Evaluation of labral pathology and hip articular cartilage in patients with femoroacetabular impingement (FAI): comparison of 64-slice multidetector CT arthrography and 1.5 T MR arthrography

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Aims and objectives

The assessment of patients with chronic and mechanical hip pain is a clinical dilemma. In these cases, hip pain can be caused by various pathologies. Femoraasetabular impingement (FAI) is one of the causes of chronic hip pain, and it is an important factor in the development of osteoarthritis (1). Chronic microtrauma from recurrent impingement can lead to acetabular labral tears and breakdown of the articular cartilage, subsequently resulting in osteoarthritis. Surgical intervention may prevent later cartilage loss and development of osteoarthritis, if it is performed before cartilage breakdown has begun (2). For this reason, imaging may play an important role in planning joint-preserving treatment options and thus preventing early hip osteoarthritis. MR arthrography (MRa) is considered the best imaging modality for routinely evaluating the internal hip pathology (3-6). The most important advantages of this method include better visualisation of the joint anatomy owing to easy differentiation of the joint surface and a higher soft tissue contrast obtained by intra-articular gadolinium dilution (7). A number of groups have also investigated the role of non-contrast MRI in the detection of labral tears associated with FAI and acetabular dysplasia (8-11). However, both methods have limitations in terms of spatial resolution, which can make the detection of subtle labral and cartilage pathology challenging (12).

Novel multidetector CT (MDCT) technology enables sub-millimeter spatial resolution and restored interest in the role of CT arthrography in the shoulder, wrist, knee, ankle and elbow (13). There are only few studies on the use of this technique in the detection of intra-articular hip pathology. Several studies have examined the efficiency of MDCT arthrography to assess cartilage loss in the hip and have demonstrated that its accuracy is equal to, or can precede, MR arthrography (14-16). There are only limited data regarding the efficiency of MDCT to assess labral pathology (7, 11, 13).

The aim of this study was to prospectively compare the MRa and CTa findings with surgical findings in patients with FAI and to investigate the superiority of these methods.

Methods and materials

Between October 2009 and April 2011, a total of 51 patients with hip symptomatology suggestive of FAI were examined with both arthrographic methods. All patients were evaluated by a hip surgeon with 19 years of experience before imaging, and arthrography was performed in patients with suspected hip impingement. Ten patients (seven females and three males, age range of 19-52 years, mean 37 years) underwent surgery and were included in this study. CTa and MRa images were independently evaluated by
two musculoskeletal radiologists with 10 and 20 years of experience, respectively. The reviewers were not aware that this group of patients was scheduled for arthroscopy at the time of interpretation. The study was approved by the local ethical committee and written informed consent was obtained from each patient. The intra-articular administration of gadolinium is licensed by the national drug administration. In all cases the symptoms were unilateral and thus 10 hips were finally studied. The detailed analysis of our population study is shown in Table 1.

<table>
<thead>
<tr>
<th>Patient age (years) and sex</th>
<th>Hip examined</th>
<th>Underlying pathology</th>
</tr>
</thead>
<tbody>
<tr>
<td>43/F</td>
<td>L</td>
<td>Mixed-type FAI</td>
</tr>
<tr>
<td>52/F</td>
<td>R</td>
<td>Mixed-type FAI</td>
</tr>
<tr>
<td>42/M</td>
<td>L</td>
<td>Cam-type FAI</td>
</tr>
<tr>
<td>36/M</td>
<td>L</td>
<td>Cam-type FAI</td>
</tr>
<tr>
<td>30/F</td>
<td>L</td>
<td>Mixed-type FAI</td>
</tr>
<tr>
<td>50/F</td>
<td>R</td>
<td>Mixed-type FAI</td>
</tr>
<tr>
<td>19/F</td>
<td>R</td>
<td>Mixed-type FAI</td>
</tr>
<tr>
<td>20/F</td>
<td>L</td>
<td>Cam-type FAI</td>
</tr>
<tr>
<td>42/F</td>
<td>L</td>
<td>Mixed-type FAI</td>
</tr>
<tr>
<td>37/M</td>
<td>L</td>
<td>Mixed-type FAI</td>
</tr>
</tbody>
</table>

Table 1: Patient population study group with femoroacetabular impingement

Arthrography

Arthrography was performed under guidance of ultrasonography and fluoroscopy by a senior musculoskeletal radiologist with 20 years of experience. The patient was placed supine on the fluoroscopy table, and the lower extremity was held in neutral or slight internal rotation. Standard sterile precautions were used. Using an anterolateral approach, a 22-gauge needle was advanced towards the hip joint space. The intra-articular position of the needle tip was verified with 2-3 mL of contrast material. A mean volume of 13 mL (range, 10-16 mL) of standard dilute gadolinium solution was injected. Preparation of the mixture was as follows: 0.8 mL of gadolinium (376, 9 mg Megluminingadoterat (Dotarem/guerbet) at 1 ml) was added to 100 mL of normal saline solution. Ten mL of that solution was mixed 10 mL of iodinated contrast material (61, 4 mg Iomeprole (Iomeron 300, Bracco) at 100 ml). The solution was injected under ultrasonography guidance to obtain sufficient joint distension until resistance was met or the patient experienced discomfort. MDCT was performed subsequently walking about 10-15 min. for intra-articular diffusion of the contrast and the patient was transferred.
to MRI suite. MR arthrograms were obtained within 20-30 min after contrast material injection.

**Imaging Protocol**

The CTa examinations were performed with a 64-row MDCT scanner (Toshiba Aquillion 64, Tokyo, Japan). The parameters for all scans were the same: pitch 1.50, 120-140 kVp, 120-130 mAs, high-resolution filter, slice thickness 0.5 mm, 15-cm field of view and a 512X512 matrix. Isotropic data acquisition allowed multiplanar reformation with 0.5 mm section thickness and 0.1 mm overlapping in the axial, coronal, sagittal, and coronal-oblique planes. All volume images (vital images) were assessed at the working station (HP XW8200 base unit, program Vitrea).

The MRa examinations were performed with 1.5 T scanner (Magnetom vision plus, Siemens, Germany), and a flexible wrap-around receive-only surface coil. Four image planes including axial, coronal, sagittal and coronal-oblique planes were used, according to the standard MR imaging protocol. Plain and fat-saturated T1-weighted MR images were obtained axial, sagittal and coronal planes with the following parameters: TR/TE 588/12, matrix size 512x512, section thickness 4-5 mm, field of view 15 cm. The routine protocol for MRa was completed with Proton/T2 fat-suppressed turbo spin-echo sequence in sagittal and coronal oblique planes: TR/TE 3000/12, matrix size 512x512, section thickness 4-5 mm, field of view 15 cm; fat-suppressed turbo spin-echo T2-w image acquisition sequence: TR/TE 4500/54, matrix size 512x512, section thickness 5-6 mm, field of view 15 cm; and an axial T2*-w FLASH 2d image acquisition sequence: TR/TE 500/15, matrix size 512x512, section thickness 4-5 mm, field of view 15 cm.

**Image Analysis**

All images were evaluated independently by two musculoskeletal radiologists. Each reviewer evaluated both examinations during the same sessions. The nature of study was prospective. Sensitivity, specificity, accuracy, and positive predictive value were determined for both MRa and CTa using surgical findings as the standard of reference. Interobserver reproducibility with both imaging modalities was also calculated.

Acetabular labrum was divided into 12 regions, according to the clock quadrant for the localization of labral tears (refer to figure 1).
Fig. 1: Diagram showing acetabular quadrants

References: Department of Radiology, School of Medicine, Eskisehir Osmangazi University, Eskisehir, Turkey

A route was centralized between the 3 and 9 o’clock positions and the region above the route was determined as superior and region below the route was determined as inferior. Thus, with respect to location, labral tears were classified anterosuperior (from 1 to 3), superior (from 11 to 1) and posterosuperior (from 9 to 11). While the labral tear was defined by contrast matter transition into the labrum, acetabular and femoral cartilage defects were identified by contrast matter transition to the secondary cartilage and contrast matter stratification there (delamination).
Fig. 1: Diagram showing acetabular quadrants
**Results**

Intraarticular findings detected by two observers with both methods and intraoperative findings are shown in Table 2 and Table 3, respectively.

<table>
<thead>
<tr>
<th>Patient age (years) and sex</th>
<th>Labral pathology</th>
<th>Acetabular cartilage pathology</th>
<th>Osteophyte Bump</th>
<th>Femoral cartilage pathology</th>
<th>Labral tear location</th>
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</thead>
<tbody>
<tr>
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<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>-</td>
</tr>
<tr>
<td>52/F</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>-</td>
</tr>
<tr>
<td>42/M</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>-</td>
</tr>
<tr>
<td>36/M</td>
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<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No Anterosuperior</td>
</tr>
<tr>
<td>30/F</td>
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<td>Yes</td>
<td>Yes</td>
<td>No Anterosuperior</td>
</tr>
<tr>
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<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No Anterosuperior</td>
</tr>
<tr>
<td>19/F</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes Anterosuperior  Posterosuperior</td>
</tr>
<tr>
<td>20/F</td>
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<td>Yes</td>
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</tr>
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<td>42/F</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>37/M</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No Anterosuperior  Posterosuperior</td>
</tr>
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**Table 2: Surgical findings in patients with femoroacetabular impingement**

<table>
<thead>
<tr>
<th>Labral Pathology</th>
<th>Acetabular Cartilage Pathology</th>
<th>Osteophyte</th>
<th>Bump</th>
<th>Femoral Cartilage Pathology</th>
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<tbody>
<tr>
<td>MRa</td>
<td>CTa</td>
<td>MRa</td>
<td>CTa</td>
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<td><strong>Observer 1</strong></td>
<td></td>
<td></td>
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<td></td>
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<td>4</td>
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**Observer 2**

<table>
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<tr>
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<th>MRa</th>
<th>CTa</th>
<th>MRa</th>
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<th>MRa</th>
<th>CTa</th>
<th>MRa</th>
<th>CTa</th>
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<td>8</td>
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<td>8</td>
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<td>6</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>6</td>
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</table>

**Table 3: Intraarticular findings detected by two observers with both methods**
Regarding other intraarticular findings including osseous bump and osteophyte, there was a disagreement between the observers. Six patients had surgically confirmed labral tear. CTa correctly identified and localized all labral tears (see figure 2).

![Fig. 2: Cam-type FAI and labral tear in a 36 year-old male with right hip pain of 4 months duration. Coronal reconstruction (a) shows contrast extension into anterosuperior labrum compatible with a tear. Coronal oblique reconstruction (b) clearly demonstrates posterior extension of the contrast medium in the superior labrum (arrows).](image)

**Fig. 2:** Cam-type FAI and labral tear in a 36 year-old male with right hip pain of 4 months duration. Coronal reconstruction (a) shows contrast extension into anterosuperior labrum compatible with a tear. Coronal oblique reconstruction (b) clearly demonstrates posterior extension of the contrast medium in the superior labrum (arrows).

**References:** Department of Radiology, School of Medicine, Eskisehir Osmangazi University, Eskisehir, Turkey

Tears were most commonly detected in the anterosuperior location (75%). There was a complete consensus between two observers in all cases in the presence of a tear with MRa and CTa. Although two cases were diagnosed with labral tear with MRa by both observers, labral degeneration was detected surgically in these patients (refer figure 3).
Fig. 3: 33-year-old female with hip pain and surgically proven labral degeneration. The coronal (a) and axial (b) CTa images demonstrate degenerative labrum (arrow) but with no signs of tear. Based on MRa (not shown here), both observers considered the findings as a labral tear which was not verified surgically.

References: Department of Radiology, School of Medicine, Eskisehir Osmangazi University, Eskisehir, Turkey

Regarding articular cartilage loss, the disagreement between observers was recorded in two cases (20%) of femoral cartilage loss with MRa. However, there was a complete consensus with CTa. Disagreement was also found in two cases (20%) of acetabular cartilage loss with CTa. While, MRI showed high sensitivity in the assessment of acetabular cartilage, CTa showed better demonstration of femoral cartilage (see figures 4 and 5).
Fig. 4: A 20-year-old female with right hip pain that increases with movement. T1-w fat-saturated MRa (a) and corresponding coronal CTa (b) images. Acetabular cartilage loss (arrow) is demonstrated on MRa but not on the CTa. Note how clearly the femoral cartilage is demonstrated by CTa (arrows).

References: Department of Radiology, School of Medicine, Eskisehir Osmangazi University, Eskisehir, Turkey
Fig. 5: A 30-year-old female with left hip pain of 2 months of duration. Coronal oblique T2-w fat-suppressed MRa image clearly shows acetabular cartilage delamination (arrows).

References: Department of Radiology, School of Medicine, Eskisehir Osmangazi University, Eskisehir, Turkey

The percent sensitivity, specificity, accuracy and positive predictive value for correctly defining the labral tear were as follows for MRa/CTa, respectively: 87/100, 50/100, 80/100, 87/100 (P>0.05). The same values for acetabular cartilage assessment were 100/67, 67/100, 90/80, 87/100 (P>0.05) and for femoral cartilage assessment were 25/75, 83/83, 60/80, 50/75 (P>0.05) (refer to figure 6).
**Fig. 6:** Fig. 6 Sensitivity, specificity, accuracy and positive predictive value of MRa and CTa for labral tears and cartilage assessment

**References:** Department of Radiology, School of Medicine, Eskisehir Osmangazi University, Eskisehir, Turkey

**Images for this section:**

**Fig. 2:** Fig. 2: Cam-type FAI and labral tear in a 36 year-old male with right hip pain of 4 months duration. Coronal reconstruction (a) shows contrast extension into anterosuperior labrum compatible with a tear. Coronal oblique reconstruction (b) clearly demonstrates posterior extension of the contrast medium in the superior labrum (arrows).
**Fig. 3:** 33-year-old female with hip pain and surgically proven labral degeneration. The coronal (a) and axial (b) CT images demonstrate degenerative labrum (arrow) but with no signs of tear. Based on MR (not shown here), both observers considered the findings as a labral tear which was not verified surgically.

**Fig. 4:** A 20-year-old female with right hip pain that increases with movement. T1-w fat-saturated MR (a) and corresponding coronal CT (b) images. Acetabular cartilage loss (arrow) is demonstrated on MR but not on the CT. Note how clearly the femoral cartilage is demonstrated by CT (arrows).
**Fig. 5:** A 30-year-old female with left hip pain of 2 months of duration. Coronal oblique T2-w fat-suppressed MRa image clearly shows acetabular cartilage delamination (arrows).

**Fig. 6:** Sensitivity, specificity, accuracy and positive predictive value of MRa and CTa for labral tears and cartilage assessment.
Conclusion

FAI is strongly associated with the increased severity of labral pathology and may play a significant role in the development of early hip osteoarthritis (17). Cartilage damage and/or the labral tear can be treated surgically in early stages and thus progression to end-stage osteoarthritis could be prevented. The most important role of imaging in the preoperative period is to reveal the labrocartilaginous lesions in patients with FAI (18).

In literature, there are some studies about MR imaging using non-contrast and direct arthrographic methods to identify intra-articular hip pathologies (8, 9). However, a small number of studies using CTa to evaluate the intra-articular hip pathologies have been reported (7, 13, 14, 15). In the present study, we aimed to determine the diagnostic accuracy of CTa and MRa in compare with intraoperative findings in patients with FAI. A number of studies have reported that MRa is an effective technique for the detection of labral tears (1, 17) However, it was emphasized that small labral tears can be overlooked due to the lack of spatial resolution of MRI (19, 20). Nishii et al. investigated the success rate of MDCT for the evaluation of labral tears in 41 patients with hip dysplasia using reconstructed radial images. The authors observed an excellent correlation between imaging findings with arthroscopy results in approximately 50 % of patients and they reported 97 % sensitivity, 87% specificity and 92 % accuracy rates for CTa in detecting labral tears (11). Similarly, we found that CTa is useful for identifying labral tears. Making the accurate diagnosis and the determination of exact localization of tears are important for the planning before arthroscopic surgery. The success rate of arthroscopy mostly depends on knowing exact localization of labral tears. Therefore, we compared the diagnostic performance of both imaging methods in detecting of exact localization of tear. To the best of our knowledge, no such study investigating this issue has been previously published. CTa has the advantage of demonstrating the exact localization of tear by means of its multiplanar imaging capabilities (21). A study conducted by Blankenbaker DG et al. in which labral tear was localized on MRa by using a clock face description found that labral tear was localized to the 1-o'clock in 85 % of patients (22). Similarly, our study showed that labral tears were more frequently found in the anterosuperior quadrant. According to intraoperative findings, CTa proved to be better in determining exact localization of the tears compared to MRa. This can be explained by the inherent superior spatial resolution of MDCT.

Various studies exist for investigating the accuracy of CTa for assessing the cartilage lesions at the hip and they have found that CTa is equal to or even superior than MRa (11, 14). CTa could determine the cartilage thinning and loss with at least a similar accuracy rate or better compared to MRa even if it could not exactly identify the acetabular cartilage delamination. Similarly in our study CTa showed better demonstration of articular cartilage. Similar results on cadavers were recently reported (14).
In this study, CTa proved to be better at evaluating concomitant degenerative bone changes compared to MRa. A study conducted by Schmid MR et al, concluded that when concomitant degenerative bone changes are found in MRa images, the labral tears may be overestimated (12). Moreover, we correctly diagnosed labral tears by using CTa in three cases with degenerative bone changes.

Our study had limitations. First, our sample size was small, but arthroscopic comparison was performed in all cases. Second, there was no control group, nevertheless, it can be argued that it would be unethical to perform invasive procedures such as MRa and CTa in healthy volunteers. The limited number of patients with arthroscopic correlation makes it difficult to draw conclusions on the sensitivity and specificity of CTa in this study. Therefore, more prospective studies correlated with operative findings are needed to assess the strengths and weakness of this method to be further evaluated. Finally, CT imparts radiation on the pelvis, with the patient cohort included in this study being mostly young female patients.

In conclusion, our study confirms the popular use of MRa as the imaging method of choice in determining intrarticular hip pathologies. However, CTa seems to have a higher sensitivity than MRa for the detection and localization of labral pathology and superior ability to assess femoral cartilage. Because of its faster image acquisition, patient-based artifacts such as patient movement are less commonly observed with CTa. Finally, MDCT arthrography might be used as an alternative in patients with FAI for whom MRI is contraindicated.

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