The validity and accuracy of MRI arthrogram in the assessment of painful articular disorders of the hip

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Rajeev, A. (Aysha), Tuinebreijer, W.E, Mohamed, A. (Abdalla), & Newby, M. (Mike). (2017). The validity and accuracy of MRI arthrogram in the assessment of painful articular disorders of the hip. *European Journal of Orthopaedic Surgery and Traumatology*, 1–7. doi:10.1007/s00590-017-2022-9

ABSTRACT

The assessment of a patient with chronic hip pain can be challenging. The differential diagnosis of intraarticular pathology causing hip pain can be diverse. These includes conditions such as osteoarthritis, fracture, and avascular necrosis, synovitis, loose bodies, labral tears, articular pathology and femoro-acetabular impingement. Magnetic resonance imaging (MRI) arthrography of the hip has been widely used now for diagnosis of articular pathology of the hip.

A retrospective analysis of 113 patients who had MRI arthrogram and who underwent hip arthroscopy were included in the study. The MRI arthrogram was performed using gadolinium injection and reported by a single radiologist. The findings were then compared to that found on arthroscopy. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), accuracy and 95%confidence interval (CI) were calculated for each pathology.

Labral tear-Sensitivity 84% (74.3-90.5), Specificity 64% (40.7-82.8), PPV 91% (82.1-95.8), NPV 48% (29.5-67.5), accuracy 80%. **Delamination-**Sensitivity 7% (0.8-22.1), Specificity 98% (91.6-99.7), PPV 50% (6.8-93.2), NPV 74% (65.1-82.2) and accuracy 39%. **Chondral changes**-Sensitivity 25%(13.3-38.9), Specificity 83% (71.3-91.1), PPV 52%(30.6-73.2), NPV 59% (48.0-69.2) and accuracy 58%. **Femoral-acetabular impingement (CAM deformity)**-Sensitivity 34% (19.6-51.4), Specificity 83% (72.2-90.4), PPV 50% (29.9-70.1), NPV 71% (60.6-80.5) and accuracy 66%. **Synovitis**-Sensitivity 11% (2.3-28.2), Specificity 99% (93.6-100), PPV 75% (19.4-99.4), NPV 77% (68.1-84.6) and accuracy 77%.

Our study conclusions are MRI arthrogram is a useful investigation tool in detecting labral tears, it is also helpful in the diagnosis of femoral-acetabular impingement. However when it comes to the diagnosis of chondral changes, defects and cartilage delamination the sensitivity and accuracy is low.

Keywords: MRI arthrogram, Validity, Accuracy, Articular pathology.

INTRODUCTION

The complex anatomy and biomechanics of the hip makes the diagnosis of hip pathology very challenging [1]. The use of plain magnetic resonance imaging (MRI) is a usual imaging investigation to detect bone and soft tissue pathologies of the hip joint [2]. But it is limited in the evaluation of acetabular labral tears, cartilage defects and loose bodies [3]. MRI arthrograms is reported to have high sensitivity and specificity in the diagnosis of articular disorders of the hip[4]. MRI arthrogram with injection of contrast agent like gadolinium gives better detection of labral pathology[5]

Hip arthroscopy is considered as the gold standard for the diagnosis of intra articular pathologies and initiate appropriate treatment [6]. Recently hip arthroscopy has been widely used for the diagnosis and treatment of hip intra-articular disorders [7, 8]. But the use of hip arthroscopy as a diagnostic tool is not accepted among hip surgeons as it is invasive and costly[9]. This has led to the development and improvement in the technique and interpretation of MRI arthrograms so that an accurate diagnosis can be established before performing the hip arthroscopy[10].

In our study we compared the MRI arthrogram findings reported by a single radiologist to that of the pathologies found during hip arthroscopy. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy in the diagnosis of various hip pathology including labral tear, delamination and chondral changes, femoral-acetabular impingement (CAM and pincer lesion) and synovitis are calculated for MRI arthrogram.

MATERIALS AND METHODS

The patients who were included in the study were a consecutive series of 113 cases seen in the Hip clinic, referred with complaints of painful hip disorders. The outpatient work up included a detailed history taking and clinical examination of the hip which consists of tests to diagnose labral tears and impingement. A plain x-ray (AP and Lateral views) was taken to rule out degenerative arthritic changes. The patients who were suspected to have soft tissue pathology or signs and symptoms of impingement were then referred for MRI arthrography done by a single musculoskeletal radiologist. The patient demographics are shown in Table 1.

MRI arthrogram technique

An informed written consent including risk of infection and action to be taken in context of deteriorating symptoms over 72 hr period. Verbal information about post procedural care. Patients are positioned supine on fluoroscopic unit. The affected leg placed in 45 degrees internal rotation and foam pad under knee to flex hip 10 degrees. Skin marked under fluoroscopy guidance. Skin prepared using chloroprep

Table 1: Patient demographics

Age (in years)	
Mean	39.7753
Median	40.1232
Std. Deviation	12.08682
Variance	146.096
Range	56.87
Minimum	16.83
Maximum	73.70
Sex (M/F)	51/62
Side (R/L)	59/54

stick and draped. The injection site is infiltrated using 3-5mls 1% lidocaine to skin. Anterior approach with 22G spinal needle. Intra-articular position confirmed with 2mls omnipaque 240 and between 12-16mls of dilute gadolinium solution (0.2mls of multihance or prohance diluted in 20mls saline) injected and dressings applied. The patient is then transferred to MRI room in a wheelchair.

The usual sequences done are: Field of View 16 x 16 cm;Axial oblique and coronal T1 weighted fat saturated; Coronal Proton density fat saturated; Axial T1 Fast spin echo;3d T1 weighted Fast Field Echo.

The hip arthroscopy was performed under image intensifier control with either general or spinal anaesthesia. The patient was put on traction table with appropriate traction applied to distract the joint. A spinal needle was used to locate the joint under fluoroscopy and 70 degrees scopes were used. The central and peripheral compartments were visualised and all the findings were documented. A retrospective analysis of these 113 patients who had MRI arthrogram and who underwent hip arthroscopy were carried out. The findings were then compared to that found on arthroscopy.

Statistical analysis

The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), accuracy positive likelihood ratio, negative likelihood ratio and disease prevalence and 95%confidence interval (CI) were calculated for each pathology. The ROC curve is constructed for labral pathology as this was the commonest findings in both MRI arthrogram and hip arthroscopy. The analysis is conducted using IBM SPSS Statistics version 24.0 and MedCalc Statistical Software version 16.8.4 (MedCalc Software bvba, Ostend, Belgium; https://www.medcalc.org; 2016).

RESULTS

Labral tears-Sensitivity 83.52%, Specificity 63.64%, PPV 90.48%, NPV 48.28% and accuracy 79.6%, Table 2, Figure 1.

Femoral-acetabular impingement (CAM deformity)-Sensitivity 34.21%, Specificity 82.67%, PPV 50.00%, NPV 71.26% and accuracy 66.4%, Table 3, Figure 2.

Chondral changes-Sensitivity 24.49%, Specificity 82.81%, PPV 52.17%, NPV 58.89% and accuracy 57.5%, Table 4, Figure 3.

Delamination -Sensitivity 6.67%, Specificity 97.59%, PPV 50.00%, NPV 74.31% and accuracy 38.9%, Table 5, Figure 4.

Synovitis-Sensitivity 10.71%, Specificity 98.82%, PPV 75.0%, NPV 77.06% and accuracy 77.0%, Table 6, Figure 5.

Loose bodies-Sensitivity 0.00%, Specificity 99.11%, PPV 0.00%, NPV 99.11% and accuracy 98.2%, Table 7.

The ROC for labral tear showed AUC (Area Under the Curve) as 0.736 which is statistically significant (P value 0.0003) Figure 5 and Table 8 demonstrates the likelihood ratios.

DISCUSSION

There are several previous studies that compared the findings of MRI arthrogram and hip arthroscopy [11, 12, 13, and 14]. Most of these studies have shown that MRI arthrogram is useful in detecting acetabular labral tears, our study showed that in detecting the labral tears, the sensitivity, specificity and accuracy was slightly lower than the other published studies [11, 12, 13]. The sensitivity varied from 70 to 100% with majority more than 90%. The specificity varied from 0 to 100% with most studies showing less than 80%. This may be due to the fact that the other studies had only small patient cohorts compared to 113 patients in our study. The meta-analysis study by Smith et al showed a collective sensitivity of 87% and specificity of 64% for MRI arthrograms [15]. This is more or less agreeable with our results of sensitivity 83.5% and specificity 63.6%.

In the assessment of chondral lesions the sensitivity is usually low and specificity is high as shown in various studies [4, 16, 17]. In our series the sensitivity was 24.5% and specificity was 82.8%. But the study by Zlatkin et al showed a very high sensitivity of 82%[11]. The meta-analysis study by Smith et al also showed similar conclusions[18]. The diagnosis of cartilage delamination using MRI arthrogram is very demanding. This may be due to the fact that the hip joint distensibility is very much restricted. There are some studies which suggest that a plain MRI scan is more useful to detect cartilage injuries in the hip rather than with MRI arthrogram[19]. Anderson et al showed that for cartilage delamination magnetic

Table 2. Diagnostic test for labral tear–Overall accuracy -79.6%

Data			
	Disease Present	Disease Absent	
Test Positive	76	8	84
Test Negative	15	14	29
	91	22	
Results			
Sensitivity	83.52%		74.27% to 90.47%
Specificity	63.64%		40.66% to 82.80%
AUC	0.74		0.64 to 0.81
Positive Likelihood Ratio	2.30		1.31 to 4.02
Negative Likelihood Ratio	0.26		0.15 to 0.45
Disease prevalence	80.53%		72.02% to 87.38%
Positive Predictive Value	90.48%		82.09% to 95.80%
Negative Predictive Value	48.28%		29.45% to 67.47%

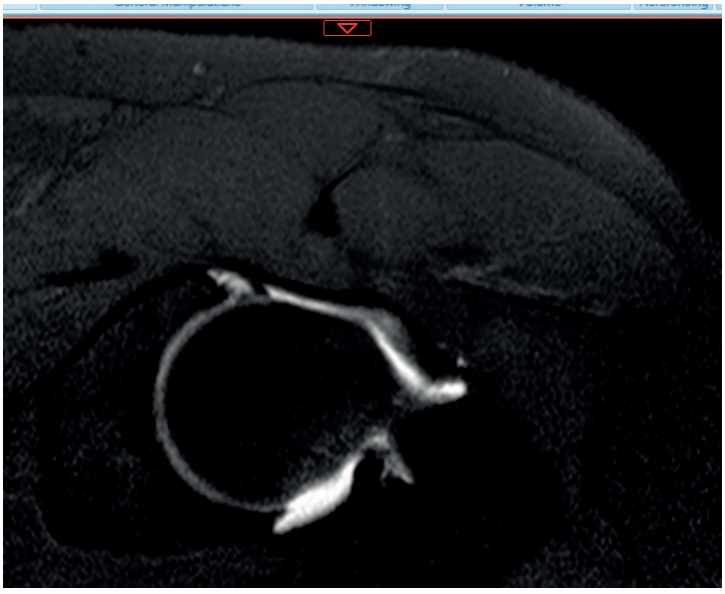

Figure 1. Axial oblique T1 fat saturated weighted MR arthrogram image showing acetabular labral tear.

Table 3. Diagnostic test CAM and FAI-Overall accuracy-66.4%

Data			
	Disease Present	Disease Absent	
Test Positive	13	13	26
Test Negative	25	62	87
	38	75	
Results			
Sensitivity	34.21%		19.63% to 51.35%
Specificity	82.67%		72.19% to 90.43%
AUC	0.58		0.49 to 0.68
Positive Likelihood Ratio	1.97		1.02 to 3.83
Negative Likelihood Ratio	0.80		0.62 to 1.02
Disease prevalence	33.63%		25.01% to 43.12%
Positive Predictive Value	50.00%		29.93% to 70.07%
Negative Predictive Value	71.26%		60.57% to 80.46%

Figure 2. Coronal T2 fat saturated weighted MR arthrogram image showing femoral head osteophytes

Table 4. Diagnostic test Chondral changes-Overall accuracy -57.5%

Data			
	Disease Present	Disease Absent	
Test Positive	12	11	23
Test Negative	37	53	90
	49	64	
Results			
Sensitivity	24.49%		13.34% to 38.87%
Specificity	82.81%		71.32% to 91.10%
AUC	0.54		0.44 to 0.63
Positive Likelihood Ratio	1.42		0.69 to 2.95
Negative Likelihood Ratio	0.91		0.75 to 1.11
Disease prevalence	43.36%		34.07% to 53.01%
Positive Predictive Value	52.17%		30.59% to 73.18%
Negative Predictive Value	58.89%		48.02% to 69.16%

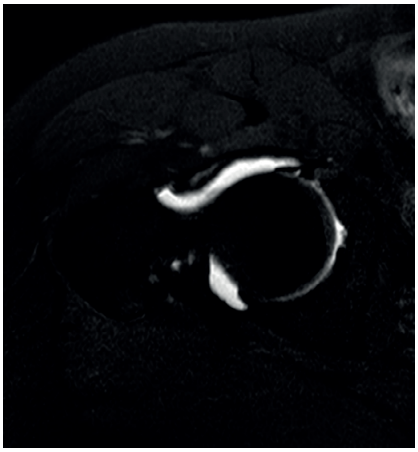

Figure 3a. Axial oblique T1 weighted Fat saturated arthrogram image which demonstrates a small focus of full thickness anterior acetabular chondral deficit

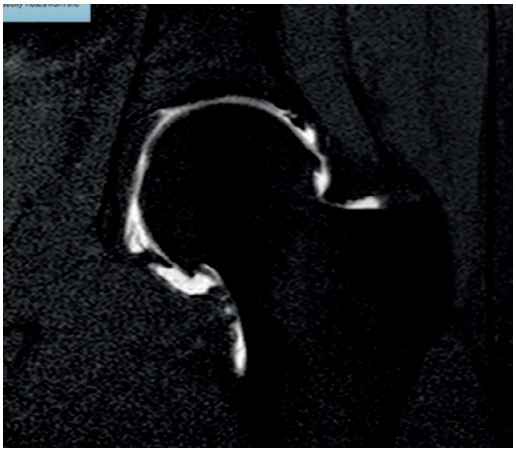

Figure 3b. Coronal T1 weighted Fat saturated arthrogram picture showing acetabular chondral delamination/grade 4 chondral changes in the lateral acetabulum

Table 5. Diagnostic test Delamination –Overall accuracy-73.5%

Data			
	Disease Present	Disease Absent	
Test Positive	2	2	4
Test Negative	28	81	109
	30	83	

Results		
Sensitivity	6.67%	0.82% to 22.07%
Specificity	97.59%	91.57% to 99.71%
AUC	0.52	0.43 to 0.62
Positive Likelihood Ratio	2.77	0.41 to 18.78
Negative Likelihood Ratio	0.96	0.86 to 1.06
Disease prevalence	26.55%	18.68% to 35.68%
Positive Predictive Value	50.00%	6.76% to 93.24%
Negative Predictive Value	74.31%	65.06% to 82.20%

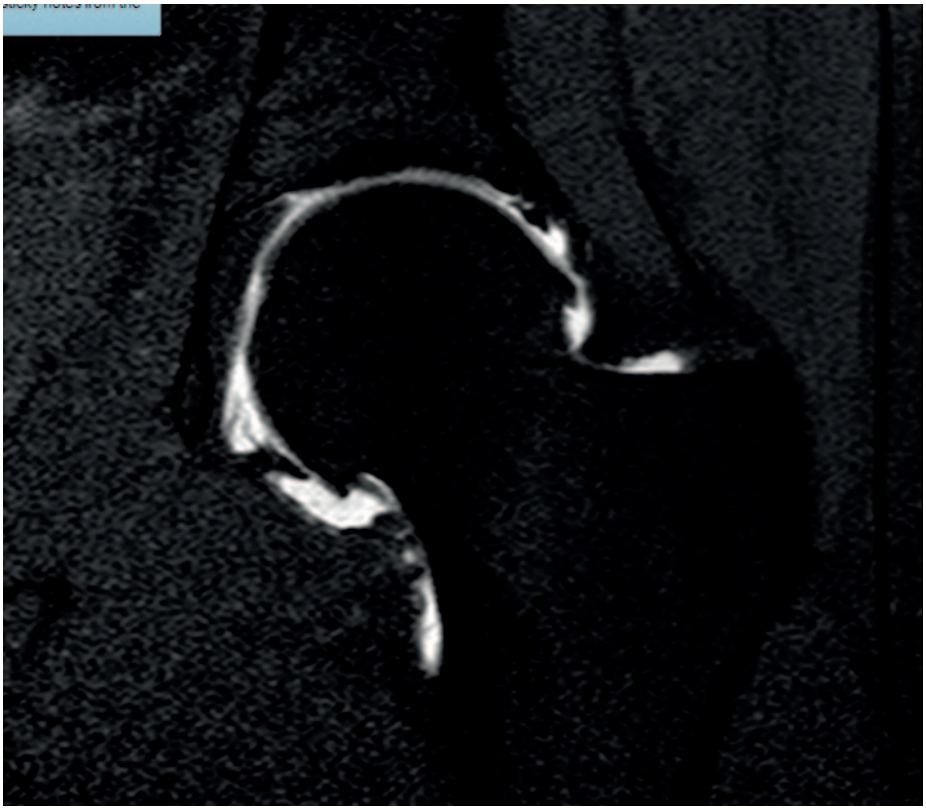

Figure 4. Coronal T1 weighted Fat saturated arthrogram image showing acetabular delamination in the lateral acetabulum

Table 6. Diagnostic test Synovitis-overall accuracy-77.0%

Data			
	Disease Present	Disease Absent	
Test Positive	3	1	4
Test Negative	25	84	109
	28	85	

Results		
Sensitivity	10.71%	2.27% to 28.23%
Specificity	98.82%	93.62% to 99.97%
AUC	0.55	0.45 to 0.64
Positive Likelihood Ratio	9.11	0.99 to 84.07
Negative Likelihood Ratio	0.90	0.79 to 1.03
Disease prevalence	24.78%	17.14% to 33.78%
Positive Predictive Value	75.00%	19.41% to 99.37%
Negative Predictive Value	77.06%	68.03% to 84.57%

Figure 5. Coronal T1 weighted fat saturated images demonstrates synovitis throughout the hip joint

Table 7. Diagnostic test Loose bodies-overall accuracy-98.2%

Data			
	Disease Present	Disease Absent	
Test Positive	0	1	1
Test Negative	1	111	112
	1	112	
Results			
Sensitivity	0.00%		0.00% to 97.50%
Specificity	99.11%		95.13% to 99.98%
AUC	0.50		0.40 to 0.59
Positive Likelihood Ratio	0.00		
Negative Likelihood Ratio	1.01		0.99 to 1.03
Disease prevalence	0.88%		0.02% to 4.83%
Positive Predictive Value	0.00%		0.00% to 97.50%
Negative Predictive Value	99.11%		95.13% to 99.98%

Table 8. Criterion values and coordinates of the ROC curve

Criterion	Sensitivity	95% CI	Specificity	95% CI	+LR	95% CI	-LR	95% CI
≥0	100.00	96.0 - 100.0	0.00	0.0 - 15.4	1.00	1.0 - 1.0		
>0	83.52	74.3 - 90.5	63.64	40.7 - 82.8	2.30	1.3 - 4.0	0.26	0.1 - 0.5
>1	0.00	0.0 - 4.0	100.00	84.6 - 100.0			1.00	1.0 - 1.0

resonance arthrography had a low sensitivity of 22% but had a high specificity of 100%[20]. In our study also the sensitivity for detecting cartilage delamination using MRI arthrogram is very low of 6.67% but very high specificity of 97.59% which is in agreement with other published studies.

One of the commonest causes of pain in young adult hip is femoro-acetabular impingement (FAI) [21]. MRI arthrogram is useful tool in the diagnosis of femoro-acetabular impingement. Notzli et al compared the MRI images of patient with FAI with control subjects and measured the alpha angle. They proposed that an alpha angle of more than 55 degrees is diagnostic of FAI[22]. The published studies by Aprato et al demonstrated that the sensitivity of MRI arthrogram for FAI was 46% and specificity was 81%[23]. This comparable to our findings for FAI with sensitivity of 34.25 and specificity of 82.7%.

The usual pathology causing mechanical symptoms and thereby giving rise to painful hip are the presence of intra articular loose bodies[24]. Intra articular loose bodies form as result of acute or chronic injury, osteochondritis dissecans and synovial osteochondromatosis[25]. They can be fibrous, cartilaginous, osseous or a mixture of composition of these tissues[26,27]. The loose bodies can be of various shapes and sizes[28]. Neckers et al in their study has shown that in the detection

of loose bodies using MRI arthrogram, the specificity was 96% and sensitivity 44%[29]. They recommended that ultrasound and CT scans with or without air or saline would give better results than MRI arthrogram.

There are no studies in the literature looking at the accuracy and usefulness in the diagnosis of synovitis of the hip using MRI arthrogram. In our study we found that the sensitivity was very low of 10% and very high specificity of 98%.

Aprato et al in their study reviewed 60 patients who had undergone a revision hip arthroscopy. Patients were divided into two groups, Group 1 which included 40 patients who had undergone arthroscopic labral surgery and Group 2 of 20 patients who had not undergone labral surgery. Sensitivity for MRA after hip arthroscopy was 53% and 71% in the study and control groups, respectively. The specificity was 50% and 92%, positive predictive value was 81% and 83%, negative predictive value was 21% and 86% and accuracy was 53% and 85%. They concluded that the MRA is not reliable after hip arthroscopy where a labral tear has been repaired[30].

Another recent study by Reurink et al concluded that when there is a high clinical suspicion of a labral lesion, magnetic resonance arthrography has a poor negative predictive [31]. In the recent study by Crespo Rodriguez et al, they found that the sensitivity and specificity of MR arthrography were 94.5% and 100%, respectively for labral tears and 92.5% and 54.5%, respectively for diagnosing lesions of the articular cartilage. These findings are not in agreement with our study which showed only 25% sensitivity for articular cartilage lesions. But they concluded that the diagnostic accuracy of MR arthrogram was not so good in small chondral lesions [32].

Limitations of the study: Our study is a retrospective analysis of 113 MR arthrograms findings compared with that found at hip arthroscopy. The cohort of patient numbers is small. The results of MR arthrogram was interpreted by one radiologist thereby inter- observer variability could not be assessed.

Future Directions: A prospective study with large group of patients with two observers should be carried out to reduce intra and inter observer variability so that the results will be statistically more significant.

Conclusion: In our study MRI arthrogram of the hip is a useful diagnostic tool in detecting labral, femoral acetabular impingement with accuracy of 80% and 66% respectively. But in the diagnosis of cartilage pathology including delamination and chondral defects the accuracy was 39% and 58% respectively.

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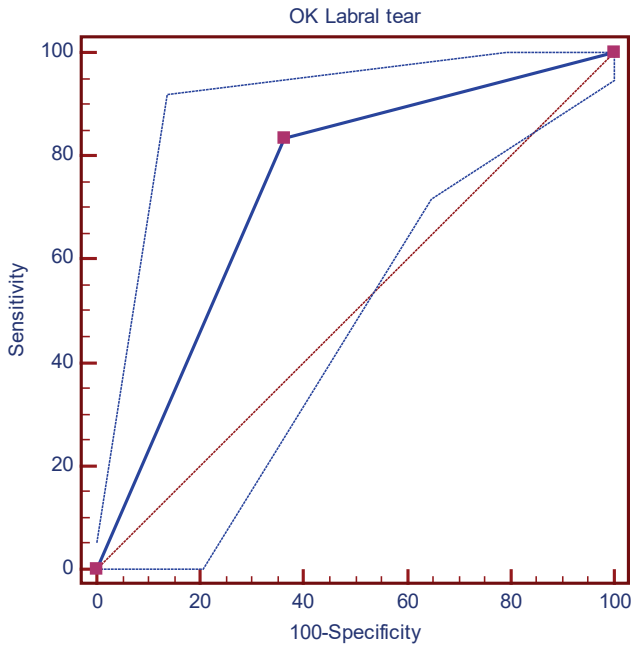

Figure 6. ROC curve for labral tear solid line showing the test and dashed lines showing likelihood ratios. The AUC is 0.74 with 95% CI – 0.645 to 0.814.