excellent assessment of the normal and pathologic acetabular capsular–labral complex.
oblique plane (parallel to the axis of the femoral neck) after intraarticular injection of 10–20 ml of a 2 mmol/l solution of gadopentetate dimeglumine (Magnevist; Schering, Berlin, Germany) (2 ml of gadopentetate dimeglumine in 230 ml of saline) into the affected hip as described previously [4]. The parameters of this sequence were as follows: a 1.5-mm section thickness with no gap, a 15-cm field of view, a 256 × 256 matrix, and one signal acquired. Correct needle placement in the hip joint before intraarticular injection of gadopentetate dimeglumine solution was confirmed by injection of a few drops of a nonionic contrast material (Iopamiro [iopamidol]; Bracco, Milan, Italy) under fluoroscopic guidance. All patients were transported from the fluoroscopy location to the MR examination location on a rolling stretcher. The ethics committee at the University of Vienna approved the study, and all patients agreed to the study before it began.

The MR images were prospectively reviewed in a masked fashion and on a consensus basis by two radiologists. The acetabular capsular–labral complex was evaluated using the following classification scheme [4] (Fig. 1): Stage 0 normal labra had homogeneous low signal intensity, a triangular shape, a recess between the joint capsule and the labrum, and a continuous attachment to the acetabulum without evidence of a sublabral sulcus. Stage 1A labra were characterized by an area of increased signal intensity within the labrum that did not extend to the margin of the labrum, a triangular shape, a recess between the joint capsule and the labrum, and continuous attachment to the lateral margin of the acetabulum. Stage 1B labra were similar to stage 1A labra but appeared thickened and deformed, and the recess between the joint capsule and the labrum was not visible. Stage II A labra showed an extension of contrast material into the labrum, but no detachment of the acetabulum could be observed. However, the labral recess with the joint capsule and the labrum was seen. Stage II B labra were similar to stage II A labra but were thickened and deformed, and no labral recess was present. Stage IIIA labra were detached from the acetabulum but were still triangular, whereas stage IIIB labra were thickened, deformed, and detached from the acetabular rim.

The positioning of lesions within the labrum—whether anteriorly, cranially, posteriorly, anterocranially, or cranior posteriorly—as seen on the MR arthrography images was described using a method similar to one previously reported [4]. Additional pathologic findings on MR arthrography images, such as ganglion cysts adjacent to the labrum or communicating with the labrum, were also noted.

All patients underwent arthroscopy of the affected hip, with inspection of the acetabular labrum. To facilitate comparison between surgical findings and MR arthrography findings, the surgeons staged the appearance of the labrum using a system similar to that used for MR arthrography staging but ignoring intralabral changes.

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Results

MR Arthrography–Surgery Correlation

The labra of the 40 patients were staged at MR arthrography; Table 1 shows the results.

Although the triangular shape was often distorted in the region of a labral tear, the remaining portion of the labrum retained its triangular shape. Normal labra appeared thinner anteriorly and thicker cranially and posteriorly. All five stage 0 labra appeared of low signal intensity on the MR arthrography images, except at the attachment to the articular cartilage, which showed a focal area of intermediate to slightly higher signal intensity (Fig. 2).

The joint capsule could be identified and was of low signal intensity in all patients (Figs. 2–8). A recess was identified and filled by a linear collection of contrast material in 13 of the patients (all five stage 0 and all eight type A labra) (Figs. 2, 3, 5, and 7). In the remaining 27 patients, all with type B labra, the recess was not identified because of a thickened labrum (Figs. 4, 6, and 8). In 22 of these 27 patients the joint capsule adjacent to the labrum was bulging (Table 2).

The labral lesions were distributed as follows: Five were in the anterior portion of the labrum, 11 were in the cranial portion, and 19 were in the anterocranial portion. No lesion was found in the posterior or cranior posterior portion of the labrum.

Associated findings at MR arthrography included 12 cases of ganglion cyst that commu-

Fig. 1.—Drawing shows different types of acetabular labrum according to staging system described in Materials and Methods.

Fig. 2.—Coronal oblique MR arthrogram of left hip of 23-year-old woman reveals triangular labrum (large solid straight arrow) of homogeneous low signal intensity without any labral sulcus at base of acetabular labrum. This labrum was called stage 0 here and at surgery. Note labral recess (curved arrow) between joint capsule (open arrow) and labrum. Also note small focal area of intermediate to higher signal intensity (small solid straight arrow) at attachment of labrum to articular cartilage.

Fig. 3.—Sagittal oblique MR arthrogram of right hip of 41-year-old woman reveals triangular labrum in anterior portion of acetabulum with intralabral signal inhomogeneities (solid straight arrow). This labrum was called stage I A here and at surgery. Note labral recess (curved arrow) and joint capsule (open arrow).
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### Table 1

<table>
<thead>
<tr>
<th>Surgical Stage</th>
<th>MR Arthrography Stage</th>
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<tr>
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</tr>
<tr>
<td>IA</td>
<td>IB</td>
</tr>
<tr>
<td>IIB</td>
<td>IIIA</td>
</tr>
<tr>
<td>IIIB</td>
<td></td>
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</tbody>
</table>

**Note.** Forty joints were examined in 40 patients. Bold numbers indicate MR arthrography findings that agreed with surgical findings; light numbers indicate MR arthrography findings that were false-positive or false-negative, based on surgical findings; blanks indicate no correlation between MR arthrography findings and surgical findings.

### Table 2

<table>
<thead>
<tr>
<th>Lesion</th>
<th>MR Arthrography Stage</th>
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<tbody>
<tr>
<td>Recess</td>
<td>0</td>
</tr>
<tr>
<td>Bulging</td>
<td>IA</td>
</tr>
<tr>
<td>Ganglion</td>
<td>IIIB</td>
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**Note.** Forty joints were examined in 40 patients.

In the paper, MR arthrography was correlated with surgical findings for staging the acetabular capsular–labral complex. The MR arthrography findings agreed with the surgical findings in 35 patients. The sensitivity of MR arthrography was 91%, the specificity was 71%, and the accuracy was 88%, compared with surgical results (Table 1). In three patients, the results of MR arthrography were false-negative, and in two, false-positive. The false-negatives were as follows: One stage IIA labrum found at surgery was staged as IA on MR arthrography, one stage IIIA labrum found at surgery was staged as IIA on MR arthrography, and one stage IIB labrum found at surgery was staged as IB on MR arthrography (Table 1). One false-positive case was suspected to be a stage IIB labrum at MR arthrography but was proven to be nonspecific synovitis at surgery, and the second false-positive case was identified as a stage IIB labrum at MR arthrography but was found to be a stage IIB labrum at surgery (Table 1). No complications attributable to the intraarticular injection of contrast material were observed during or after the examination.

**MR Arthrography—Anatomy Correlation**

In cadaveric specimens, the acetabular capsular–labral complex was well seen with MR arthrography in both the coronal oblique and the sagittal oblique planes. A normal, or stage 0, labrum was found in one cadaveric hip joint (Fig. 9). In the remaining five hip joints, MR arthrography revealed a smaller deformed labrum with intralabral signal abnormalities consistent with stage IA. No cadaveric specimens had a sublabral sulcus. However, in all cadaveric specimens a focal area of intermediate to high signal intensity was seen at the base of the labrum at its attachment with the articular cartilage (Fig. 9).

The joint capsule extended from the margin of the acetabulum and was depicted on both the oblique coronal and the sagittal images.

The outer part of the capsule consisted of strong tendonlike ligaments that were of low signal intensity on the MR arthrography images (Fig. 9). The zona orbicularis was depicted on the MR arthrography images as a circumferential thickening in the joint in the sagittal oblique plane and was also of low signal intensity.

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**Fig. 4.**—Coronal oblique MR arthrogram of right hip of 35-year-old man reveals thickened labrum (solid straight arrow) that shows inhomogeneous signal intensities within labrum. No labral recess (curved arrow) is seen between joint capsule (open arrow) and thickened labrum. This labrum was called stage IB here and at surgery.

**Fig. 5.**—Coronal oblique MR arthrogram of left hip of 42-year-old woman reveals triangular labrum with intralabral fluid collection of linear shape (solid straight arrow). Note labral recess (curved arrow) and joint capsule (open arrow). This labrum was called stage IIA here and at surgery.

**Fig. 6.**—Coronal oblique MR arthrogram of right hip of 48-year-old man reveals thickened labrum (solid straight arrow) with intralabral signal inhomogeneities and linear-shaped intralabral fluid collection. No labral recess (curved arrow) is seen between joint capsule (open arrow) and thickened labrum with tear. This labrum was called stage IIB here and at surgery.
A recess between the joint capsule and the triangularly shaped labrum was depicted in the anterior, cranial, and posterior parts of the hip joint in all cadaveric specimens (Fig. 9).

The MR arthrography findings correlated with the observations from cryosectioning in all six specimens.

Discussion

Clinical and arthroscopic studies have documented the importance of the acetabular capsular–labral complex as a biomechanical component of the hip joint [1–3, 10–13]. Recent studies have documented the accuracy of MR arthrography in detecting and staging acetabular capsular–labral lesions and have shown the superiority of MR arthrography over conventional MR imaging in evaluating the acetabular capsular–labral complex [4–6, 8]. However, few patients were included in these studies. In addition, other studies have raised questions about normal variations in the appearance of the acetabular capsular–labral complex and the possibility of a sublabral sulcus that could mimic labral tears [7, 8]. We have attempted to answer these questions through our study.

Our most important finding was that the acetabular labrum was present in all patients and cadaveric specimens—also proven by the surgical and cryosectional results. Normal acetabular labra were found to be triangular; in labra with lesions, the triangular shape was frequently distorted or deformed. Unlike other researchers investigating the infant and adult hip [4–8, 14–18], we found no instances of absent labra. However, Lecouve et al. [7], using conventional MR imaging in asymptomatic patients, described great variability in the MR appearance of the labrum and, in some cases, the absence of a labrum. One reason we could not duplicate the results of Lecouve et al. might be that our patient population was different from theirs. In addition, all our patients underwent surgery of the affected hip, and for hips that were not being deformed or distorted by a labral lesion, the surgeons could not prove that the labrum was absent or shaped abnormally. We also could not prove absence of labra in the cadaveric specimens for which clinical symptoms were unknown. Yet, in five of our cadaveric specimens we found a stage IA labrum, which might be explained by the advanced age of and signs of osteoarthritis in these patients. These characteristics could account for the deformation or distortion of the acetabular labrum.

Another possible reason for differences between our results and those of Lecouve et al. [7] is that thin MR arthrography sections show the labrum better than does conventional MR imaging [4–6]. These differences in slice thickness might also explain why thickened labra (type B) often have a round appearance as they merge with the joint capsule, especially on conventional MR images. Type B labra are frequently associated with frank labral tears or detachment and should not be considered an anatomic variant. Rather, these labra indicate a mechanical adaptation process to the hip joint forces followed by decapsulation of the capsular–labral complex, yielding labral abnormality [3, 17–19].

The presence of a sublabral sulcus has been raised as a potential pitfall in the diagnosis of labral tears [5, 8]. However, the presence of such a sulcus has not been documented in arthroscopic studies and was not found in any of our patients or cadaveric hip joint specimens [11–13]. Therefore, we believe that any intralabral collection of contrast material should not be mistaken for a normal sublabral sulcus but, rather, should be suspected to be a tear or detachment [4, 6].
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Another potential pitfall with MR arthrography was raised in an arthroscopic study of 100 hips that described a groove separating the acetabular labrum from acetabular articular cartilage in the region of the acetabular fossa [10]. This groove was not visualized in our patients but if seen should not be confused with a labral tear because its location is different from that of labral tears [4, 11, 12].

In our study and in previously published studies, the normal triangularly shaped labrum was of homogeneous low signal intensity on MR arthrography images [4–6]. However, at the attachment site of the labrum with the acetabular articular cartilage is a focal area of higher signal intensity probably representing volume averaging with the hyaline cartilage [16]. Although this site creates the potential for overdiagnosis of a labral tear on conventional MR images, the lack of contrast material in this region on MR arthrography images easily differentiates it from a true labral tear [4, 16]. A recess was seen in all patients with type A labra and in all cadaveric hip joint specimens between the labrum and the joint capsule [4, 16]. In a previous study this recess was reported to be smaller anteriorly and posteriorly compared with the superior portion of the capsular–labral junction [19]. However, in our study this difference in the size of the labral recess was not observed.

The patient study had three false-negative cases of labral lesions on MR arthrography images. One stage IIIB labrum found at surgery was called a stage IIB labrum at MR arthrography imaging, possibly because the thickened labrum was closely apposed to the joint capsule and acetabular articular cartilage, thereby preventing contrast material from penetrating into the labral defect. In the remaining two false-negative cases, the amount of contrast material injected was limited because of patient pain. The decreased volume of intraarticular contrast material was most likely the cause of the errors in these two patients.

Two cases were also false-positive on MR arthrography. In one patient the labrum appeared thickened (with intralabral signal abnormalities) on MR arthrography, but at surgery the thickness turned out to be synovial tissue associated with nonspecific synovitis. In the other patient, a stage IIIB labrum was called a stage IIIIB labrum because the thin connection of the labrum to the acetabulum was not visualized.

Ganglion cysts were seen in 12 patients, and all of the cysts communicated with the acetabular labrum [20]. All 12 cysts occurred in patients with detached labra, and all occurred in the anterior and cranial portions of the labrum, where most of the labral lesions were found. One possible cause for the formation of ganglion cysts in these patients is the presumed existence of a labral lesion and the pressure of fluid into the defect [20]. If long-standing, this cause might lead to further destruction and to formation of a cystic lesion. Therefore, if a ganglion cyst present, an associated labral tear or detachment should be suspected. In these cases, the ganglion cysts should not be confused with multiple osteoarthritic cysts in patients with osteoarthritis.

In summary, MR arthrography with thin-section three-dimensional gradient-echo sequences and the use of a small field of view is excellent both in detecting and in staging acetabular capsular–labral lesions. Furthermore, these MR arthrography sequences excellently delineate the normal acetabular labrum, which appears to be of triangular shape and of homogeneously low signal intensity. A recess between the normal and type A labra and the joint capsule is found, but a sublabral sulcus between the labrum and the acetabular articular cartilage is not normally found.

References