Comparison of magnetic resonance arthrography with arthroscopy for imaging of shoulder injuries: retrospective study

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ABSTRACT

BACKGROUND Arthroscopy is the established 'gold standard' diagnostic investigation for detection of shoulder disorders. We aimed to compare the diagnostic accuracy of arthroscopy with magnetic resonance arthrography (MRA) for detection of shoulder disorders.

METHODS Patients who underwent arthroscopy by a single surgeon and preoperative MRA between February 2011 and March 2012 for shoulder instability were identified. MRAs were reported by experienced musculoskeletal radiologists. Labral tears, anterior labral tears, superior labral anterior posterior (SLAP) lesions, posterior labral tears, rotator-cuff tears (RCTs), osteoarthritis, loose bodies and Hill–Sachs lesions were identified. Sensitivity, specificity, positive predictive value and negative predictive value, positive likelihood ratio and negative likelihood ratio were calculated.

RESULTS A total of 194 patients were identified. The sensitivity and specificity for anterior labral tears was 0.60 and 0.92, SLAP lesions was 0.75 and 0.81, posterior labral tears was 0.57 and 0.96, any labral tear was 0.87 and 0.76, Hill–Sachs lesions was 0.91 and 0.91, RCTs was 0.71 and 0.86, osteoarthritis was 0.72 and 0.95, and loose bodies was 0.22 and 0.96, respectively. The positive predictive value and negative predictive value for anterior labral tears were 0.88 and 0.71, SLAP lesions was 0.64 and 0.88, posterior labral tears was 0.74 and 0.45, any labral tear was 0.89 and 0.71, Hill–Sachs lesions was 0.66 and 0.98, RCTs was 0.47 and 0.95, osteoarthritis was 0.70 and 0.95, and loose bodies was 0.27 and 0.95, respectively.

CONCLUSIONS MRA has high diagnostic accuracy for labral tears and Hill–Sachs lesions, but whether MRA should be the first-line imaging modality is controversial.

KEYWORDS

Magnetic resonance arthrography – Arthroscopy – Rotator cuff – Tears – Hill–Sachs

Accepted 23 Aug 2015

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In recent years, there has been surge in routine use of magnetic resonance arthrography (MRA) over magnetic resonance imaging (MRI) for the diagnosis of shoulder injuries.¹ In 2012, Smith showed higher sensitivity for MRA compared with MRI for the detection of glenohumeral disorders.² In 2012, Li and colleagues concluded that MRA had superior accuracy for detection of anterior labral tears in comparison with MRI.³ In 2011, Major and coworkers noted superior accuracy with 3T MRA compared with 3T MRI for assessment of labral disorders.⁴

'Direct MRA' is an invasive procedure involving injection of contrast into the glenohumeral joint under fluoroscopic or ultrasound guidance.⁵ In 2011, Giaconci and colleagues found that 66% of patients experienced delayed onset of pain that resolved in several days.⁵ In 2010, Holzapfel and coworkers found substantial-to-excellent interobserver agreement between radiologist interpretation of MRAs for superior labral anterior posterior (SLAP) lesions.⁶

The 'gold standard' diagnostic shoulder investigation is arthroscopy, which enables direct visualisation of intra-articular soft tissues and bone tissues.⁷ In contrast with radiological modalities, arthroscopy has diagnostic and therapeutic value,⁷ but it is more invasive than MRA and requires general anaesthesia, which is associated with complications.⁷ Therefore, a preoperative investigation that is sufficiently accurate in excluding disease that does not require surgical intervention could be an excellent adjunct to surgery.

We wished to evaluate the diagnostic accuracy of 1.5T MRA compared with arthroscopy for assessment of abnormalities of the labrum, rotator cuff, and glenohumeral joint.

Methods

Shoulder arthroscopies undertaken by a single consultant orthopaedic surgeon between February 2011 and March 2012 for instability were identified using the operative

records of the surgeon. Initially, patients attended an outpatient clinic and were found to have clinical instability upon examination, with suspicion of glenohumeral disorders. Positive findings for impingement syndrome, SLAP, labral or rotator-cuff tears (RCTs) were noted upon examination with a subsequent need for investigations. Of these patients, only those who had a preoperative MRA were included and identified using a picture archiving and communication system (PACS; (Centricity®; GE Healthcare, Little Chalfont, UK), Bluespier (Bluespier International, Droitwich, UK) and clinic letters. Patients were included regardless of demographics, background or side of surgery. MRAs were requested by the consultant orthopaedic surgeon to ensure that radiologists were made aware of the positive clinical findings on the request forms. Investigations and procedures were conducted over three hospital sites. 1.5T MRI scanners with gadolinium as contrast were used throughout with a routine standard protocol of T1 and T1 fat saturation axial; T1 fat saturation coronal oblique; T1 fat saturation sagittal oblique; T2 fat saturation coronal oblique. MRAs were reported by experienced specialist musculoskeletal radiologists and were analysed to identify: anterior, SLAP, posterior labral tears; labral tears regardless of position; partial- or full-thickness RCTs; osteoarthritis; loose bodies; Hill-Sachs lesions. If such disorders were identified, a comparison was made with arthroscopy. Each arthroscopy was used to diagnose these shoulder disorders. For subjects with multiple disorders upon arthroscopy or MRA, each lesion was considered individually. Findings were graded as 'positive' only if the reporting radiologist or arthroscopist provided a definitive diagnosis.

Statistical analyses

Sensitivities, specificities, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (PLR) and negative likelihood ratio (NLR) were calculated using SPSS v22.0 (IBM, Armonk, NY, USA).

Results

A total of 744 patients underwent arthroscopic procedures to assess shoulder instability. Of these, 194 patients had a pre-operative MRA. Mean age was 29.9 (range, 13–69) years; males:females, 73%:27%. Ratio of right:left disorders was 52%:48%. Patients whose disorders were identifiable readily upon clinical examination or simpler radiological investigations (e.g., ultrasound, radiographs) did not undergo MRA.

The greatest number of lesions found at arthroscopy and MRA was any labral tear (136 *vs.* 132) in comparison with the least (loose bodies, 12 *vs.* 11), respectively (Table 1). The highest sensitivity was seen with Hill-Sachs lesions (0.91 (95% confidence interval: 0.75–0.98)) and the lowest with loose bodies (0.25 (0.06–0.57)). The highest specificity was observed in SLAP lesions (0.98 (0.73–0.88)) compared with any labral tears (0.76 (0.63–0.86)). In general, specificities were higher in comparison with sensitivities for most lesions except labral tears.

The highest PPV was seen for any labral tears (0.89 (0.83–0.94)) and lowest for loose bodies (0.27 (0.06–0.61)). The highest NPV was recorded for Hill-Sachs lesions (0.98 (0.94–1.00)) in comparison with the lowest for anterior labral tears (0.71 (0.62–0.78)) and any labral tear (0.71 (0.58–0.82)). Osteoarthritis showed the highest PLR (13.28 (6.77–26.04)),

Table 1 Number of lesions found at arthroscopy and magnetic resonance arthrography

Lesion	Number found at AY	Number found at MRA	Sensitivity	Specificity	PLR	NLR	PPV	NPV
Anterior labral tear	96	66	0.60 (0.49–0.70)	0.92 (0.85–0.96)	7.45 (3.75–14.78)	0.44 (0.34–0.57)	0.88 (0.77–0.94)	0.71 (0.62–0.78)
Posterior Labral tear	28	24	0.57 (0.39–0.74)	0.96 (0.91–0.98)	12.98 (5.96–28.29)	0.45 (0.31–0.66)	0.74 (0.54–0.89)	0.45 (0.31–0.66)
Any labral tear	136	132	0.87 (0.80–0.92)	0.76 (0.63–0.86)	3.59 (2.27–5.70)	0.17 (0.11–0.27)	0.89 (0.83–0.94)	0.71 (0.58–0.82)
SLAP lesion	67	77	0.75 (0.62–0.86)	0.98 (0.73–0.88)	3.99 (2.70–5.89)	0.3 (0.19–0.48)	0.64 (0.52–0.76)	0.88 (0.81–0.93)
Osteoarthritis	29	30	0.72 (0.53–0.87)	0.95 (0.90–0.97)	13.28 (6.77–26.04)	0.29 (0.16–0.53)	0.70 (0.51–0.85)	0.95 (0.91–0.98)
Hill-Sachs lesion	32	44	0.91 (0.75–0.98)	0.91 (0.85–0.95)	9.79 (5.97–16.05)	0.10 (0.04–0.30)	0.66 (0.50–0.80)	0.98 (0.94–1.00)
Loose bodies	12	11	0.25 (0.06–0.57)	0.96 (0.92–0.98)	5.69 (1.73–18.72)	0.78 (0.57–1.09)	0.27 (0.06–0.61)	0.95 (0.91–0.98)
Rotator-cuff tear	29	42	0.71 (0.51–0.87)	0.86 (0.80–0.91)	5.12 (3.28–8.00)	0.33 (0.18–0.60)	0.47 (0.31–0.62)	0.95 (0.90–0.98)

AY = arthroscopy, MRA = magnetic resonance arthrography, PLR = positive likelihood ratio, NLR = negative likelihood ratio, PPV = positive predictive value, NPV = negative predictive value, SLAP = superior labral anterior posterior

whereas any labral tears showed the lowest (3.59 (2.27–5.70)). The NLR was best for Hill–Sachs lesions (0.10 (0.04–0.30)) compared with loose bodies (0.78 (0.57–1.09)).

Discussion

In 2013, Lenza and colleagues showed MRA to have a sensitivity and specificity of 0.94 and 0.92, respectively, for detection of full-thickness RCTs.¹ In 2013, Stoppino and coworkers found MRA to have a sensitivity of 0.92, specificity of 0.78, PPV of 0.95 and NPV of 0.64.⁸ In 2011, Kalson and colleagues found a sensitivity of 0.40 and specificity of 0.81 for RCTs.⁹ In 2014, Magee and coworkers found that conventional MRI could not be used to detect some full-thickness tears of the supraspinatus tendon seen on MRA and arthroscopy.¹⁰ In 2004, Magee and colleagues suggested that MRA may yield greater diagnostic information in high-performance athletes in comparison with MRI.¹¹ There are clear differences between those studies for diagnostic accuracy achieved by MRA which may be accounted for by different sample sizes, populations, methods and subjective interpretation of imaging. Our results of a PLR of 5.12, NLR of 0.33, PPV of 0.47, and NPV of 0.95 suggest that MRA could be reliable for excluding partial- or full-thickness tears of the rotator cuff but less reliable at confirming the definitive presence of tears. We accepted identification of partial- or full-thickness RCTs as positive findings for RCTs and did not subcategorise, which could have accounted for further differences in results. During the initial assessment, if clinical findings were suspicious only for a RCT, then the patient underwent ultrasound in the clinic. MRA was requested only for RCTs if the diagnosis was questionable, further information regarding muscle quality was needed, or if other disorders contributing to symptoms were likely.

The sensitivity and specificity of anterior labral tears was shown to be 0.58 and 1.00 by Jonas and colleagues in 2012, 0.75 and 0.73 by Kalson and coworkers in 2011, and 0.95 and 1.00 by Parmar and colleagues in 2002, respectively.^{7,9,12} MRA in our study was useful for identification but less helpful for exclusion of anterior labral tears based upon a high PPV (0.88 (0.77–0.94)) and lowest NPV (0.71 (0.62–0.78)).

The sensitivity and specificity of posterior labral tears was shown to be 0.75 and 0.98 by Jones and colleagues in 2012 and 0.50 and 0.92 by Kalson and coworkers in 2011, respectively, data that are similar to our results.^{7,9} We found MRA to be a valuable tool for detection of posterior labral tears, with a PLR of 12.98 (5.96–28.29) and PPV of 0.91 (0.86–0.95). MRA was less accurate for exclusion of posterior labral tears, with a NLR of 0.45 (0.31–0.66) and NPV of 0.45 (0.31–0.66). Jones and colleagues in 2012 documented a sensitivity and specificity of 0.65 and 1.00 for any labral tear, respectively.⁷

The NLR of 0.10 (0.04–0.30) for Hill–Sachs lesions in our study showed that they can be excluded reliably if not detected using MRA. Similarly, a high PLR of 9.79 (5.97–16.05) suggests a substantial increase in the likelihood of a Hill–Sachs lesion on arthroscopy if the MRA is positive. Kalson and coworkers in 2011 reported a sensitivity and specificity of 0.71 and 0.85, respectively, similar to the data of our study.⁹

Amin and colleagues in 2012 compared the diagnostic value of MRA with arthroscopy for SLAP lesions, and revealed an overall sensitivity and specificity of 0.90 and 0.50, respectively,¹⁰ and the PPV was 0.82 and NPV was 0.67.¹³ They also found MRA to be sensitive for grading SLAP tears and thereby preventing unnecessary diagnostic arthroscopies.¹⁵ Kalson and coworkers in 2011 showed a sensitivity and specificity of 0.71 and 0.91 for detection of SLAP lesions.⁹ Sheridan and collaborators in 2014 showed a PPV of 0.24, NPV of 0.95, as well as a sensitivity and specificity of 0.66 and 0.77, respectively, for detection of SLAP lesions using MRI.¹⁴ Jones and colleagues in 2012 demonstrated a sensitivity and specificity of 1.00 and 0.97, respectively, using MRA.⁷ Smith and colleagues in 2012 found MRA to be marginally more accurate than MRI for detection of glenohumeral disorders.¹⁵ All our patients had instability and were referred for an MRA based upon the surgeon's clinical assessment rather than a fixed protocol. The sensitivity in our study was lower (0.75 (0.62–0.86)) but the specificity higher (0.81 (0.73–0.88)). The PPV in our study was lower (0.64 (0.52–0.76)) but the NPV was higher (0.88 (0.81–0.93)).

Use of less invasive and less expensive imaging initially could provide the correct diagnosis (eg ultrasound for identification of RCTs).¹⁶ Naqvi and colleagues in 2009 found a comparable accuracy of ultrasound with MRI (88.89% *vs.* 89.09%) and Lenza and collaborators in 2013 found no significant difference in sensitivity or specificity between ultrasound and MRA for any RCTs or partial tears.^{1,16} Usually, partial-thickness tears can be managed conservatively, whereas full-thickness tears are more likely to require surgical treatment.¹⁶ This fact is particularly relevant bearing in mind that ultrasound can be used within the clinic and is inexpensive, dynamic and non-invasive, making it very advantageous as first-line investigation for RCTs.¹⁶ Al-Shawi and coworkers found similar accuracy for detection of full-thickness tears using ultrasound undertaken by trained orthopaedic surgeons and radiologists.¹⁷ Sipola and colleagues in 2010 suggested that ultrasound should be used for screening, with MRA reserved for negative cases with strong suspicion of a tear or intra-articular glenohumeral disorders (eg labral tears).¹⁸ Stoppino and collaborators in 2013 found MRA to have an accuracy of $\leq 90\%$ for detection of rotator cuff 'footprint' tears, most of which are articular,⁸ and that MRA and ultrasound underestimated RCT size.⁸ However, Chun and colleagues in 2010 found MRA to be useful for detection of partial-thickness tears but had low sensitivity for articular- and bursal-sided tears.¹⁹ Furthermore, Lee and collaborators in 2014 showed a reduced diagnostic accuracy of 78.6% for ultrasound compared with 92.9% on MRA, and de Jesus and coworkers in 2009 found MRA to be most sensitive and specific for diagnoses of full- and partial-thickness tears.^{20,21}

Preoperative imaging for surgical planning remains important but whether MRA should be first-line imaging is controversial. MRA is particularly useful if glenohumeral damage is suspected (especially labral tears), but less invasive methods (eg ultrasound) should be considered as the first-line investigation for RCTs. Pavic and colleagues in

2013 found MRA to be superior for the diagnosis of labral disorders compared with MRI and ultrasound.²² Magee in 2009 found MRA to show a significant increase in detection of partial-thickness tears of the articular surface of the supraspinatus tendon, anterior labral tears, and SLAP tears compared with conventional MRI at 3T.²⁵ However, Jonas and collaborators in 2012 found a reduced diagnostic accuracy of MRA, and suggested that its importance may not be as high as recognised previously.⁷ Our data are comparable with other studies, and improve on them because our study cohort was broader and larger.

Our study had three main limitations. First, we required 100% commitment to the diagnosis, with terms such as 'possible' and 'cannot exclude' being identified as negative findings. Second, time differences between MRA and arthroscopy of the shoulder could account for worsening disease and possible subsequent additional injury, thereby leading to altered findings. MRA reports were available to the arthroscopist before the procedure, which may have added an element of bias. However, we tried to minimise this potential bias by standardising the method of the procedure to detect specific glenohumeral disorders regardless of MRA. Clinical findings were available to the radiologist and arthroscopist before their assessments. Furthermore arthroscopy, although considered to be the gold standard, is imperfect because it is dependent on the operator and may result in overlooked disorders. Further studies assessing the inter-observer variability of radiologists directly could aid assessment of the diagnostic potential of MRA.

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