

Magnetic Resonance Arthrography of the Glenohumeral Joint: Ultrasonography-Guided Technique Using a Posterior Approach

Omuz Ekleminin MR Artrografisi: Ultrasonografi Klavuzluğunda Posterior Yaklaşım Tekniği

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Abstract

Objective: The purpose of this study was to assess the efficacy and feasibility of ultrasound (US)-guided magnetic resonance (MR) arthrography of the glenohumeral joint via a posterior approach.

Materials and Methods: Thirty-four patients (18 males and 16 females) who were suspected to have glenohumeral joint pathology were examined using MR arthrography. The patients ranged in age from 21 to 85 years, and the average age was 45±15.9 years. A Toshiba Xario US unit was utilized. Ultrasonography examinations were conducted using a broad-band 5-12 MHz linear array transducer. Gadolinium was injected into the shoulder joint using an 18-20 gauge needle. MR imaging was performed within the first 30 min after the injection.

Results: The injection of gadolinium into the shoulder joint was successfully accomplished in all 34 patients. Major contrast media extravasation outside the joint was depicted in only two patients (5.9%). No major complications were encountered.

Conclusion: Ultrasonography is an effective alternate guidance technique for the injection of gadolinium into the glenohumeral joint for MR arthrography. US-guided arthrography via a posterior approach to the glenohumeral joint is safe, accurate, well tolerated by patients and easy to perform with minimal training.

Key Words: Arthrography technique, MR arthrography, Shoulder, Ultrasound guided

Özet

Amaç: Bu çalışmanın amacı, manyetik rezonans artrografi için ultrasonografi klavuzluğunda posterior yaklaşım kullanarak omuz eklemine enjeksiyon tekniğinin etkinliğini ve uygulanabilirliğini değerlendirmektir.

Gereç ve Yöntem: Omuz eklemi patolojisinden şüphelenilen 34 olgu manyetik rezonans artrografi ile muayene edildi. Olguların yaş aralığı 21-85 yaş arasında ve yaş ortalaması 45±15.9 idi. Prosedürde Toshiba Xario ultrasonografi cihazı kullanıldı. Sonografik incelemeler geniş bantlı 5-12 MHz transdüserlerle gerçekleştirildi. Omuz eklemine gadolinium enjeksiyonu için 18-20 gauge iğne kullanıldı. Enjeksiyondan sonraki 30 dakika içerisinde manyetik rezonans görüntüleme gerçekleştirildi.

Bulgular: Omuz eklemine gadolinium enjeksiyonu 34 hastanın tamamında başarıyla uygulandı. Eklem dışına belirgin kontrast madde sızımı sadece 2 (%5.9) hastada tanımlandı. Majör komplikasyonla karşılaşılmadı.

Sonuç: Manyetik rezonans artrografisi için omuz eklemi içine gadolinium enjeksiyonunda ultrasonografi tekniği etkili alternatif bir görüntüleme klavuzluğudur. Posterior yaklaşım kullanarak omuz eklemi içine ultrason klavuzluğunda yapılan artrografik inceleme güvenli, doğru, hastalar tarafından iyi tolere edilen ve az bir çabayla kolaylıkla uygulanan bir yöntemdir.

Anahtar Kelimeler: Artrografi tekniği, MR artrografi, Omuz, Ultrason klavuzluğu

Introduction

Direct Magnetic Resonance (MR) arthrography of the glenohumeral joint with intra-articular injection of diluted gadolinium chelates is the preferred imaging technique for the evaluation of the labroligamentous complex [1-3], the articular cartilage [3], the intra-articular portion of the rotator cuff tendons [1, 4], and the postoperative shoulder [1, 5, 6]. Fluoroscopic control of needle placement during the intra-articular injection of contrast media into the glenohumeral joint is the standard technique [7-10]. However, injection for

direct MR arthrography can be palpation-directed, ultrasonography-guided or computerized tomography (CT)-guided [11-18]. Deployment of ionizing radiation is a disadvantage of fluoroscopic and CT-guided shoulder arthrography. As for injection by direct manual palpation, this technique requires experience in musculoskeletal radiologic procedures and is unreliable [12, 13, 19]. In recent years, the US-guided shoulder arthrography technique has been used as an alternative real-time imaging modality.

Different approaches to enter the shoulder joint have been described. Although the anterior approach is the most

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commonly used [7, 8, 13, 20], the posterior approach has become the preferred technique in recent years [13, 17, 21]. We believe that US-guided injection of contrast material using the posterior approach into the glenohumeral joint is reliable, well tolerated by patients and easy to perform.

Materials and Methods

Thirty-four US-guided shoulder arthrographies were obtained prospectively in 34 consecutive patients. The patients consisted of 16 women and 18 men and were 21-85 years old (mean age 45 ± 15.9 years old). Clinical indications for MR arthrography were suspicion of a tear in the rotator cuff ($n=20$), shoulder instability ($n=10$), and adhesive capsulitis ($n=4$). Injections directly into the glenohumeral joint space were performed by a single radiologist with 5 years of ultrasonography experience and six months of arthrography experience. All injections were performed using a posterior approach. The study was approved by our institutional ethics committee, and verbal consent was obtained from all patients.

The patient was seated in a chair in the upright position, with the anterior chest wall facing the back of the chair. The upper arm on the side of the shoulder undergoing the injection was placed, with the forearm flexed 90° , in mild internal rotation, thereby enlarging the posterior joint surface. To protect this position, the elbow was held by the contralateral arm.

Before glenohumeral joint injection, the area corresponding to the injection site was defined under sonographic observation. A Toshiba Xario US unit was used with a broadband 5-12-MHz linear array transducer. For the glenohumeral joint arthrography, a 20-gauge needle was utilized. In obese individuals, injections were performed with an 18-gauge needle. The patient and US unit were aligned so that the radiologist holding the transducer was opposite the patient. A linear array transducer was positioned over the long axis of the myotendinous junction of the infraspinatus muscle, inferior to the spine of the scapula. The transducer was angled to show the contours of the posterior glenoid rim, posterior glenoid labrum and posteromedial portion of the humeral head. The point of needle entry was marked on the skin. The skin was then cleaned with betadine, and the skin and subcutaneous tissues were anesthetized with 2-4 mL of 2% lidocaine (Xylocaine 2%; Astra Zeneca, Bosiglio, Italy). Following the local anesthesia and antisepsis of the skin, the transducer was covered with a sterile glove. The needle was inserted, from lateral to medial, obliquely from the skin mark to the glenohumeral joint space, parallel to the long axis of the transducer. The needle was advanced into the glenohumeral joint between the posterior glenoid labrum and humeral head using real-time US guidance (Figure 1).



Figure 1. Glenohumeral joint injection using sonographic guidance. Photograph showing introduction of needle. Photograph shows transducer positioning for transverse sonography of shoulder and needle positioning for injection. Following local anesthesia and antisepsis of skin, needle is introduced at skin surface just lateral to linear array transducer, and advanced using real-time US guidance along imaging plane in oblique direction toward glenohumeral joint.

If the needle tip was positioned within the glenohumeral joint space, resistance to the injection was abruptly decreased. The needle tip was identified as a moving reflector between the free margin of the posterior glenoid labrum and the humeral head, and the needle was visualized tangentially along the curvature of the humeral head as a bright echogenic line. Thus, its intra-articular position was confirmed by US.

A gadolinium-based solution was comprised 0.8 ML of dimeglumine gadopentetate (Magnevist; Schering, Berlin, Germany; 469 mg/mL) and 100 mL of saline. Immediately after the intra-articular needle placement was confirmed by US (Figure 2A), gentle aspiration was performed to avoid gas bubbles. Between 12 and 18 mL of the gadolinium-based solution was delivered until the joint capsule was appropriately distended (Figure 2B). The volume of injection was determined according to patient comfort and resistance to the injection. After the injection procedure was completed, a dressing was placed on the skin over the entrance site of the needle. Following covering of the skin, the patients were asked to rate injection-related discomfort during the skin puncture. The patients remained seated for several minutes after the procedure and were instructed to avoid strenuous activity involving the injected shoulder.

Magnetic resonance arthrography was performed with a 1.5 T superconductive system (Siemens; Erlangen, Germany) within 15 min after the injection. The patients were placed in the supine position on the MRI table with the injected arm at the side in a mild external rotation. T1-weighted spin-echo fat-suppressed imaging was performed in the transverse,

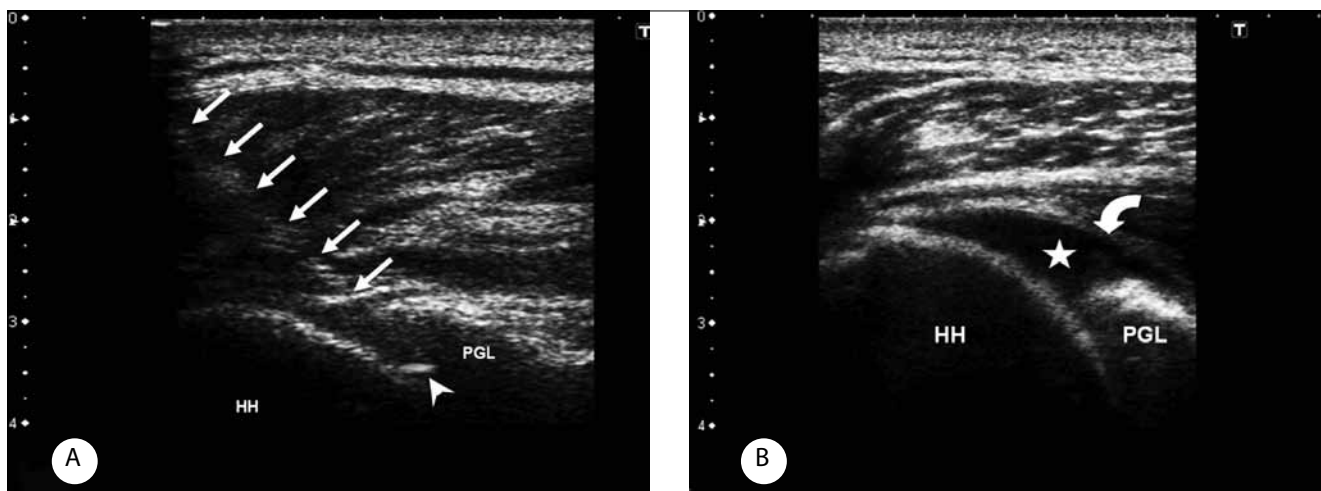


Figure 2. Sonography of posterior glenohumeral joint. A) Needle-tip location. Axial oblique sonogram of posterior aspect of glenohumeral joint at the level of musculotendinous junction of infraspinatus muscle shows needle-tip (arrowhead) and extra-articular needle (arrows) location just before intra-articular injection. Needle tip is positioned between posterior glenoid labrum (PGL) and articular cartilage of humeral head (HH). B) Axial sonogram of posterior glenohumeral joint shows that injected contrast media (asterisk) has distended the posterior joint capsule (curve arrow) away from humeral head (HH), confirming intra-articular placement of injected material.

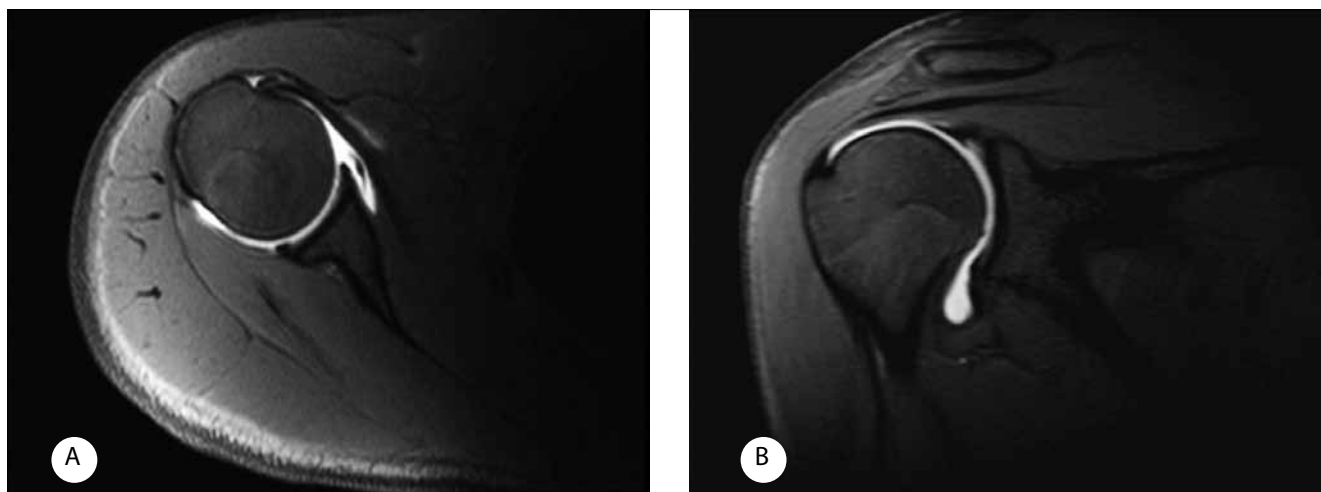


Figure 3. Normal right shoulder in an 28-year-old man. A) Axial T1-weighted fat-suppressed MR image after intraarticular injection shows no contrast material extravasation. The joint is distended by diluted gadolinium chelates. B) Oblique coronal T1-weighted fat-suppressed MR image after intraarticular injection shows high-signal-intensity contrast material distending the glenohumeral joint.

oblique coronal, and oblique sagittal planes with surface coils placed around the shoulder joint (650/15; echo train length, eight; section thickness, 3 mm; spacing, 0.3 mm; field of view, 16 cm; matrix 256x50; number of signals acquired, three).

Results

Gadolinium-based contrast media injection into the glenohumeral joint was successfully performed in all cases, of which 100% (34/34) were completed on the first attempt. The needle placement and real time ultrasound guided contrast injection

took an average of 3 minutes to complete (range 1-5 minutes). Complete distention of the articular cavity was visualized on all MR images (Figure 3A, B). No patients were excluded from the study because of incomplete data. In two (5.9%) of the 34 patients, major contrast media extravasation occurred. The site of contrast media extravasation in one patient was around the infraspinatus and teres minor muscles, along the needle track (Figure 4). In the other patient, extravasation occurred around the subscapularis muscle into a location unrelated to the injection path (Figure 5). Contrast media extravasations did not negatively affect the diagnostic quality of the MR image. Gas bubbles

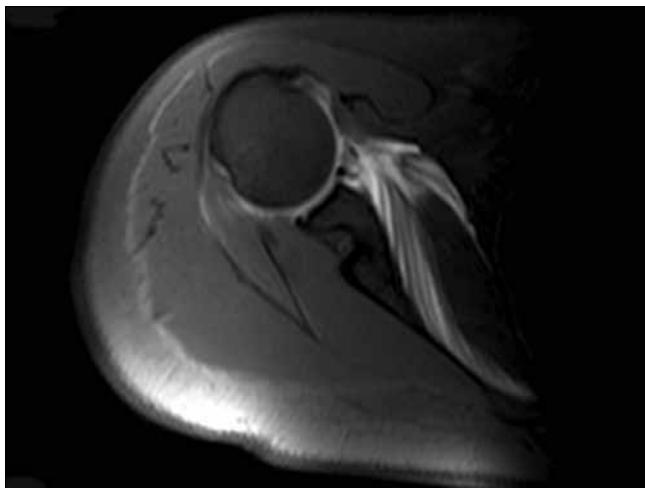


Figure 4. A 23-year-old woman with painful right shoulder. Axial T1-weighted fat-suppressed MR image after intraarticular injection shows contrast material extravasation through and around subscapularis muscle.

were not detected in any of the patients. The procedure was well tolerated by patients. No complications, such as intense pain, hemorrhage, compromise of movements, syncope, swelling, skin sensitivity, fever or infection, were observed either during or after the procedure. Four (12%) of the 34 patients reported slight discomfort associated with the injection.

Discussion

Direct MR arthrography of the glenohumeral joint is an excellent method to image the shoulder when used in conjunction with MR imaging. Because of its benefits, which include capsular distention, separation of intra-articular structures and excellent contrast resolution, this technique has higher sensitivity and specificity than routine MR imaging for

the detection of abnormalities in the shoulder joint [22, 23]. MR arthrography has an important role in the assessment of rotator cuff lesions, labral tears, glenohumeral ligaments, rotator interval lesions, and abnormalities in the postoperative shoulder [1-6].

The concept of arthrography was first introduced by Oberholzer et al. [24] in 1933. Different methods of injecting the glenohumeral joint for diagnostic arthrography have been previously described. These methods involve fluoroscopic, sonographic and CT image-guidance, as well as non-image-guided techniques.

Fluoroscopy-guided injection of the shoulder joint using the classic anterior technique was first described by Schneider et al. [25] in 1975, and it was the procedure most commonly used by radiologists. In 2001, Chung et al. [10] analyzed six cadaveric specimens, documenting the potential damage in the glenohumeral joint of the Schneider technique. They reported that the inferior glenohumeral ligament, the antero-inferior labrum and the subscapularis tendon were crossed and damaged by the needle in this technique. In addition, the subcoracoid bursa may be penetrated when a lower needle entry site is targeted. Thus, even the most seasoned radiologist may encounter inadvertent injection of the subcoracoid bursa [10, 20]. Because the subcoracoid bursa has an anatomical connection with the subacromial-subdeltoid space, inadvertent injection of the subcoracoid bursa may create confusing findings in MR arthrography, especially when the differentiation of full-thickness from partial-thickness cuff tears is required [10, 20, 26].

Because the antero-inferior portion of the glenohumeral joint contains important stabilizing structures, including the anterior band of the inferior glenohumeral ligament and the antero-inferior labrum, some authors [8, 10, 13] have recently advocated a posterior approach to avoid damage to these structures. The posterior approach to the glenohumeral joint

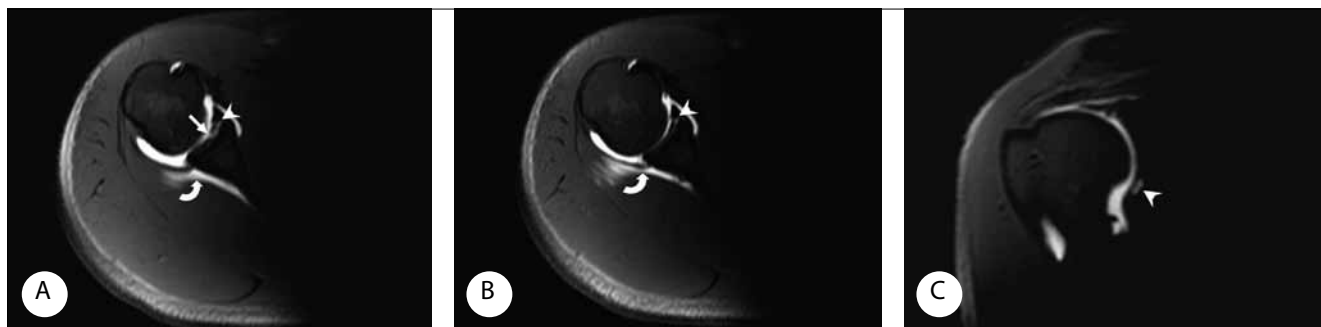


Figure 5. A 24-year-old man with right shoulder instability. A) and B) Axial T1-weighted fat-suppressed MR arthrography images show contrast material extravasation (curve arrow) from glenohumeral joint through and around infraspinatus muscle. These MR arthrograms also demonstrate a full-thickness chondral lesion with an associated injury of the antero-inferior labroligamentous complex (arrow and arrowhead). This lesion was interpreted as a GLAD lesion at MR arthrography and arthroscopy. C) Oblique coronal T1-weighted fat-suppressed MR arthrography image clearly shows a full-thickness chondral lesion (arrowhead).

is the most commonly used by orthopedic surgeons during arthroscopy. Although some complications, including injury to the suprascapularis nerve and circumflex scapular vessels, have been reported after arthroscopic procedures, to our knowledge, no such injury has been reported as a complication of the arthrography until now [8, 13, 16]. It may be, in part, due to the small needle size that was used [8]. In addition, Zwar et al. [17] advocated that an oblique needle path, which transverses the infraspinatus muscle and courses medially from a lateral direction, eliminates any potential risk for suprascapular or circumflex scapular neurovascular structures.

Fluoroscopy-guided direct MR arthrography is frequently used by radiologists, but there are potential limitations to this technique. In the fluoroscopy-guided technique, both the patient and the physician are exposed to ionizing radiation and the procedure time is generally longer than it is for other techniques. Because it also requires iodinated contrast material, the procedure includes the additional risk of allergic contrast agent reactions.

Some authors have recently advocated non-imaging-guided techniques for the injection of the glenohumeral joint [12, 13]. These techniques are performed by the palpation of certain anatomic landmarks. The landmarks may be difficult to palpate, especially in very muscular or obese individuals, which is potentially limiting to the procedure, as is the required arthrography experience.

Our method of contrast media injection into the glenohumeral joint involves a posterior approach under sonographic guidance. This technique reveals the relationship between the humeral head and posterior labrum. The posterior labrum is easily evaluated with axial scans of the glenohumeral joint at the level of the infraspinatus tendon. Because there is real-time visualization of the needle tip entering the joint space, the tip can be guided more effectively with US than with fluoroscopy [15]. If glenohumeral joint effusion is detected, the needle tip is clearly visualized in the fluid. In these patients, the US-guided injection is much easier. This advantage is not available with fluoroscopic guidance [15]. Sonographic visualization of the needle tip can occasionally be difficult in obese or athletic patients, but the use of a convex probe with lower frequency may provide adequate depth penetration. Cicac et al. [16] achieved 100% success using US-guided posterior MR arthrography. Gokalp et al. [21] completed the procedure on the first attempt in 96.7% of their patients. Using this approach, we had successful sonographic needle placement for MR arthrography in all cases, as well as successful glenohumeral joint space injection on the first attempt in all 34 interventions (100%). All injections in our study were performed by a single radiologist with only six months experience in arthrographic procedures. We believe that this success shows that US guided posterior MR arthrography can

be learned and performed easily and rapidly by radiologists with no experience in arthrographic procedures. In this procedure, we used an oblique needle path. The joint capsule is punctured through the infraspinatus muscle, with the needle extending transversely from lateral to medial. Because suprascapular nerve and circumflex scapular vessels course medial to the glenoid rim [27, 28], our approach avoided injury of these structures. Our technique was not associated with any complications, excluding the slight discomfort reported by four patients during and after the procedure. For this reason, we believe that this procedure was well tolerated by patients.

In conclusion, ultrasound guided posterior MR arthrography technique avoids the puncture of the anterior stabilizing structures and the inadvertent injection of the subcoracoid bursa, thus preventing confusing findings on the MR arthrography images. Using an oblique needle path in posterior injection avoids injury of the important nerve and vessels that course medial to the glenoid rim. Sonographic guidance avoids the use of ionizing radiation and iodinated contrast material. Thus, this method protects both the patient and the radiologist from radiation and avoids the rare adverse reactions after iodinated contrast material administration [15]. In addition, real-time visualization of the needle tip entering the joint space can be achieved more effectively with this technique compared with fluoroscopy. US guided posterior MR arthrography can be learned and performed easily and rapidly by radiologists with no experience in arthrographic procedures. In conclusion, we believe that US guided posterior approach for MR arthrography is accurate, safe, well tolerated by patients and easy to perform by radiologists with no experience in arthrographic procedures.

Conflict of interest statement: The authors declare that they have no conflict of interest to the publication of this article.

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