MR Arthrography of the Shoulder Using an Anterior Approach: Optimal Injection Site

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OBJECTIVE. The purpose of our study was to optimize anterior MR arthrography of the shoulder by comparing three injection sites.

MATERIALS AND METHODS. Seventy-eight patients were divided into three groups of 26 each, according to the injection site selected: the upper third of the medial part of the humeral head, the lower third of the medial part of the humeral head, or the area between the middle and lower thirds of the glenohumeral joint. A marker plate with radiopaque coordinates was used in performing the technique. Radiologist time and exposure time were recorded, and the intensity of the patient’s pain was measured using a Visual Analogue Scale (VAS). Groups were compared using variance analysis and the least significant difference method.

RESULTS. Shoulder arthrography was considered satisfactory for all three injection sites. Mean exposure time was 20.9 ± 7.8 (SD) milliseconds, and mean radiologist time was 6.4 ± 0.8 minutes. Mean pain intensity registered by the VAS was 1.7 ± 0.9, the lowest values tending to be those recorded by patients who received an injection in the upper third. Exposure and radiologist times were lower for these latter patients; differences between the upper third and the other two areas were statistically significant (p < 0.005).

CONCLUSION. The optimal injection site for anterior MR arthrography of the shoulder is the upper third of the humeral head, a simple, rapid procedure that is well tolerated by patients and reduces the radiation dose administered.

Keywords: arthrography, joint, shoulder

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Shoulder arthrography was first performed in 1933 by Oberholzer [1]. Since then, several methods have been described for the same procedure [2–13]. At present, shoulder arthrography is performed as the first phase of a diagnostic process that includes MRI or CT [14–16].

One of the most difficult aspects of shoulder arthrography is determining the best place for injection. Although the most commonly used approach is the anterior, the exact site is still a topic of debate. One of the three following sites is usual: the upper third of the medial part of the humeral head, the lower third of the medial part of the humeral head, or the area between the middle and lower thirds of the glenohumeral joint that corresponds to the Schneider standard technique [2]. To our knowledge, no comparative study of the three areas has been performed to determine the optimal injection site for MR arthrography of the shoulder. Such was the aim of this study.

Materials and Methods

Patients

Between February 2005 and September 2007, a prospective randomized block design was followed to study 78 consecutive MR arthrography examinations (50 men and 28 women). The mean age of the patients was 45.2 years (range, 15–75 years). The criteria for inclusion in the study were glenohumeral instability (n = 43), chronic shoulder pain (n = 20), suspicion of a tear in the rotator cuff (n = 14), and adhesive capsulitis (n = 1). The criteria for exclusion were fracture in the shoulder area, anticoagulant treatment or coagulation problems, history of allergy to contrast material, and articular infection or inflammation. The study was approved by our institutional review board. All patients were given detailed information about the procedure and informed consent was obtained.

Technique

The areas corresponding to the injection sites were defined by tracing a notional horizontal line from the center of the sclerotic line corresponding to the anatomic neck of the humeral head as far as
the cortex of the humeral head (Fig. 1). Injection sites were the upper third of the medial part of the humeral head, the lower third of the medial part of the humeral head, and the area between the middle and lower thirds of the glenohumeral joint.

The 78 patients were randomly distributed by permuted and equilibrated blocks of six patients to the three injection sites. In this way we were sure that after the use of every block the quantity of participants assigned to each of the injection sites would turn out to be equivalent and equilibrated at the end of the study. Thus, three groups of 26 patients were obtained with equal probability for the three injection sites. Arthrography examinations were performed consecutively by two examiners. The first 39 injections (13 patients for each of the injection sites) were performed by a staff radiologist with 17 years of experience with arthrography. The remaining 39 were performed by a resident in training who had no experience with arthrography but who was always supervised by the experienced radiologist.

Before arthrography was performed, a thick coating of 2 g of 5% EMLA cream (AstraZeneca; a 1:1 mixture of 2.5% lidocaine and 2.5% prilocaine) was applied to the skin corresponding to the glenohumeral joint area and covered with an occlusive dressing for 20–60 minutes (mean, 35 minutes). When the patient was in the fluoroscopy room, the anesthetic cream was removed with an alcohol swab before starting the examination.

Patients were placed in a supine position on the fluoroscopy table (Siregraph CF, Siemens Medical Solutions) with the shoulder in external rotation; in patients in whom this position caused discomfort, the shoulder was placed in neutral rotation. Rigorous aseptic measures were applied. The intraarticular contrast material was injected following the arthrography technique described in detail previously [12], using a marker plate with radiopaque coordinates to select the injection site without the need for fluoroscopic guidance. The adhesive marker plate was placed on an area of skin over the shoulder and a spot radiograph was obtained to determine the injection site (Fig. 2A).

When the injection was to the upper or lower third of the humeral head, we took care that the injection site selected was close to the glenohumeral joint. A 22-gauge, 1.5-inch (4-mm) spinal needle was used for injections to the upper third and lower third of the medial part of the humeral head, and a 22-gauge, 3.5-inch (88-mm) spinal needle was used for injections to the glenohumeral space. The needle insertion was performed in an anteroposterior direction, progressively and slowly, until the needle came into contact with the humeral head (for the upper third or lower third of the medial part of the humeral head) or until a change in resistance was perceived (for the glenohumeral joint). A spot radiograph was then obtained to confirm the localization of the tip of the needle (Fig. 2B). Next, a small test injection of anesthetic was performed [10]. If the needle is in the articular space, there will be little resistance to the injection; a small quantity of iodinated contrast material must be injected to verify intraarticular needle placement (Fig. 2C). Between 0.5 and 4 mL of gadopentetate dimeglumine (Magnevist, Bayer HealthCare [formerly Schering]) was diluted in 100 mL of sterile saline. The solution was slowly injected until the joint capsule was appropriately distended. After the needle was removed, a dressing was placed over the injection site.

**Data Collection**

We recorded whether the shoulder was in external rotation or in neutral rotation, whether the needle had to be repositioned to inject into the joint, and whether any complications arose within 30 minutes of the procedure being performed.

Radiologist times—that is, the time elapsing from positioning of the adhesive marker plate on the shoulder to withdrawal of the needle—were recorded for each procedure by a radiography technician. Exposure time was recorded by a radiophysicist. Both technician and radiophysicist were blinded to the arthrographic approach and were unaware of the injection site used during the procedure.

Pain intensity was registered using a Visual Analogue Scale (VAS) of 0–10, in which 0 meant no pain and 10, the worst possible pain. We also used a verbal scale for pain from 0 (no pain) to 5 (worst possible pain). In every case, MRI was evaluated for extraarticular contrast material and for any possible distortion of the anatomic intraarticular structures resulting from the injection (i.e., injection into the biceps tendon).

**Statistical Analysis**

For statistical analysis of the data, the SPSS software package, version 14.0 (SPSS for Windows, 2006) was used. A descriptive statistical analysis of each variable was made, giving the frequency of distribution. For quantitative variables, the usual parameters were also calculated: mean; SD; and standard errors of the mean, maximum, and minimum. The relationship between qualitative variables was obtained using Pearson’s chi-square test, and the quantitative variables were analyzed using Pearson’s lineal correlation coefficient.

Analysis of variance was used to compare groups, complemented by comparing mean pairs using the least significant difference. Differences were considered statistically significant at \( p < 0.05 \).

**Results**

All arthrography examinations were performed successfully in all patients, regardless of injection site, and no immediate complications were observed. MR images were found to be of high quality in all patients. The procedure involved 50 cases (64.1%) with the shoulder in external rotation and 28 cases (35.9%) with the shoulder in the neutral position. In two patients (2.5%) in whom the injection had been given in the glenohumeral space, repositioning of the needle was necessary because the contrast material had been injected into extracapsular soft tissue.

The mean volume of contrast material injected was 14.9 ± 6.2 (SD) mL (range, 9–20 mL). Mean exposure time was 20.9 ± 7.8 milliseconds (range, 11.2–29 milliseconds) and mean radiologist time was 6.4 ± 0.8 minutes (range, 5–8 minutes). Mean pain intensity registered by the VAS was 1.7 ± 0.9 (range, 0–3), and the mean pain registered on a verbal scale was as follows: 10 patients (12.8%) gave a score of 0 (no pain); 40 (51.3%), a score of 1 (slight pain); and 28 (35.9%), a score of 2 (discomfort).

A significant degree of correlation was seen between the verbal scale and the VAS \( (r = 0.858, p < 0.0005) \). When the VAS was used to evaluate the pain of the 39 arthrographic examinations performed by the resident in training, the mean was 1.6 ± 0.9 (range, 0–3), and the mean for the corresponding score for the examinations performed by the experienced radiologist was 1.7 ± 0.9 (range, 0–3). No differences were observed in arthrographic technique times between the experienced radiologist and the resident.
An association was seen between the injections in the lower third of the humeral head and those performed in the glenohumeral space: Both showed higher pain intensities on the verbal and VAS scales than the injections in the upper third of the humeral head. Significant correlations were recorded between VAS and exposure time ($r = 0.387, p < 0.001$), VAS and radiologist time ($r = 0.383, p < 0.001$), and exposure time and radiologist time ($r = 0.724, p < 0.0005$).

Table 1 shows several parameters related to the injection sites. Statistically significant differences ($p < 0.005$) were observed between radiologist time and pain felt during arthrography and between the injection sites (the upper third vs the other two sites). Lower values were associated with the upper third site. With respect to total exposure time, statistically significant differences ($p < 0.005$) were observed between the upper third and lower third injection sites, and between the lower third injection site and the glenohumeral space site.

**Discussion**

MR arthrography of the shoulder and subsequent MRI are commonly used for evaluating structures such as the labrum and glenohumeral ligaments, especially in cases of an unstable shoulder [14–17]. The anterior approach is favored by most radiologists [2, 6, 10–12]. Some authors [8, 9, 13] recommend a posterior approach to avoid damage to the stabilizing structures of the shoulder, including the glenohumeral ligaments and the capsulolabral complex, and to avoid misleading diagnoses.

Many of these structures are concentrated around the anteroinferior aspect of the articulation, the inferior glenohumeral ligament complex, and the anterior labrum. When the Schneider technique is used, the needle traverses the subscapularis muscle or tendon and can traverse the inferior glenohumeral ligament and anteroinferior labrum and penetrate the subcoracoid bursa; there is a risk of causing distortion of these structures and creating confusing findings on MR arthrography [8]. Moreover, when the inferomedial third of the humeral head is the site chosen for injection, the needle traverses the subscapularis tendon and avoids the inferior glenohumeral ligament and the anteroinferior labrum. Regarding the injection site corresponding to the superomedial third of the humeral head, the injection is performed in the rotator cuff interval, a triangular space located between the supraspinatus and subscapularis tendons [11]; the needle can traverse the coracohumeral ligament but accessing the superior glenohumeral ligament is difficult. Another structure traversing this space is the long head of the biceps tendon, which during the procedure can be cleared laterally by external rotation of the arm. Furthermore, when the rotator cuff interval is used, perforation of the anterosuperior labrum, anteroinferior labrum, and inferior glenohumeral ligament is avoided. Thus, when injections are performed over the

### TABLE 1: Relation of Several Parameters to the Three Injection Sites

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Injection Site</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Upper Third</td>
</tr>
<tr>
<td>Radiologist time (min)</td>
<td>5.3 (0.4)</td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>5–6</td>
</tr>
<tr>
<td>Exposure time (ms)</td>
<td>12.9 (3.9)</td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>11.2–14.5</td>
</tr>
<tr>
<td>Range</td>
<td>10–18</td>
</tr>
<tr>
<td>Contrast volume injected (mL)</td>
<td>14.2 (4.7)</td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>10–18</td>
</tr>
<tr>
<td>Visual Analogue Scale</td>
<td>1.1 (0.9)</td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>0–15</td>
</tr>
<tr>
<td>Range</td>
<td></td>
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humeral head in either the inferomedial or the superomedial space, the stabilizing structures of the shoulder can be avoided.

We agree with other reports [11, 12] that the anterior approach is safe and nontraumatic, especially when the injection involves the upper third of the humeral head. In addition, by performing the injection in the rotator cuff interval, the subcoracoid bursa, which can be penetrated when the conventional technique is used, can be avoided.

In our study, we used short spinal needles for both the upper and lower third sites because these are easier to use than the long spinal needles necessary for the glenohumeral space; we thus avoided possible movement of the needle when inserted into soft tissue. The use of longer needles for the upper and lower thirds of the humeral head is recommended only in the case of obese patients or those with voluminous soft tissue on the shoulder. We used an adhesive marker plate with radiopaque coordinates to select the different injection points for performing shoulder arthrography without the need for fluoroscopic guidance. This method protects the radiologist from radiation and minimizes patient exposure, especially when using the upper third of the humeral head for arthrography. We have observed that when the upper third of the humeral head is used, injection of a small quantity of iodinated contrast material is sufficient to rapidly establish that the needle is correctly inserted into the articular space because the material is evenly distributed. When the lower third of the humeral head or the glenohumeral space is used, it is sometimes necessary to inject more contrast material to confirm that the needle is correctly placed; this requires an additional spot radiograph, more time is needed for the procedure, and the patient undergoes greater exposure.

Because no significant differences were observed between the experienced radiologist and the resident, we tend to prefer the upper third of the humeral head as the injection site, with the lower third of the humeral head as the second best. The glenohumeral space is considered the most difficult to use, especially by inexperienced operators.

In the 78 patients in the present study, the MRI findings were evaluated and no diagnostic dilemmas based on the site of injection arose because no qualitative differences were observed. No distortion of the anterosuperior labrum, superior glenohumeral ligament, or coracohumeral ligament was observed in the patients in whom the injection site was in the space corresponding to the rotator cuff interval. In only two cases of injections performed in the glenohumeral articular space was repositioning of the needle necessary to achieve adequate distribution of contrast material in the articular space. In both of these cases, extraarticular contrast material was observed. On the basis of our results, we recommend the use of the superomedial third of the humeral head for the performance of shoulder arthrography.

The results of this study show that for MR arthrography examinations of the shoulder, contrast injection into the upper third of the humeral head is best tolerated by patients. In addition, the time required by the radiologist and patient exposure to radiation are both reduced. Injection in both of these cases, extraarticular contrast material was observed. On the basis of our results, we recommend the use of the superomedial third of the humeral head for the performance of shoulder arthrography.

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