M. *Acta Orthop. Belg.*, 2019, **85**, 100-106

ORIGINAL STUDY

Conventional versus direct magnetic resonance imaging in detecting labral lesions in femoroacetabular impingment - a retrospective multicenter study

Ahmed M Saied, Caroline Redant, Joris Anthonissen, Emmanuel Audenaert, Jan Somers, Filiep Bataillie, J. Myncke, Christophe Pattyn

From the Department of Orthopaedics and Traumatology, Ghent University Hospital, Ghent, Belgium

The purpose of this study was to assess the reliability of Direct Magnetic Resonance Arthography (MRA) and Conventional Magnetic Resonance Imaging (MRI) in diagnosing labral lesions in patients with symptoms of femoroacetabular impingement (FAI).
Materials and methods: Imaging and surgical data (n=490) were retrospectively collected from 5 high-volume centres providing arthroscopic treatment of FAI patients. Preoperative magnetic resonance imaging findings were compared with the actual surgical findings regarding labral condition in order to assess the effectiveness of MRI and MRA in identifying the presence of labral tears in patients with FAI.
The results of this study indicate that MRI and MRA may both be useful for the diagnosis of acetabular labral lesions. The accuracy is slightly higher for MRI (71,4 %) compared to MRA (68,2 %), although MRA has higher sensitivity (74.4%,) as compared to MRI (66,9%).
Conclusions: In a clinically suspected labral tear MRA has higher sensitivity than MRI. Further studies on asymptomatic patients may be needed to determine the specificity of different MRI techniques.

Keywords : Hip arthroscopy ; Labral lesion ; Femoroacetabular impingement ; Magnetic Resonance.

INTRODUCTION

Femoroacetabular impingement (FAI) is a mechanical hip disorder, characterized by early and/or repetitive contact between the acetabular rim and proximal femur, inflicting repetitive damage of the surrounding structures most notably the labrum and the adjacent chondral surface *(3,9,21)*. Depending on the clinical and radiographic findings, two distinct types of FAI have been described. Cam-type FAI is characterized by a non-spherical portion of the femoral head with the potential risk of delamination and abrasion of the acetabular cartilage. This type includes the pistol-grip deformity, a decreased head-neck offset, an increased alpha angle, over-growth

No benefits or funds were received in support of this study.
The authors report no conflict of interests.

- Ahmed M Saied[1,2], MD.
- Caroline Redant[2], MD.
- Joris Anthonissen[2], MD, Resident.
- Emmanuel Audenaert[2], MD, PhD.
- Jan Somers[3], MD.
- Filiep Bataillie[4], MD.
- Jan Myncke[5], MD.
- Christophe Pattyn[2], MD, PhD.

[1]*Department of Orthopaedic Surgery and Traumatology, Mansoura University Hospital Mansoura, Egypt.*
[2]*Department of Physical Medicine and Rehabilitation, Ghent University Hospital, Ghent, Belgium.*
[3]*Department of Orthopaedic Surgery and Traumatology, Jan Ypermanziekenhuis, Ieper, Belgium.*
[4]*Department of Orthopaedic Surgery and Traumatology, AZ Herentals, Herentals, Belgium.*
Correspondence : Christophe Pattyn, De Pintelaan 185, 9000 Gent, tel. 093326778
E-mail : pattynchristophe@yahoo.com

of the femoral head epiphysis and subclinical slipped epiphysis. Pincer-type FAI is characterized by anterior over-coverage of the acetabulum, including coxa profunda, acetabular retroversion and lateral rim lesions, resulting in early abutment with the femoral neck at end-range of motion. Most patients however, present with a mixed morphology and both femoral (cam) and acetabular (pincer) factors are present *(9,16)*.

The characteristic FAI anatomical presentations are highly prevalent in the asymptomatic population reaching 30% in some studies. This indicates that the presence of such a morphological variation is not always a pathological finding that needs treatment *(5,10,12,14,21)*. In addition, both clinical examinations and plain radiographs have been questioned in terms of limited reliability in identification of labral and chondral lesions *(16)*. This may be a big challenge for clinical diagnosis and surgical decision making. For this reason, magnetic resonance imaging (MRI) has become popular to evaluate the condition of the labrum and cartilage in patients presenting with typical clinical and imaging findings in FAI.

MRI in general has superior soft tissue contrast and is fairly reliable in assessment of labrum and articular cartilage of the hip. In order to improve diagnostic accuracy some authors have advocated the use of contrast enhancement. Introduction of contrast material may be done directly by intra-articular injection into the joint as in dMRA or indirectly by intravenous injection as in iMRA *(1,4,19,22,23,24,27)*. There are some potential advantages for conventional MRI over dMRA as it is a less invasive procedure compared to dMRA and may be therefore more accepted by patients. Also, conventional MRI can be easily scheduled and performed at any imaging facility.

Several studies compared the accuracy of these different techniques *(13,15,17,18,25)(13,14)*. Most of these studies are dealing with small numbers, various scanning modalities as well as mixed patient populations. There is a debate about whether introduction of contrast material increases the accuracy of MRI or not. In a meta-analysis Smith et al. advocates the use of MRA over conventional MRI, although MRA is more invasive. The use of gadolinium is costlier and more time consuming compare to conventional MRI. However, this may be justified by the increased diagnostic accuracy and indication for surgical intervention *(23)*. In this respect different scanning techniques have been developed such as conventional magnetic resonance imaging (MRI), direct magnetic resonance arthrography (dMRA) and indirect magnetic resonance arthrography (iMRA).

Until now there are no clear protocols and recommendations for MRI in diagnosing FAI. The purpose of this study was therefore to assess the accuracy of Direct Magnetic Resonance Arthography (dMRA) versus Conventional Magnetic Resonance Imaging (MRI) in diagnosing labral lesions in patients presenting with typical signs of femoroacetabular impingement (FAI) in a large multicentre study.

MATERIALS AND METHODS

A multicentre study was designed with participation of five high-volume orthopaedic units. Imaging data of patients clinically suspected with FAI and treated by hip arthroscopy between 2014 and 2015 were reviewed retrospectively. MRI findings were compared with the surgical findings regarding the labral condition in order to assess the effectiveness of MRI in identifying the presence of labral tears in FAI patients.

Only patients who received magnetic resonance imaging prior to surgery were included in the analysis. Additional inclusion criteria for this study were anterior hip pain, positive impingement test and radiological signs of FAI. The exclusion criteria were radiological signs of degenerative or dysplastic hip, external tendon pathology, history of open surgery and age above 60 or below 22 years of age. Within these constraints a total of 490 hips in 482 patients were selected for further statistical analysis.

Magnetic resonance imaging was carried out using a 1.5-T magnet (GE Medical Systems, Milwaukee, WI, USA or Siemens Medical Systems, Issaquah, WA, USA) and multicoil-array. High-resolution T1-weighted images of the affected hip were obtained in transverse, sagittal, and coronal

planes. Fat suppression was applied in at least two imaging planes and T2-weighted, fast-spin echo images were also obtained in one or two of the imaging planes. For MRA, 15 cc of 1:200 dilutions of gadodiamide (Omniscan, Amersham Health, Princeton, NJ, USA) in sterile saline and iodinated contrast was injected into the affected hip joint under radiographic control. All MRI studies were reviewed by a musculoskeletal radiologist and the reports were available to the surgeon at the time of surgery. Findings of abnormal labral shape, detachment of labrum from the underlying acetabular rim, abnormal signal within the labrum and presence of gadolinium within the labrum were considered positive for labral lesion and the location of the lesion was assessed.

All hip arthroscopy procedures were performed in the supine position under general anaesthesia. The preoperative MRI findings were compared with the peroperative findings. Data regarding presence and location (quadrant) of labral pathology were recorded. If a tear was noted to extend beyond a single quadrant it was referenced to as multiregional. The mid-transverse acetabular ligament was defined as the 6 o'clock position. The labrum was further divided into the following quadrants: antero-superior (AS) 12-3 o'clock, antero-inferior (AI) 3-6 o'clock, postero-inferior (PI) 6-9 o'clock and postero-superior (PS) 9-12 o'clock.

The sensitivity, specificity, positive and negative predictive values, and accuracy of MRA and MRI were calculated. All analyses were performed using SPSS 22 for Macintosh (SPSS, IBM, Armonk, NY, USA).

RESULTS

A total of 490 hips in 482 patients were included for analysis. Right and left hips were involved in 54.9% and 45.1% respectively. A slightly higher percentage of women (53.5%) were included. The average time from onset of symptoms until surgical procedure ranged between 10 days and 10 months. Mean age of patients was 39.5 years (range 22 - 60 years). Patients were divided into 2 groups of age, a first group containing patients from 22 years to 40 years of age and a second group older than 40 years of age. 62,9% of hips were evaluated using MRA (308 hips) and 37,1% (182 hips) using conventional MRI.

Labral tears were identified during arthroscopy in 388 hips (79,2%). Location of the labral tear was described during arthroscopy as anterior-superior (AS) in 296 hips, anterior-inferior (AI) in 2 hips, posterior-superior (PS) in 47 hips and multiregional in 43 hips, while 102 hips did not demonstrate to have a labral tear on arthroscopy.

Results for MRI

Labral tears were identified in 96 of 182 hips (52.7%) on MRI. The location of the labral tear was described as anterior-superior (AS) in 89 hips, anterior-inferior (AI) in 3 hips, posterior-superior (PS) in 3 hips, no posterior-inferior (PI) locations and multiregional in 1 hips.

MRI had a sensitivity of 66.9%, a positive predictive value of 90,6 %, a specificity of 82.6%, a negative predictive value of 50.0%, and an accuracy of 71.4% for the detection of labral tears (Table 1).

Result for MRA

Labral tears were identified in 224 of 308 hips (72.7%) on MRA. The location of the labral tear was described as anterior-superior (AS) in 203 hips, anterior-inferior (AI) in 5 hips, posterior-superior (PS) in 3 hips, posterior-inferior (PI) in 1 hip and multiregional in 12 hips.

MRA had a sensitivity of 74.4%, a positive predictive value of 85,7%, a specificity of 36.0%, a negative predictive value of 21.4%, and accuracy of 68.2% for the detection of labral tears (Table I).

The sensitivity, specificity, positive predictive value, negative predictive value for both techniques and age groups is described in Table I.

The sensitivity, specificity, positive predictive value, negative predictive value for both techniques and for each separate part of the labrum is described in Table II.

DISCUSSION

This study is the largest of its kind to our knowledge. Previous studies that compare results

Table I. — The sensitivity, specificity, positive predictive value, negative predictive value for both techniques and age groups

	cMRI			dMRA		
Performance /Value	All population	Age 1	Age 2	All population	Age 1	Age 2
True Positive (TP)	87	33	54	192	111	81
True Negateive (TN)	43	22	21	18	11	7
False Positive (FP)	9	5	4	32	19	13
False Negative (FN)	43	14	29	66	39	27
Total:	182	74	108	308	180	128
Sensitivity (%)	66,9	70,2	65,1	74,4	74,0	75,0
Specificity (%)	82,6	81,5	84,0	36,0	36,7	35,0
Pos. Predictive Value (%)	90,6	86,8	93,1	85,7	85,4	86,2
Neg. Predictive Value (%)	50,0	61,1	42,0	21,4	22,0	20,6
Accuracy (%)	71,4	74,3	69,4	68,2	67,8	68,8

Table II. — The sensitivity, specificity, positive predictive value, negative predictive value for both techniques and for each separate part of the labrum.

	Antero Superior		Postero Superior		Antero Inferior		Postero Inferior		Multiple	
Performance/ Value	cMRI	dMRA	cMRI	dMRA	cMRI	dMRA	cMRI	dMRA	cMRI	dMRA
True Positive (TP)	67	126	1	0	0	0	0	0	0	3
True Negative (TN)	50	42	162	273	175	302	179	307	171	264
False Positive (FP)	22	77	2	3	3	5	0	1	1	9
False Negative (FN)	40	63	14	32	1	1	0	0	7	32
Total	179	308	179	308	179	308	179	308	179	308
Sensitivity (%)	62,6	66,7	6,7	0	0	0	n/a	n/a	0	8,6
Specificity (%)	69,4	35,3	98,8	98,9	98,3	98,4	100	99,7	99,4	96,7
Pos. Predictive Value (%)	75,3	62,1	33,3	0	0	0	n/a	0	0	25,0
Neg. Predictive Value (%)	55,6	40,0	92,0	89,5	99,4	99,7	100	100	96,1	89,2
Accuracy (%)	65,4	54,5	91,1	88,6	97,8	98,1	100	99,7	95,5	86,7

of MRA and MRI with arthroscopic findings have smaller sample sizes *(2,4,6,7,13,15,20,22,25,26,28,29)*

The results indicate that MRA has a higher sensitivity but lower specificity compared to MRI. One has to consider though that the MRA-group was slightly larger. A similar sensitivity and specificity was found in both age groups and at the different locations of the lesion.

A meta-analysis carried out in 2010 showed that MRI and MRA may be useful adjuncts in the

diagnosis of acetabular labral tears in adults and that MRA appears to be superior to conventional MRI. The data in this meta-analysis, however, include all causes of labral pathology with no specificity to FAI. They found that the pooled sensitivity and specificity for diagnosing acetabular labral tears were 66% and 79% for MRI and 87% and 64% for MRA. These results are in accordance with our results and show a higher sensitivity for MRA and a higher specificity for MRI as well *(23)*.

Keeney et al. *(13)* stated that a negative result of a MRA does not exclude important intra-articular pathology as a negative predictive value of only 12.9% was noted in their study. Reurink et al. *(20)* also showed that the overall sensitivity and specificity of dMRA for detecting labral lesions were 86% and 75% respectively, with similar sensitivities for the various locations of the labral tear. They concluded that MRA has a poor negative predictive value and cannot be used to rule out a labral tear when there is a high clinical suspicion of such. James et al. showed sensitivity and specificity of 100% for both in the detection of labral lesions with conventional MRI and concluded that a high resolution, non-arthrographic technique can provide the best preoperative information regarding the presence and anatomic location of labral abnormalities *(11)*.

A Comparison of MRA and MRI in the evaluation of labral lesions associated with FAI was already done in a few studies (17,25,26). Tian et al. showed that the relatively low sensitivity (61.0–66.1%) and specificity (74.2–77.4%) of conventional MRI, even at 3 T, for detecting acetabular labral tears significantly improved with MRA (90.48% - 95.24% and 84.62%, respectively) *(26)*. Their conclusion was that MRA at 3.0T was a more reliable method for evaluating acetabular labral tears, with a significant greater sensitivity and NPV compared with MRI, however, in their study only 30% of the patients underwent MRA. To date, however, 3T imaging is not yet routinely available in the clinical field. Sutter et al. compared MRA and MRI in assessing labral lesions, demonstrating that MRA showed to be advantageous over conventional MRI in the detection of labral tears for one radiologist, whereas both methods were equivalent for the other radiologist, indicating that MRI interpretation may be operator dependent *(25)*. McGuire et al. also showed that musculoskeletal radiologists achieved a higher accuracy than general radiologists in detecting labral lesions *(17)*. They also showed a greater accuracy of MRA in diagnosing labral tears when analyzing both groups of radiologists in comparison with MRI.

In all studies, including this study, hip arthroscopy was only performed in clinically symptomatic hips and this could affect specificity because the ability of the dMRA or MRI to accurately detect an intact labrum may not be reliably assessed.

The findings of our study confirm the requirement for a high clinical suspicion to diagnose symptomatic acetabular labral pathology. Although MRA is a good adjunctive study providing important diagnostic information, the importance of a careful patient history and physical examination cannot be overemphasized.

There are however a number of disadvantages related to MRA. The introduction of contrast material makes MRA more invasive and therefore can be more uncomfortable for the patient compared to MRI *(8)*. Furthermore, the use of gadolinium increases both the cost and the time of a MRA examination over conventional MRI.

Nevertheless, this study also has some limitations. As it is a retrospective study, a control group of both absence of FAI or asymptomatic FAI could not be included. Protocols of MRI and MRA of different centres are not checked for reliability between different reporters. In this study 1.5 T was used for magnetic resonance while in the literature 3 T is mostly used. It is not clear what the effect of this difference may be on the results.

In conclusion, for a clinically suspected FAI, MRA seems to have a higher sensitivity compared to MRI for detection of labral tears in the hip. Further studies on asymptomatic patients may be needed to further clarify the specificity of the different MRI techniques.

REFERENCES

1. **Anderson LA, Peters CL, Park BB** *et al.* Acetabular cartilage delamination in femoroacetabular impingement. Risk factors and magnetic resonance imaging diagnosis. *J Bone Joint Surg Am* 2009 ; 91 : 305-313.
2. **Aprato A, Masse A, Faletti C** *et al.* Magnetic resonance arthrography for femoroacetabular impingement surgery: is it reliable? *J Orthop Traumatol* 2013 ; 14 : 201-216.
3. **Audenaert EA, Peeters I, Van Onsem S, Pattyn C.** Can we predict the natural course of femoroacetabular impingement? *Acta Orthop Belg* 2011 ; 77 : 188-196.
4. **Bittersohl B, Hosalkar HS, Apprich S** *et al.* Comparison of pre-operative dGEMRIC imaging with intra-operative findings in femoroacetabular impingement: preliminary findings. *Skeletal Radiol* 2011 ; 40 : 553-561.
5. **Chakraverty JK, Sullivan C, Gan C, Narayanaswamy S, Kamath S.** Cam and pincer femoroacetabular impingement: CT findings of features resembling femoroacetabular impingement in a young population without symptoms. AJR *Am J Roentgenol* 2013 ; 200: 389-395.
6. **Chan YS, Lien LC, Hsu HL, Wan YL, Lee MS, Hsu KY** *et al.* Evaluating hip labral tears using magnetic resonance arthrography: a prospective study comparing hip arthroscopy and magnetic resonance arthrography diagnosis. *Arthroscopy* 2005 ; 21 : 1250.
7. **Crespo Rodriguez AM, de Lucas Villarrubia JC, Pastrana Ledesma MA, Millan Santos I, Padron M.** Diagnosis of lesions of the acetabular labrum, of the labral-chondral transition zone, and of the cartilage in femoroacetabular impingement: Correlation between direct magnetic resonance arthrography and hip arthroscopy. *Radiologia* 2015 ; 57 : 131-41
8. **Czerny C, Hofmann S, Neuhold A, Tschauner C, Engel A, Recht MP** *et al.* Lesions of the acetabular labrum: accuracy of MR imaging and MR arthrography in detection and staging. *Radiology* 1996 ; 200 : 225-30.
9. **Ganz R, Parvizi J, Beck M, Leunig M, Notzli H, Siebenrock KA.** Femoroacetabular impingement: a cause for osteoarthritis of the hip. *Clin Orthop Relat Res* 2003 ; 112-120.
10. **Hack K, Di Primio G, Rakhra K, Beaule PE.** Prevalence of cam-type femoroacetabular impingement morphology in asymptomatic volunteers. *J Bone Joint Surg Am* 2010 ; 92 : 2436-2444.
11. **James SL, Ali K, Malara F, Young D, O'Donnell J, Connell DA.** MRI findings of femoroacetabular impingement. AJR *Am J Roentgenol* 2006 ; 187: 1412-1419.
12. **Jung KA, Restrepo C, Hellman M, AbdelSalam H, Morrison W, Parvizi J.** The prevalence of cam-type femoroacetabular deformity in asymptomatic adults. *J Bone Joint Surg Br* 2011 ; 93 : 1303-1307.
13. **Keeney JA, Peelle MW, Jackson J, Rubin D, Maloney WJ, Clohisy JC.** Magnetic Resonance Arthrography versus Arthroscopy in the Evaluation of Articular Hip Pathology. *Clin Orthop* 2004 ; 429 : 163-169.
14. **Laborie LB, Lehmann TG, Engesaeter IO, Eastwood DM, Engesaeter LB, Rosendahl K.** Prevalence of radiographic findings thought to be associated with femoroacetabular impingement in a population-based cohort of 2081 healthy young adults. *Radiology* 2011 ; 260 : 494-502.
15. **Lattanzi R, Petchprapa C, Glaser C, Dunham K, Mikheev AV, Krigel A** *et al.* A new method to analyze dGEMRIC measurements in femoroacetabular impingement: preliminary validation against arthroscopic findings. *Osteoarthritis Cartilage* 2012 ; 20 : 1127-1133.
16. **Leunig M, Beaule PE, Ganz R.** The concept of femoroacetabular impingement: current status and future perspectives. *Clin Orthop Relat Res* 2009 ; 467 : 616-622.
17. **McGuire CM, MacMahon P, Byrne DP, Kavanagh E, Mulhall KJ.** Diagnostic accuracy of magnetic resonance imaging and magnetic resonance arthrography of the hip is dependent on specialist training of the radiologist. *Skeletal Radiol* 2012 ; 41 : 659-65.
18. **Mintz DN, Hooper T, Connell D, Buly R, Padgett DE, Potter HG.** Magnetic resonance imaging of the hip: detection of labral and chondral abnormalities using noncontrast imaging. *Arthroscopy* 2005 ; 21: 385-93.
19. **Petchprapa CN, Rybak LD, Dunham KS, Lattanzi R, Recht MP.** Labral and cartilage abnormalities in young patients with hip pain: accuracy of 3-Tesla indirect MR arthrography. *Skeletal Radiol* 2015 ; 44 : 97-105.
20. **Reurink G, Jansen SP, Bisselink JM, Vincken PW, Weir A, Moen MH.** Reliability and validity of diagnosing acetabular labral lesions with magnetic resonance arthrography. *J Bone Joint Surg Am* 2012 ; 94 : 1643-1648.
21. **Rubin DA.** Femoroacetabular impingement: fact, fiction, or fantasy? AJR *Am J Roentgenol* 2013 ; 201 : 526-534.
22. **Schmid MR, Notzli HP, Zanetti M, Wyss TF, Hodler J.** Cartilage lesions in the hip: diagnostic effectiveness of MR arthrography. *Radiology* 2003 ; 226 : 382-6.
23. **Smith TO, Hilton G, Toms AP, Donell ST, Hing CB.** The diagnostic accuracy of acetabular labral tears using magnetic resonance imaging and magnetic resonance arthrography: a meta-analysis. *Eur Radiol* 2011 ; 21 : 863-874.
24. **Smith TO, Simpson M, Ejindu V, Hing CB.** The diagnostic test accuracy of magnetic resonance imaging, magnetic resonance arthrography and computer tomography in the detection of chondral lesions of the hip. *Eur J Orthop Surg Traumatol* 2013 ; 23 : 335-44.
25. **Sutter R, Zubler V, Hoffmann A** *et al.* Hip MRI: how useful is intraarticular contrast material for evaluating surgically proven lesions of the labrum and articular cartilage? AJR *Am J Roentgenol* 2014 ; 202 : 160-169.
26. **Tian CY, Wang JQ, Zheng ZZ, Ren AH.** 3.0 T conventional hip MR and hip MR arthrography for the acetabular labral tears confirmed by arthroscopy. *Eur J Radiol* 2014 ; 83 : 1822-1827.

27. **Zaragoza E, Lattanzio PJ, Beaule PE.** Magnetic resonance imaging with gadolinium arthrography to assess acetabular cartilage delamination. *Hip international* 2009 ; 19 : 18-23.
28. **Ziegert AJ, Blankenbaker DG, De Smet AA, Keene JS, Shinki K, Fine JP.** Comparison of standard hip MR arthrographic imaging planes and sequences for detection of arthroscopically proven labral tear. AJR Am J Roentgenol 2009 ; 192 : 1397-1400.
29. **Zlatkin MB, Pevsner D, Sanders TG, Hancock CR, Ceballos CE, Herrera MF.** Acetabular labral tears and cartilage lesions of the hip: indirect MR arthrographic correlation with arthroscopy - a preliminary study. AJR Am J Roentgenol 2010 ; 194 : 709-714.