Ultrasound-guided posterior approach for magnetic resonance (MR) arthrography of the shoulder joint

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Aims and objectives

Magnetic resonance arthrography (MRA) of the shoulder with injection of paramagnetic contrast medium (CM) directly into the glenohumeral joint is a preferred imaging technique for evaluation of intraarticular lesions: glenoid labrum, glenohumeral ligaments, articular cartilage, intraarticular portions of rotator cuff tendons, rotator interval and evaluation of postoperative status [1]. The most standard technique for glenohumeral joint puncture uses anterior approach under fluroscopic guidance described by Schneider et al. in 1975 [2]. Since then many different approaching techniques have been described for shoulder joint puncture guidance such as CT, ultrasound or free hand technique without imaging guidance [3,4,5]. Ultrasound guided injection of paramagnetic contrast media into the glenohumeral joint has many advantages. It does not expose patients or radiologists to the ionizing radiation and does not involve iodinated contrast medium application. Ultrasound also offers real-time guidance of the needle tip [1].

In relation to the anatomic location for shoulder joint puncture anterior inferior approach is still most often used, although alternative approaches through rotator interval and posterior approach have also been described recently [6,7,8]. Posterior approach avoids the puncture of the anterior stabilizing structures and unintended injection of the subcoracoid bursa, preventing inconclusive findings on the MRA images [9]. Using an oblique needle path transversely through the infraspinatus muscle during the posterior injection avoids injury of the important nerves and vessels that course medial to the glenoid rim [10].

The objective of this prospective study is to evaluate feasibility and efficacy of ultrasound (US) guided joint injection of contrast medium for shoulder MRa using posterior approach.
Methods and materials

Patients

Over a 6-month period (between April and September 2015), a total of 31 consecutive patients scheduled for shoulder MR arthrography in UMC Ljubljana were included in our prospective study. A written consent form for MR arthrography procedure was obtained from all patients.

The study group comprised of 11 females (35.5%) and 20 males (64.5%) with the average age of 38.5 years (age span from 17 to 65 years). Clinical indications for MRa were anterior shoulder instability in 6 patients (22.6%), suspected rotator cuff injury in 17 patients (54.8%), suspected SLAP lesion in 7 patients (25%) and unspecificied shoulder pain in one case (3.2%). Exclusion criteria for shoulder MRa included bleeding disorders, otherwise disturbed coagulation or infection. All procedures were performed by 3 experienced musculoskeletal radiologists with more than five years of experience in shoulder arthrography.

Technique and procedure

All patients were seated upright, slightly leaning forward with back facing the radiologist and contralateral arm resting on an exam table provided for support, while ipsilateral hand was positioned on contralateral shoulder to achieve maximum posterior shoulder joint exposure.

Standard broadband linear array transducer (5-13 MHz, Prosound F75, Hitachi AlokaMedical) was used in all procedures. Before the beginning of the puncture procedure a quick ultrasound scan of posterior shoulder was performed to visualize the contours of the posterior glenoid rim, the labrum and the posteromedial aspect of the humeral head and to determine the puncture site (Fig. 1 on page 5). Standard sterile precautions were routinely used in all procedures. Skin and subcutaneous tissues on the puncture site were first anesthesized with a local anesthetic (2% lidocaine). A 20-Gauge needle with coaxial system was inserted through linear probe puncture attachment set at 45° angle traversing the infraspinatus muscle and under real-time US-guidance directed to the inferior third of glenohumeral joint. Correct intraarticular position was assessed with direct ultrasonographic visualization of the needle tip within joint space and confirmed with application of 1-2 ml of saline in order to visualize capsular distension (Fig. 2 on page 5). After achieving satisfying needle position a mean volume of 10 ml of standard diluted gadolinium solution was injected (Fig. 3 on page 6). Afterwards patients were instructed to gently move affected shoulder in order to achieve homogenous joint space enhancement. MR imaging followed within 30 minutes of application, conducted either on a 3T MR scanner (Siemens Magnetom Trio a Tim system) or on 1,5T MR scanner.
(General Electric SignaEchoSpeed) with surface coil centering shoulder (Fig. 4 on page 7, Fig. 5 on page 8).

The protocol included T1w fat suppressed sequences in coronal and axial plane and T1w in sagittal plane (TE 13 ms: TR 550 ms - 650 ms; matrix size 340 x 340, field of view 17,0 cm, slice thickness 2.5 mm) and T2w fat suppressed sequence (TE 89 ms: TR 4500 ms; matrix size 340 x 340, field of view 17,0 cm, slice thickness 2.5 mm).

**Evaluated parameters**

*Technical success* was defined as an intraarticular placement of CM with proper distension of glenohumeral joint capsule to obtain fully diagnostic MR images [5].

*Contrast extravasation.* All MRa images were evaluated for the rate and the extent of contrast extravasation, which was classified as none, minimal, moderate and severe. The extent of extravasation was evaluated on T1W images in axial, coronal and sagittal planes. Minimal extravasation was defined as contrast media occurring extracapsular only around the needle path. Moderate extravasation was defined as a concurrent infiltration of adjacent fasciae and muscles. Severe extravasation was defined as an extensive extracapsular contrast medium deposition with insufficient capsular distension and impaired diagnostic value of MRa [1] (Fig. 6 on page 9). A *number of attempts* was defined as a number of skin punctures needed to achieve intraarticular needle placement [11].

*Volume of injected contrast solution* was recorded.

*Procedural time definition.* A total procedural time (including preparation time) and puncture time solely (time for the puncture and the application of the CM) were measured by radiology resident with a stopwatch.

*Pain evaluation.* Immediately after injection of contrast solution patients were asked to evaluate periprocedural pain verbally on a scale from 0 (no pain) to 10 (worst pain imaginable) [12].

*Periprocedural complications.* Any potential complications or side effects were recorded including vasovagal reactions, hypersensitivity reactions, bleeding, restricted mobility and others.

*Statistical analysis.* Descriptive statistics for age and gender with mean and standard deviation, mean duration of the procedure, average pain score, mean volume of the contrast injected, the rate and the extent of the extravasation were calculated.
Fig. 1: Patient is seated in upright position during the ultrasound-guided puncture of the glenohumeral joint using posterior approach. In sterile conditions a linear probe is placed over the posterior aspect of the glenohumeral joint. The needle is introduced just below the lower tip of the probe through the ultrasound puncture attachment set at 45°.

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Fig. 2: Ultrasound image of the posterior aspect of the glenohumeral joint (axial-oblique): contours of humeral head (H), infraspinatus tendon (I), posterior recess of the glenohumeral joint (upward arrow) and US puncture guidance line (dotted line). a. Ultrasonographic visualization of the needle tip in the glenohumeral joint space. b. Clearly visible distension of the joint capsule upon injection of saline additionally confirming correct needle placement.

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Fig. 3: Ultrasound image of the posterior aspect of the glenohumeral joint (axial oblique); a. contours of humeral head (H), scapular glenoid (S), infraspinatus tendon (I), posterior recess (upward arrow) and US puncture guidance line (dotted line); b. Needle track (asterix) following the ultrasound-guided path is shown, with the tip of the needle placed in the posterior glenohumeral joint (upward arrow). Left arrow is marking the head of the humerus.

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Fig. 4: Normal shoulder MR arthrogram in coronal plane showing proper enhancement and distension of the glenohumeral joint capsule after direct injection of contrast media; a. T2W FS sequence; b T1W FS sequence.

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Fig. 5: Normal shoulder MR arthrogram in axial plane showing proper enhancement and distension of the glenohumeral joint capsule after direct injection of contrast media; a. T1W FS sequence; b. proton density sequence.
Fig. 6: MR arthrography of the shoulder after ultrasound-guided injection of the contrast solution (axial plane, T1W FS images); a. Intra-articular placement of the contrast solution with no extravasation; b. Mild extravasation of the contrast solution along the needle path (white arrow); c. Moderate extravasation with contrast solution along the needle path and between the muscle fascicles (white arrow).
Results

All 31 (100%) US-guided injections of gadolinium based contrast solution for shoulder MR arthrography were technically successful. In 27/31 (87,1%) of our patients an injection was completed in the first attempt. Two attempts were performed in three patients (9,7%), and in one patient (3,1%) three attempts were required.

Overall rate of extravasation was 41,9% (13/31). Mild extravasation occurred in 10/31 patients (32,3%) and moderate in 3/31 patients (9,7 %). No severe extravasation was recorded (Table 1). Average total procedural time was 9,0 min, while average puncture time was 4,1 min. Mean periprocedural pain estimated by patients was 4,3 (ranging from 0,5 - 10). Mean volume of injected contrast solution was 9,7 ml. Mild, brief vasovagal reaction with spontaneous resolution was observed in 3 patients (9,7%). No hypersensitivity reactions or other complications were recorded.

Table 1.

<table>
<thead>
<tr>
<th>No. of patients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technically successful procedures</td>
<td>31/31</td>
</tr>
<tr>
<td>1 attempt</td>
<td>27/31</td>
</tr>
<tr>
<td>2 attempts</td>
<td>3/31</td>
</tr>
<tr>
<td>3 attempts</td>
<td>1/31</td>
</tr>
<tr>
<td>Extravasation rate</td>
<td>13/31</td>
</tr>
<tr>
<td>Mild extravasation</td>
<td>10/31</td>
</tr>
<tr>
<td>Moderate extravasation</td>
<td>3/31</td>
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<tr>
<td>Severe extravasation</td>
<td>0/31</td>
</tr>
</tbody>
</table>
Conclusion

The results of our study show that US-guided approach for shoulder MRa is feasible and accurate technique. US offers real-time image guidance without radiation exposure, which are considerable advantages compared to standardly used imaging techniques. Although US guided posterior approach requires a sufficient experience to perform, it is effective and time efficient. Our results showed relatively high rate of contrast media extravasation, but in no case it did not hamper the diagnostic value of MR images. Our research results confirm that the procedure is safe and well tolerated by patients. Although, our study was completed on a relatively small number of patients the results confirm that US-guided MR arthrography using posterior approach is a good alternative to standardly used imaging guided techniques.
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