Ultrasound-guided injection through the rotator cuff interval: a clinical perspective of one institution’s results and description of technique

Context: Fluoroscopic injection through the rotator cuff interval (RCI) is a common technique for diagnostic arthrography and therapeutic intervention. Ultrasound approaches through the RCI have been less commonly studied, but there is a growing body of literature.

Objectives: The purpose of this study was to present a standardized technique of ultrasound-guided injection into the glenohumeral joint utilizing the RCI in magnetic resonance imaging (MRI) arthrography (MRA) and to report one medical group’s experience with the technique.

Methods: A retrospective chart review of all ultrasound-guided injections into the glenohumeral joint utilizing the RCI was performed from July 1, 2014 through June 1, 2021. Data were compiled for age, gender, body mass index (BMI), and prior surgery on the shoulder. The primary endpoint was successful administration of intra-articular dilute gadolinium contrast adequate for radiologic interpretation. A total of 487 injections into the glenohumeral joint via the RCI were performed. One hundred and fifty patients had previous shoulder surgery, with the remainder naive to intervention.

Results: The success rate of injections into the glenohumeral joint was 99.4%, with only three injections considered unsuccessful. The three unsuccessful injections did not succeed because of a lack of intra-articular contrast media present. This success rate is impressive and promising, particularly when considering that 155 of the patients had previous surgery, which could potentially cause complications, and because these injections were performed over a long period of 7 years.

Conclusions: Accessing the RCI under ultrasound guidance is a very successful technique for injection within the glenohumeral joint.

Keywords: diagnostic; injection; rotator cuff interval; therapeutic; ultrasound-guided MRI arthrography
technique for arthrography, specifically for magnetic resonance imaging (MRI) arthrography (MRA).

Prior to implementation, the technique was considered novel. Similar techniques had made a rare appearance in the literature to that point [8, 13]. The earliest was described in 2008 in the Korean language by Lim et al. [13] Over the last decade, an increasing number of publications have reported ultrasound approaches to the shoulder and the RCI for arthrography and therapeutic intervention. There is great diversity in quality, technique, approach, and even definition of what constitutes a RCI approach [10, 14–19]. All previously published series have been small or limited to technique descriptions. The advantages of ultrasound over traditional fluoroscopy or CT are typically characterized by improved patient comfort, lack of ionizing radiation, and comparable accuracy [5, 6, 10, 14, 20–22]. Issues of cost-effectiveness have yet to be specifically studied. Several studies comparing the RCI approach with other approaches have been published with variable definitions but comparable results [10, 18, 19]. There is a need for a more consistent, standardized approach to allow both experienced clinicians and those in training to achieve accurate access of the glenohumeral joint for the purposes of therapeutic intervention and radiographic interpretation in arthrography.

Methods

The University of Tennessee Health Science Center Institutional Review Board determined that this retrospective chart review was exempt from ethical approval. Electronic medical records, dated from July 1, 2014 to June 1, 2021, within a single practice were reviewed. These dates included the time of initiation of the MRA program at the institution. Inclusion criteria for review were MRA of the shoulder and utilization of the RCI approach. Charts were reviewed and data compiled for patient age, gender, body mass index (BMI), handedness, and prior surgery on the shoulder.

All injections were performed under the direct supervision of a single chief interventional sonographer and originator of the technique with the participation of primary care sports medicine and sports ultrasound fellows. All joint injections for MRA were performed under ultrasound guidance.

The primary endpoint was successful administration of intra-articular dilute gadolinium contrast adequate for radiographic interpretation. This was determined by the reading of a board-certified musculoskeletal specialty radiologist. After the chart review, if there was any doubt as to whether the contrast agent had been injected successfully within the glenohumeral joint, the chief interventional sonographer reviewed the original contrasted MRI imaging.

Technique

The RCI is defined as the anatomic region between the superior edge of the subscapularis and the anterior edge of the supraspinatus (Figure 1).

Laterally, the region begins at the superior edge of the lesser tuberosity and expands as a nearly triangular window in the rotator cuff, terminating medially at the glenoid rim/labrum. Within the boundaries of the window and filling its potential space is the long head of the biceps tendon superiorly and the superior glenohumeral ligament (SGHL) inferiorly. Superficial to these is the coracohumeral ligament (CHL), which acts as the roof or cover of the interval, with the anterior subacromial-subdeltoid bursa and deltoid immediately overlying it. The interval can be imaged well and potentially accessed via sagittal, axial, or oblique views (Figures 2 and 3) [10, 14–19]. The interval can be of varying size and appearance and often requires a few moments of diagnostic scanning in a standard position to identify the appropriate anatomic landmarks.

Patients are positioned supine with the shoulder adducted and externally rotated. The patient’s head is directed away from the shoulder. Optional shoulder external rotation is facilitated by hand supination and elbow extension. Often the gentle weight of a clean, folded sheet placed on the open palm can assist the patient in maintaining this relaxed position.

The RCI is examined steriley, often utilizing the tuberosities of the humerus, the coracoid process, and the clavicle as palpable landmarks to begin scanning. A high-frequency linear transducer 10–12 MHz is utilized. After the anterior shoulder and interval are scanned thoroughly, a standard view of the subscapularis is obtained in the short axis. This is performed according to standard shoulder ultrasound imaging and provides a reproducible soft-tissue reference for the lower border within the proximal interval. The biceps tendon can be helpful in the initial orientation. If the biceps tendon is absent because of prior biceps tenotomy or tenodesis, the subscapularis is the most dependable soft-tissue imaging landmark. The SGHL is typically dark from anisotropy and can be very large or relatively small and of variable cross-sectional shape. It usually appears as a hypoechoic region adjacent to the superior edge of the subscapularis. Visualization of articular cartilage

![Figure 1: Traditional radiographic/fluoroscopic view of the RCI with superimposed illustrative anatomy. The RCI is bordered by the anterior supraspinatus tendon and the upper edge of the subscapularis. It extends from the lesser tuberosity to the anterior superior glenoid rim in roughly a triangular shape. It is roofed by the CHL (gold region). The long head of the biceps tendon (blue region) is present along the superior margin. The inferior margin contains the SGHL (orange region).](image-url)
within the interval or deep to the subscapularis is helpful for mid-RCI positioning, but such visualization is not always possible. Typically, the probe is placed obliquely 15–60° from the short axis of the subscapularis and RCI (sagittal plane) to allow ease of positioning and needle access while maintaining a view of the proximal interval as the needle’s target (Figure 2).

A 25-gauge, 1.5-inch-long needle is utilized to place a local anesthetic into the skin. The same needle is then advanced into the CHL, with the tip placed adjacent to the inferior, caudal edge of the biceps tendon within the interval (Figure 4A). As a typical alternative, the needle tip is placed beneath the SGHL against the articular cartilage if visualized, or on the underlying humeral bony surface (Figure 4B). The local anesthetic is infiltrated to confirm easy flow into the joint before dilute gadolinium or therapeutic intervention is administered via a sterile tube connection. Slight distension within the interval is typical; however, observed distension of the superior subscapularis muscle is ill-advised because a disproportionate amount of injectate can unnecessarily dissect the fascia of the subscapularis. Similarly, significant fluid should not be seen tracking along the needle into the overlying bursa. Leakage of a small amount of injectate through the CHL after needle withdrawal between the injection and initiation of MRI is common, but it should not be tolerated significantly at the time of injection. Needle repositioning with the local anesthetic already administered is typically well tolerated, and moving the needle tip closer to the inferior edge of the biceps tendon and its circumferential synovial extension of the joint and/or slightly medially (toward the joint line) will typically ensure appropriate flow patterns.

Previous trauma or shoulder surgery involving the superior labrum or biceps tendon can cause significant scarring or change in appearance of the interval, and careful consideration of the available sonographic landmarks is essential for success. Rarely in individuals with extreme BMI or an extensively developed anterior deltoid mass, as in some competitive athletes, a 22-gauge spinal needle may be required to access the joint once the local anesthetic has been administered. For arthrography, 10–15 mL of total injectate typically is sufficient, with smaller volumes administered depending on therapeutic intentions. Confirming appropriate joint distension for radiographic study can be performed during and after the injection by looking for effusion extending down the biceps tendon sheath below the biceps groove of the humerus or by imaging the anterior window of the inferior joint recess, scanning caudal and medial to the standard subscapularis short-axis view. If there is uncertainty about adequate joint distension, 3 mL of iodinated contrast may be administered and a single Grashey view radiograph obtained before MRI. Issues with observed filling can occur

![Figure 2: An ultrasonographic oblique sagittal view of the RCI with a high-frequency linear probe. This represents the typical optimal view for access. An oblique short axis of the subscapularis muscle (SUB) is seen above the humeral head (HUM). The long head of biceps tendon (BT) is seen in the short axis bordered by the supraspinatus tendon anterior edge. The SGHL (white arrow) is seen as a hypoechoic region adjacent to the BT. The CHL (black arrow heads) overlies both. The articular cartilage interface is seen deep to the SGHL (white arrow head).](image)

![Figure 3: Two additional views of the RCI under ultrasound. (A) A true sagittal view of the RCI with near short-axis views of the biceps tendon (BT), subscapularis (SUB), SGHL (white arrow). In this image, the coracoacromial ligament can be seen as a hypoechoic oval superior to the long head biceps tendon (black arrow heads). The coracoacromial ligament will intersect and overlie the most proximal portions of the interval. (B) A true axial view of the RCI. The long head BT is oblique due to the natural curve of the interval. The hypoechoic region seen medially is an oblique longitudinal view of the SGHL (white arrows).](image)
in large full-thickness rotator cuff tears because of massive leakage into the subacromial-subdeltoid bursa.

In patients with adhesive capsulitis, the presence of adhesions may prevent inferior recess and biceps tendon-sheath distension. In extreme cases, the RCI can remain collapsed medially despite maximal-tolerated patient external rotation. Further obliquity of the probe beyond $60^\circ$, approaching a long-axis view of the RCI (axial plane) (Figure 5) can be utilized to access the interval similar to what another author has described [10, 15, 23].

**Results**

A total of 478 injections into the glenohumeral joint via the RCI approach were performed. One hundred and fifty-five patients had previous shoulder surgery, with the remainder naive to intervention. The ages ranged from 16 to 80 years (mean, 36 years). The mean BMI was 28.9 kg/m$^2$.

Figure 4: Illustrated standard injection approach through the RCI. (A) Needle tip placement (white arrow) adjacent to the inferior edge of the long head of the biceps tendon (BT) is typically optimal. The bevel of the needle is turned toward the tendon at the time of injection. (B) Alternate needle placement is illustrated (white arrow), with the tip placed against the humeral head beneath the SGHL, which is necessary in the absence of a BT or due to a patient's individual anatomy. In this view, the edge of hyaline cartilage is visualized (white arrow head) and an ideal target. After needle placement adjacent to the cartilage, the bevel is turned toward bone and cartilage to best establish intra-articular flow of local anesthetic.

Figure 5: Alternate access through the RCI is typically needed in patients with very poor external rotation. Further obliquity of the linear transducer can occur until approximating an axial (lateral to medial) approach. This lateralized approach is more difficult in patients who are obese because of fat distribution on the shoulder and the inability to completely adduct the arm. It is also challenging in patients with previous BT tenotomy/tenodesis because the soft-tissue landmarks are less well-visualized. (A) If the BT is present, needle tip placement against the superficial surface or medial-most edge of its oblique profile may establish appropriate flow. (B) Visualized positions of the SGHL in oblique long axis (LAX) can be accessed typically with the needle tip direction tangential to the curve of the humeral head and adjacent to the medial edge of the humerus seen. Access that is too lateral, especially in the patient with previous surgery, may result in poor access due to scarring or thickening within the interval.
(range, 20–50.5 kg/m²). The majority of patients were male (64%), nearly double the number of female patients (36%). Seventy-five of the 478 injections (16%) were performed on patients with a BMI of 35 or greater.

Of the 478 injections, only three were unsuccessful (due to a lack of intra-articular contrast media present), representing a success rate of 99.4% over the 7-year period. Two of the three injections showed the contrast agent within the subacromial-subdeltoid bursa and within the fascia of the subscapularis without contrast within the joint capsule. The third injection showed no gadolinium contrast present within the shoulder region. One failure was in a postsurgical shoulder. None were in patients with a BMI over 35.

Discussion

The described technique of ultrasound-guided injection of the glenohumeral joint through the RCI is an effective method to ensure intra-articular access in most individuals, including those who have previously had shoulder surgery and those with an elevated BMI. Only three shoulders failed to have adequate contrast for MRI interpretation. The first two likely failed as the path of least resistance to injection was through the RCI into the bursa and within the fascia of the subscapularis instead of within the synovium, and may represent adhesions within the RCI, but this concept has not yet been investigated thoroughly. This specific failure could likely be prevented by pausing injection and monitoring for positive fluid filling the inferior recess of the glenohumeral joint and the biceps tendon sheath, similar to the technique utilized in fluoroscopy. Similarly, monitoring of the appearance of the subscapularis for intramuscular/fascial distension can be easily performed with a short break during active injection or dynamically during it. If monitoring fails to confirm adequate intra-articular flow, needle repositioning can be undertaken as described. The third failure likely represents an error in gadolinium injection preparation or mechanical failure of the needle tubing system. Exact resolution of this result cannot be established in a retrospective case review.

Despite these three failures, the overall success rate is very compelling. Another strength is that this technique allows the use of a small and typically well-tolerated needle size. Alternatives to our technique exist. The isolated lateral-to-medial RCI approach is the preferred probe position of many authors, but it is more technically difficult in patients who lack a biceps tendon or in individuals with large deltoid musculature and obesity [3, 4, 10, 14–18, 23]. In patients with adhesive capsulitis or other joint derangements that limit external rotation, positioning can be difficult, and further obliquity of the probe is required to access the interval. This technique variation places more emphasis on the bony landmarks and is closer to other anterior approaches, which typically tend to be trans-subscapularis and require larger needle sizes [3, 4, 8, 24, 25]. Similar success has been obtained in therapeutic injection for adhesive capsulitis despite the range-of-motion challenges [19]. Utilizing a posterior approach is standard in therapeutic injections and is effective in arthrography as well [7, 8, 10, 24–26].

This institution’s version of accessing the RCI has become the preferred technique among our faculty for therapeutic injection in obese patients or in those with anterior shoulder symptoms. Although this study did not look at therapeutic injections, it properly establishes the ability to achieve intra-articular placement of a therapeutic substance. Clinical success has been described elsewhere in therapeutic injection through the RCI for adhesive capsulitis [19]. There is room for further research in the area of therapeutic applications, with few other studies published to date.

The RCI approach also has proven to be very teachable at our institution. Although resident and fellow education was not discussed in this study, the arthrogram injections were performed in the context of a primary care sports medicine training program of musculoskeletal ultrasound. Part of the educational curriculum at this institution includes ultrasound-guided arthrogram injection, and this method was actively being taught to sports medicine and sports ultrasound fellows during the study period. The technique continues to be utilized for both diagnostic imaging and therapeutic injection by fellows and faculty at this institution.

Although considered relatively novel at its introduction, this technique with its high accuracy readily became apparent and allowed the rapid, high-quality development of our institution’s MRA program. Other authors and institutions have continued to contribute to the available literature on ultrasound-guided injection of the shoulder, including the description of approaches and efficacy of injections through the RCI, although none to date are of this size.

Study limitations and future perspectives

The primary limitation of this study was its retrospective nature, which prevented inclusion of additional data points of potential interest. A prospective trial in which this technique is compared to alternative approaches could be
helpful, especially in measures of patient discomfort, clinical efficacy, or further investigation into quality of imaging.

Conclusions

In the context of the growing literature, this technique should no longer be considered novel but rather as a standard-option approach for accessing the glenohumeral joint under ultrasound guidance.

Author contributions: All authors provided substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; all authors drafted the article or revised it critically for important intellectual content; all authors gave final approval of the version of the article to be published; and all authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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References