Diagnostic value of US, MR and MR arthrography in shoulder instability

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KEYWORDS
- Musculoskeletal ultrasound
- Acute and chronic shoulder instability
- Magnetic resonance arthrography of shoulder
- Capsulolabral complex lesion
- Rotator cuff rupture

ABSTRACT

Introduction: The aim of our study was to compare US, conventional MRI and MR arthrography findings in patients with anterior shoulder instability and with a clinical diagnosis of labral capsular ligamentous complex lesion. At the same time we evaluated the accuracy of MR arthrography in the diagnosis of this lesion.

Methods: After approval of the local Ethics Committee, our department’s Trauma Registry from July 2008 up to February 2012 was retrospectively reviewed to identify all eligible patients. Eligibility criteria included: 1) history of acute or chronic shoulder instability (more than three dislocations over a period of more than two months); 2) diagnosis of labroligamentous lesion.

All patients were investigated with plain radiographs, Ultrasound Scans (US), Magnetic Resonance Imaging (MRI) and MR arthrography. Finally, all patients underwent an arthroscopy that confirmed the diagnosis.

Results: A total of 200 consecutive patients who met the inclusion criteria were included in this study. The mean age was 39 years (range 15 to 83); 147 were male and 133 involved the right shoulder. Chronic instability was documented in 133 patients, whereas acute instability was documented in 67 patients. We detected a statistically significant difference between US and MR arthrography in SLAP (Superior Labrum Anterior to Posterior) lesions (Type II, III and IV), in Bankart lesions, in glenohumeral ligament lesions (superior, middle, anterior-inferior and anterior inferior glenohumeral ligament) in Hill-Sachs lesions, in diagnosing internal subacromial impingement and in normal findings. MR arthrography was superior to the US.

A statistically significant difference was evident between MRI and MR arthrography findings in SLAP lesions (III and IV Type lesions), in glenohumeral ligament lesions (anterior inferior and posterior inferior glenohumeral ligament), in partial rotator cuff ruptures and in normal findings. MR arthrography diagnosed this lesion better than MRI without contrast.

We also found a statistically significant difference between US and MRI findings in SLAP Type II lesions, in partial rotator cuff ruptures, in Hill-Sachs lesions and in diagnosing internal subacromial impingement.

Conclusion: The US scan is a valuable diagnostic technique for rotator cuff complete or incomplete ruptures. For evaluating Hill-Sachs lesions or bony Bankart lesions, MR is more accurate. In the case of labral capsular ligamentous complex lesions, MR arthrography is superior.

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labrum and extends anteriorly and posteriorly. It is diagnosed when contrast media interposed between superior and anterior glenoid labrum oriented laterally towards the biceps brachii tendon insertion. Type I is characterized by marked fraying of the free edge of the superior labrum. Type II occurs when the labral-bicipital complex is avulsed from the glenoid. Type III is a displaced bucket handle tear of the superior labrum with an intact biceps anchor and Type IV is a bucket handle tear of the superior labrum, with extension into the fibers of the biceps tendon.

The classic Bankart lesion is defined as a defect of the capsulolabral complex at the site of the inferior glenohumeral ligament (Figure 1). Its variants include: Perthes lesion (Figure 2), anterior labral periosteal sleeve avulsion (ALPSA) (Figure 3), humeral avulsion of the glenohumeral ligament (GLAD) (Figure 4), bony humeral avulsion of the glenohumeral ligament and the floating anteroinferior glenohumeral ligament (HAGL). Any of these lesions can be associated with glenolabral articular disruption.

In Perthes lesions, the scapular periosteum remains intact but is stripped medially resulting in incomplete avulsion of the labrum from the glenoid margin, whereas in Bankart lesions, the scapular periosteum is torn. In ALPSA lesions, the labrum, capsule and ligaments are medially displaced, inferiorly rotated and fibrosed. In GLAD lesions the anterior glenoid labrum is partially torn with an adjacent articular cartilage chondral defect in clinically stable patient. Hill-Sachs lesion is an impacted fracture of dorsolateral aspect of the humeral head with/without changes in intensity of adjacent bone (Figure 5). The criteria for defining a ligamentous lesion are: rupture, thickness and changing of intensity of the ligament.

Many methods have been described in the literature for diagnosing shoulder pathology. These include standard radiograms, conventional arthrotomography, ultrasound, CT arthrography and MR imaging.

For the evaluation of rotator cuff injuries, ultrasound (US) and magnetic resonance imaging (MRI) are considered to be the most accurate. MRI however, is more universally accepted although it can be limited in evaluating partial tears of the rotator cuff. On the other hand, labral capsular ligamentous complex lesions can be diagnosed by MRI but subtle lesions are better visualised after intra-articular injection of contrast media and subsequent distension of capsule.

The aim of our study was to compare US, conventional MRI and MR arthrography findings in patients with anterior shoulder instability and with a clinical diagnosis of labral capsular ligamentous complex lesion. At the same time we evaluated the accuracy of MR arthrography in the diagnosis of this lesion.

**Materials and methods**

After approval of the local Ethics Committee, our department’s Trauma Registry from July 2008 up to February 2012 was retrospectively reviewed to identify all eligible patients. Eligibility criteria included: 1) history of acute or chronic shoulder instability (more than three dislocations over a period
of more than two months); 2) diagnosis of labroligamentous lesion.

Details including patient age, gender, mechanism of injury, clinical examination, finding of imaging modalities (standard radiograms, US, conventional MRI and MR arthrography), were recorded and analysed.

Imaging

US were performed on a SHIMADZU 2200 using a 7-15 MHz linear probe. Patients were examined according to the accepted standard Musculoskeletal Ultrasound Technical Guidelines published by the European Society of Musculoskeletal Radiology.17

Conventional MRI and MR arthrography were performed by a 1.0-T system (Magnetom Expert; Siemens, Erlangen, Germany) and a dedicated phased-array shoulder coil (Siemens). Patients underwent imaging with the humerus in neutral position. Conventional MRI was done using a dedicated shoulder coil, 3 mm slice thickness, 12-16 cm FOV and 512 x 512 matrix; the following sequences were used: oblique coronal proton density, axial proton density, oblique coronal T2 with fat saturation and oblique sagittal T2 with fat saturation. Injection of contrast media for MR arthrography was performed with a posterior approach by radiologists with at least 2 years of experience in arthrography. Intra-articular positioning of the needle (22-gauge needle) was confirmed by means of injection of 5ml of iodinated contrast media (Iopromide, Ultravist 300; Schering Berlin, Germany). Once the needle is in position 0.1 ml of gadopentetate dimeglumine (Magnevist; Schering) diluted with 20 ml saline was injected. After injection of contrast material, the patient was escorted to the MR imaging room. MR imaging was performed within 45 minutes after contrast agent injection. Coronal oblique, sagittal oblique and transverse T1-weighted, spin-echo sequences and a coronal oblique T2-weighted fast spin-echo pulse sequence were performed. For the image analysis of the MR arthograms and the classification of labroligamentous lesions, pre-established criteria were applied (Figures 6 and 7).18–21

All patients were consented before undergoing the procedure and all images were evaluated by a single experienced musculoskeletal radiologist (>12 years’ experience in musculoskeletal radiology).

A shoulder arthroscopy was finally performed to all patients, where the definitive diagnosis was made.

Statistical Analysis

To test for marginal homogeneity, the exact McNemar test was used (small sample size). A p-value of less than 0.05 was considered as statistically significant.

Results

A total of 200 consecutive patients who met the inclusion criteria were included in our study. The mean age was 39 years (range 15 to 83 years); 147 were male and 133 involved the right
shoulder. Chronic instability was documented in 133 patients, whereas acute instability was documented in 67 patients.

All patients had plain radiographs, US scans and conventional MRIs.

Plain radiographs were reported as normal in all patients, whereas the US scans revealed rotator cuff ruptures in 80 patients (complete in 27 patients and partial in 54 patients) (Table 1). MRI scans identified 20 patients with SLAP lesions (Type II: 16 patients; Type II: 4 patients), while for 67 patients the report was unremarkable. The MR arthrograms revealed a labroligamentous lesion in 159 patients and an isolated Hill-Sachs lesion in 4 patients (Table 2).

We then compared each the treatment modalities using the exact McNemar test (Tables 3, 4 and 5).

Discussion

For the evaluation of the rotator cuff tears, both MRI and ultrasound are regularly used in clinical practice. Kelly et al. reported that US and MRI are both useful in diagnosis of rotator cuff tears, although no method was considered superior. In our study we didn’t find any statistically significant difference between these techniques in diagnosing incomplete rotator cuff rupture; however, there was a statistically significant difference with regards to partial rotator cuff rupture. When we analysed the detection of labrum and ligamentous defects (SLAP Type II lesion and in Hill-Sachs lesion), we found a statistically significant difference between the two techniques (Table 5).

Shahabpour et al. compared the different diagnostic imaging methods for assessing the soft tissues and articular pathology of the shoulder. He concluded that all the imaging modalities were less accurate for partial-thickness tears. Nevertheless, when comparing them he found that MR arthrography and US are more accurate in detecting these defects, compared to MRI.

Conversely, for SLAP lesions (Type II, III and IV), Bankart lesions, glenohumeral ligament lesions (superior, middle, anterior-inferior and posterior-inferior glenohumeral ligaments) and Hill-Sachs lesions, the MR arthrography was superior to US (Table 3).

MRI represents a more universally accepted imaging modality, because it is easier to perform and can be evaluated by more than one radiologist. On the other hand, US is more challenging

**Table 1**

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Ultrasound (number of participants)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete rotator cuff rupture</td>
<td>27</td>
</tr>
<tr>
<td>Partial rotator cuff rupture</td>
<td>54</td>
</tr>
<tr>
<td>Hill-Sachs lesion</td>
<td>17</td>
</tr>
<tr>
<td>Osseous Bankart lesion</td>
<td>1</td>
</tr>
<tr>
<td>Degenerative changes</td>
<td>36</td>
</tr>
<tr>
<td>Negative</td>
<td>65</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
</tr>
</tbody>
</table>

Bankart lesion: injury of the anterior (inferior) glenoid labrum of the shoulder due to repeated (anterior) shoulder dislocation; Hill-Sachs lesion: cortical depression in the posterolateral head of the humerus bone.

**Table 2**

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Conventional MR (number of participants)</th>
<th>MR arthrography (number of participants)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLAP lesion</td>
<td>16 - Type II</td>
<td>2 - Type I</td>
</tr>
<tr>
<td>ALPSA lesion</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>GLAD lesion</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Bankart lesion</td>
<td>5 - bony lesion</td>
<td>15 - fibrous lesion</td>
</tr>
<tr>
<td>Perthes lesion</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Glenohumeral lesion (GHL)</td>
<td>1 - superior GHL</td>
<td>11 - superior GHL</td>
</tr>
<tr>
<td>Rotator cuff rupture</td>
<td>27 - complete rupture</td>
<td>27 - complete rupture</td>
</tr>
<tr>
<td>Hill-Sachs lesion</td>
<td>40</td>
<td>4</td>
</tr>
<tr>
<td>Degenerative changes</td>
<td>85</td>
<td>86</td>
</tr>
<tr>
<td>Negative findings</td>
<td>67</td>
<td>5</td>
</tr>
</tbody>
</table>

ALPSA: anterior labral periosteal sleeve avulsion; Bankart lesion: injury of the anterior (inferior) glenoid labrum of the shoulder due to repeated (anterior) shoulder dislocation; GLAD: anterior-inferior labral tear associated with an injury to the glenoid articular cartilage; Hill-Sachs lesion: cortical depression in the posterolateral head of the humerus bone; MR, magnetic resonance; Perthes lesion: anterior glenohumeral injury in which the anterior labrum is lifted from the edge of the glenoid along with a sleeve periosteum which is displaced medially, off the underlying bone; SLAP: superior, anterior-posterior labral lesion.
to perform and is operator dependent. For assessing the glenoid labrum, the origin and course of glenohumeral ligaments, tears of the glenoid labrum, the relationship of the labrum with the bicipital tendon and glenohumeral ligaments, MR arthrography is superior to conventional MR imaging. 

Jin et al. described the findings of Type II SLAP lesions in MR arthrography.\(^{24}\) They assessed 57 patients, of which 34 patients had SLAP Type II lesions and 23 patients had a sub-labral recess. They concluded that anteroposterior (AP) extension of high signal intensity on axial images was a helpful finding in diagnosing type II SLAP lesions. This confirms our findings, where all of the 21 patients with SLAP lesions had an AP extension of high signal intensity on axial images (Table 6).

<table>
<thead>
<tr>
<th>Type of lesion</th>
<th>MR arthrography findings</th>
<th>US findings</th>
<th>McNemar exact test p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLAP Type II (n)</td>
<td>Yes, MRA found lesion</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td>SLAP Type III (n)</td>
<td>Yes, MRA found lesion</td>
<td>4</td>
<td>21</td>
</tr>
<tr>
<td>SLAP Type IV (n)</td>
<td>Yes, MRA found lesion</td>
<td>0</td>
<td>155</td>
</tr>
<tr>
<td>Anterior inferior glenohumeral ligament lesion (n)</td>
<td>Yes, MRA found lesion</td>
<td>5</td>
<td>35</td>
</tr>
<tr>
<td>Posterior inferior glenohumeral ligament lesion (n)</td>
<td>Yes, MRA found lesion</td>
<td>2</td>
<td>19</td>
</tr>
<tr>
<td>Partial rotator cuff rupture (n)</td>
<td>Yes, MRA found lesion</td>
<td>58</td>
<td>13</td>
</tr>
</tbody>
</table>

Bankart lesion: injury of the anterior (inferior) glenoid labrum of the shoulder due to repeated (anterior) shoulder dislocation; MR, magnetic resonance; n, number of participants; SLAP: superior, anterior-posterior labral lesion; US, ultrasonography.

Waldt et al. evaluated the accuracy of MR arthrography in classifying the anteroinferior labroligamentous injuries.\(^{6}\) He reported that MR arthrography was accurate both for acute and chronic anteroinferior labroligamentous injuries, a finding similar to ours (Table 6).
Bencardino et al. concluded in their study that MR arthrography is a useful and accurate technique in the diagnosis of SLAP lesions of the shoulder. More specifically, it provided pertinent pre-operative information with regards to the exact location of tears and grade of involvement of the biceps tendon. It also allowed for the differentiation between a labral lesion and a normal anatomical variant, small partial rupture of rotator cuff or ligamentous lesion. ALPSA lesions are also important to be diagnosed on arthrograms since they can be missed during arthroscopy, particularly after chronic injuries.

Generally, ample experience is required to distinguish between a labral lesion and a normal anatomical variant, small partial rupture of rotator cuff or ligamentous lesion. In our case series, a single experienced radiologist reported all MR images. Observer variation was not assessed in our study because all MRIs were evaluated by only one musculoskeletal radiologist.

US scans were performed in all of our patients. Our results correspond to results in literature. The topography and extend of the lesion could be clearly visualised as well, which represents critical information in planning the arthroscopic treatment. In detail, detail pre-operative assessment of the extension of the labral tear assists with planning the suture anchor placements and saves time during arthroscopy. ALPSA lesions are also important to be diagnosed on arthrograms since they can be missed during arthroscopy, particularly after chronic injuries. ALPSA is indicative of a more severe trauma and recurrent dislocation, which causes displacement of the labrocapsular complex medially along the scapular neck.

Our study has some limitations. Because our cases were collected from a non-selected patient population with a history of chronic shoulder pain and instability, no specific images were obtained. In only 35 cases arthroscopy followed MR arthrography and confirmed MRI findings. In other cases patients went on rehabilitation or they are still waiting for arthroscopy. Also, inter observer variation was not assessed in our study because all MR images were evaluated by only one musculoskeletal radiologist.

Conclusion

The US scan is a valuable diagnostic technique for rotator cuff complete or incomplete ruptures. For evaluating Hill-Sachs lesions or bony Bankart lesions, MRI is more accurate. In the case of labral capsular ligamentous complex lesions, MR arthrography is superior.
Conflict of interest

All authors declare they have no conflicts of interest.

References