Direct magnetic resonance (MR) arthrography in femoroacetabular impingement and correlation with hip arthroscopy

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Aims and objectives

The hip is an anatomical complex region that historically has supposed a treatment challenge for the orthopedic surgeons (1). The increasing interest in hip arthroscopy has driven to a better knowledge of the anatomy, the biomechanics and the pathology concerning the coxofemoral joint. As a consequence, femoroacetabular impingement (FAI) is now a recognized cause of hip pain and restriction of hip motion in young adults, and a major cause of early primary osteoarthritis of the hip (2). Cam FAI and pincer FAI can be differentiated on the basis of a predominance of either a femoral or an acetabular abnormality (3,4). In order to diagnose and treat patients with FAI according to the disease severity, radiologist's update is mandatory. Imaging techniques have an important role in the evaluation of patients with FAI. Conventional Radiology adequate depict morphologic anomalies that characterize FAI, hip displasia or osteoarthritis (5). Conventional MRI allows to exclude other inguinal pain causes as well as initial degenerative changes of osteoarthritis. Direct MR arthrography (MRA), with the introduction of a contrast solution within the hip, allows an accurate depiction of acetabular labral tears (6,7,8).

The study focused on the intra-articular abnormalities secondaries to FAI, not only in labral tears but also in labral-chondral transitional zone and articular cartilage lesions. We correlated imaging findings of the hip direct MRA with arthroscopy. The aim of the study was to determine diagnostic performance of MRA, using hip arthroscopy as gold standard.

Methods and materials

Subjects

We retrospectively reviewed MRA imaging findings of patients with femoroacetabular impingement who had underwent hip arthroscopy between october 2009 and july 2012.

Exclusion criteria were previous surgery on the hip and other causes of groin pain as hip dysplasia, avascular necrosis, transient osteoporosis, bony lesions (tumors, insufficiency fractures…), synovial pathology (pigmented villonodular synovitis, synovial chondromatosis…), tendinopathy, bursitis an dextraarticular diseases (inguinal hernial…).

The study group consisted of 51 patients, 25 males and 26 females; mean age 43 years +/- 9. A history of chronic hip or groin pain and a clinical examination with findings consistent with femoroacetabular impingement were present in all cases. According to radiographic findings, patients with FAI were classified into pincer impingement (14), cam impingement (28) or mixed impingement (9).
Median delay between MRA and surgery was 6 months (range 1 to 13 months). A review of the patients' clinic notes revealed no new episodes of hip trauma between the time of the MRA arthrography examinations and the time of arthroscopy.

**Direct MR arthrography (MRA)**

MR examination was performed in a 1.5 T MR magnet (Achieva nova 1.5-T Philips, Eindhoven, Países Bajos) with the cardiac body 5Ch-Cardiac-coil. During MR examination was performed with a 5kg of weight skeletal traction. Pulse sequences performed are summarized in Table 1 on page 5.

<table>
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<tr>
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<th>Gap</th>
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<td>7</td>
<td>200 X 150</td>
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<td>230 X 230 X 90</td>
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**Table 1**: Protocol of direct MR arthrography (MRA) of the hip, postcontrast intra-articular injection examination in a 1.5-T magnet. It is specified pulse sequence, plane, RT or repetition time (msec), ET or echo time (msec), matrix size, section thickness (mm), gap, echo train length, field of view (FOV), inversion time (IT), flip angle and fat suppression. Pulse sequences included are T1, 3D WATer Selective Fluid (3D-WATsf) and T1 High-Res Isotropic Volume Excitation (THRIVE). Fat suppression techniques detailed are SPectral Attenuated Inversion Recovery (SPAIR), Spectral Presaturation with Inversion Recovery (SPIR) and PRinciple Of Selective Excitation Technique (ProSet).

**References**: Department of Radiology, Hospital Universitario Puerta de Hierro Majadahonda, Madrid, Spain

Patients had MRA studies within 30 minutes of contrast injection.

Contrast solution of 15cc contained 0.2cc of gadoterate meglumine (Dotarem®), 3cc lidocaine 1% and 12cc sterile saline.

Intra-articular injection was performed using an echogenic tip Chiba needle (Cook®) under ultrasound guidance.

**Criteria for Interpretations**
Three musculoskeletal radiologists with 3 (AHJ), 5 (AMCR), and 20 (MPL) years of experience completed separate, independent reviewed MRA examinations. The final interpretation was based on a majority consensus.

- **Acetabular labrum:**

A labral tear is filled by the intraarticular contrast material, which fills the labral tear, thereby increasing the conspicuity of detached labral fragments (8).

- **Labral-chondral transitional zone:**

Pathology was subdivided using the following classification of James (9): 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; grade 2, articular cartilage fraying, thinning, or separation immediately adjacent to the labral attachment; and grade 3, full-thickness loss of articular cartilage leading to bare bone exposure immediately adjacent to the labral attachment.

- **Articular cartilage:**

Femoral and acetabular articular surfaces were assessed. Cartilage within the labral-chondral transitional zone was evaluated independently of the rest of the acetabular cartilage.

The articular cartilage was graded on the MRI with a modification of the classification system of Outerbridge (10). Grade 0 indicated intact cartilage; grade 1, chondral softening or blistering with an intact surface; grade 2, shallow superficial ulceration, fibrillation, or fissuring involving less than 50% of the depth of the articular surface; grade 3, deep ulceration, fibrillation, fissuring or a chondral flap involving 50% or more of the depth of the articular cartilage without exposure of subchondral bone; and grade 4, full-thickness chondral wear with exposure of subchondral bone.

**Arthroscopic Evaluation**

Arthroscopic findings were used as the standard of reference. Surgery was performed by an orthopedic surgeon (JCLV) with extensive experience in hip arthroscopy (more than 150 procedures). The surgeon was not blinded to the diagnostic reports or preoperative MRA images and were given an independent interpretation at the time the patient initially presented for the study. The surgeon provided dictated operative reports about all patients who underwent hip arthroscopy. Each report included an assessment of the integrity of the labrum, the labral-chondral transitional zone and articular cartilage and description of the treatment administered. The labrum was considered abnormal if treated with débridement or repair and normal if described as intact.

**Statistical Analysis**
The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), accuracy of MRA examination were calculated with a 95% confidence interval, using arthroscopy as the reference standard.

Cohen’s kappa index was calculated as statistical mesure of agreement between hip MRA and arthroscopy. Kappa values between 0-0.20 indicates a slight agreement, 0.21-0.40 fair, 0.41-0.60 moderate, 0.61-0.80 substantial, and 0.81-1 almost perfect agreement.

Images for this section:

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Results

Of the 51 patients with FAI who underwent hip arthroscopy, only 3 had no intra-articular lesions, 37 labral tears, 44 lesions at the labral-chondral transitional zone and 40 articular cartilage were found. Correlation of hip MRA and arthroscopic findings is shown in Table 2 on page 9.

<table>
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<td></td>
<td>Acetabular labrum</td>
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<td>Tear</td>
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<td>Hip direct MRA</td>
<td>Lesion</td>
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<td>Normal</td>
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<td>Total</td>
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Table 2: Comparison between hip MRA and arthroscopy, using arthroscopy as standard of reference.

References: Department of Radiology, Hospital Universitario Puerta de Hierro Majadahonda, Madrid, Spain

Statistical indicators of the comparison between hip direct MRA and arthroscopy are summarized in Table 3.

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- Acetabular labrum:

MRA correctly identify a normal acetabular labrum in 5 patients, degenerative changes in 9 patients and 35 out of 37 acetabular labral tear (94.6%).

![Fig. 1](image.png)

**Fig. 1:** 39-year-old man with cam FAI in the right hip. MRA findings: (a) Axial THRIVE image shows a labral tear in the anterior region of the acetabulum (yellow arrow). (b) Coronal THRIVE image shows a normal labrum in the superolateral acetabulum (purple arrow), perilabral recess distended by intra-articular contrast media (pink arrow) and lost of normal signal of the cartilage at the labral-chondral transitional zone (yellow arrow). (c) Arthroscopic image shows a wide area of chondral lesion, typical in cam FAI (yellow arrows).

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- Labral-chondral transitional zone:

Diagnostic accuracy of MRA was 98%: 7 patients with normal findings, 22 patients with grade 1 lesions, 17 with grade 2 and 4 with grade 3.

- Articular cartilage:

Diagnostic accuracy of MRA was 84.3%. Concordant cases were 37 patients with chondral lesions (17 grade 1, 3 grade 2, 2 grade 3 and 15 grade 4) and 6 patients without. Discordant cases were 8 patients (15.7%): MRA didn't diagnose 2 patients with chondral lesions grade 1 (Fig. 1 on page 9) and one with grade 3. In one case, MRA depicted a chondral lesion grade 1 and hip arthroscopy revealed a normal cartilage. In 3 cases, hip arthroscopy underestimated grade 4 chondral lesions with cystic changes on MRA (Fig. 2 on page 10).
Fig. 2: 44-year-old man with cam FAI in the right hip. MRA findings: (a) Coronal THRIVE image shows a small cleft (red arrow) and low signal intensity of the cartilage (green arrow) at the labral-chondral transitional zone and subchondral cysts (oranges arrows). (b) Sagittal THRIVE image shows a small labrum with normal signal intensity (purple arrow), hypointensity foci within de acetabular cartilage (green arrows), subchondral cysts (orange arrows) in communication (yellow arrow) with the articular space (yellow arrow). (c) Arthroscopic image shows a grade 2 chondral lesion at the labral-chondral transitional zone (LCTZ) while a fraying labrum (L) is seen. (d) Arthroscopic image shows a wide area of chondral lesion (yellow arrows) even with full-thickness loss of articular cartilage, subchondral cysts are not evident.

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Conclusion

MRA has a well-established high accuracy in the diagnosis of labral tears (7,8) and our results are in keeping with several previous studies (11). However, limited correlation between arthrographic appearance of acetabular labral tears (8) and the Lage arthroscopic classification has been found and so Blankenbaker et al. recommend to be descriptive in the morphology as well as in the location of the labral tear (13).

The labral-chondral transitional zone plays an important role in the pathogenesis of FAI (14,15,16). Early alterations in FAI occur in the attachment of the labrum to the acetabular cartilage as result of repetitive microtrauma between the femur and the acetabular rim (9).

The chondral lesion is a poor prognosis factor in the mid-long term outcomes for surgical treatment. It is important to know that surgical treatment of FAI is only suitable in patients without advanced degenerative changes and without extensive articular cartilage damage (14). Patients at greatest risk for a bad outcome after surgery have advanced osteoarthritis before surgery (17). The most important role of preoperative MR imaging in patients with FAI is to assess the exact extent of the damage already present within the joint.

In conclusion, MRA detects and characterizes labral tears and lesions at labral-chondral transitional zone. Low grade chondral lesions are still a challenge for MRA. However, MRI (including MRA) adequate diagnose high grade chondral lesions, in particular when osseous changes occur (subchondral sclerosis, subchondral cysts and osseous edema).

To sum up, MRA is an excellent method of preoperative assessment in patients with FAI and may enable the referring surgeon to decide which patients may benefit from a hip arthroscopy.

Personal information

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- Miguel Pastrana Ledesma MD, Department of Radiology, Hospital Universitario Puerta de Hierro Majadahonda, Madrid, Spain.
References


