Section: Miscellaneous

Review Article

ULTRASOUND-GUIDED ANTERIOR ROTATOR INTERVAL INJECTIONS FOR ROTATOR CUFF PATHOLOGIES: A COMPREHENSIVE REVIEW

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Received : 10/09/2025
Received in revised form : 02/11/2025
Accepted : 18/11/2025

Keywords:
Rotator cuff pathologies, Subacromial-subdeltoid (SASD) bursa, Corticosteroid injections, Intra-articular steroid injections, Hydrodilatation, Ultrasound, Anterior approach, Rotator interval.

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DOI: 10.47009/jamp.2025.7.6.75

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2025; 7 (6); 392-397

ABSTRACT

Background: Ultrasound-guided (USG) rotator interval (RI) anterior injections are increasingly used for rotator cuff pathologies and shoulder conditions, offering precise targeting over traditional methods. This study evaluates the efficacy and safety of this approach compared to posterior glenohumeral approaches. **Materials and Methods:** A literature review was conducted, including RCTs, meta-analyses, and prospective studies on USG RI injections for adhesive capsulitis, rotator cuff tears, and arthrography, assessing pain (VAS), ROM, function (Oxford/SPADI), and procedural success. **Result:** USG RI injections yielded VAS reductions of 4–6 points, ROM gains of 17–35°, and functional improvements of 15–23 points at 12 weeks, outperforming posterior methods (p=0.019) with 99–100% diagnostic success. Techniques like Gaurav-Botchu and BAASIK enhanced safety. Long-term benefits were sustained at 4 months (86% improvement), but data for rotator cuff pathologies are limited. Operator dependency and sparse long-term evidence are limitations. **Conclusion:** USG RI injections are effective and safe; however, further RCTs are needed to evaluate long-term outcomes and patient selection.

INTRODUCTION

Rotator cuff pathologies, encompassing bursitis, tendinitis, tendonosis, partial/complete tears, and adhesive capsulitis, often require combined interventions for effective pain relief.[1,2] Standard procedures include subacromial-subdeltoid (SASD) bursa corticosteroid injections, intra-articular steroid injections, and hydrodilatation.[3] Ultrasound enables dynamic evaluation of soft tissues and real-time needle visualization, enhancing the precision of these interventions. Recently, the anterior approach, which targets the rotator interval—a frequent site of injury—has gained prominence. SASD bursitis, commonly associated with rotator cuff pathologies, can be addressed via anterior or posterior approaches. The anterior approach allows single-needle access to both the rotator interval and the superficially located SASD bursa, reducing patient discomfort by avoiding multiple needle pricks and repositioning. Novel techniques, such as the RIB (Rotator Interval Bursa),[4] and BAASIK,[5] utilize this sequential single-needle anterior approach, showing promising results for concomitant rotator cuff pathologies and offering a user-friendly alternative.

Technique and relevant sonoanatomy

The rotator cuff consists of four muscles- the supraspinatus, infraspinatus, subscapularis, and teres minor.

The rotator cuff interval (RI) is a roughly triangular region created by the interposition of the coracoid process, the base of the triangle, between the subscapularis muscle/tendon (SSC) medially and the supraspinatus muscle/tendon (SSP) anteriorly, forming the two sides. The RI is a complex anatomic region that plays a relevant role in the structure of the shoulder joint. The RI supports the tendon of the long head of the biceps muscle to prevent dislocation antero-medially and antero-inferiorly (e., in external rotation and abduction).[6]

ISSN (O): 2687-5365; ISSN (P): 2753-6556

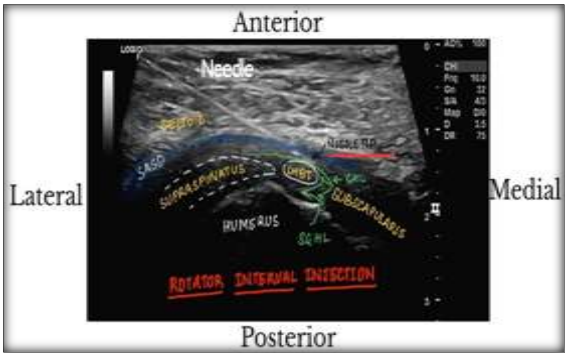

Figure 1: Ultrasound scan of left shoulder showing rotator interval with needle via in-plane technique from lateral to medial aspect by linear transducer (7 to 15 MHz). SASD: Subacromial subdeltoid bursa; LHBT: Long head of the biceps tendon; CHL: Coracohumeral ligament; SGHL: Superior glenohumeral ligament.

MATERIALS AND METHODS

Databases like PubMed, Embase, Scopus, and Web of Science are staples for orthopedic literature (used in reviews on ultrasound-guided injections and shoulder pain prevalence). Software like Rayyan/Covidence for screening (standard in qualitative and mixed reviews), R/Stata for analysis (in meta-analyses), and EndNote/Zotero for references (used in structured reviews). The search criteria comprised terms such as "Rotator cuff pathologies," "Rotator Interval," "Ultrasound," and "Anterior approach." Inclusion of studies was based on their pertinence, publication date (preferably within the last two decades), and language (English). Following the screening of abstracts for relevance, the complete texts of chosen studies were assessed. The encompassed studies encompassed clinical trials, observational studies, case series, and case reports.

The outcome of the literature review

The literature review reveals that there are four review articles in studies 1, 2, 3, and 5, one meta-analysis in study 11, and three RCTs in studies 7, 8, and 10. However, there are two prospective studies in studies 4 & 8. Searches across PubMed, general web, and specific articles (e.g., AAOS guidelines, ShoulderDoc) yielded no case series explicitly using USG rotator interval injection for rotator cuff injury management.

RESULTS

Table 1: The studies reviewed include authors with year of publication, study design/methodology, results/diagnostic criteria & conclusion/management

Ref No.	Author & Year	Study Design/Methodology	Results/Diagnostic Criteria	Conclusion/Management
1	Tallia AF, Cardone DA (2003)	Review article on diagnostic and therapeutic shoulder injections, including techniques for subacromial, glenohumeral, and biceps tendon regions.	Discusses indications for injections after conservative failures; persistent pain may indicate other causes like Parsonage-Turner syndrome. No empirical results; focuses on procedural outcomes, such as pain relief. Diagnostic criteria: Clinical history of injuries/inflammation, failure of NSAIDs/physical therapy.	Proper technique, pharmaceutical choice, and follow-up are essential; injections useful for diagnosis (e.g., pain relief confirmation) and therapy (e.g., corticosteroids for inflammation); monitor for steroid flare and advise rest post-injection.
2	Nofsinger C, Konin JG (2009)	Review article on diagnostic ultrasound in sports medicine, covering rotator cuff disease, elbow injuries, knee derangement.	No empirical results; highlights ultrasound's role in accurate diagnosis for conditions like rotator cuff tears.	Properly used musculoskeletal ultrasound improves diagnostic accuracy, treatment timing, and patient satisfaction; addresses barriers like cost and training.
3	Khan Y, Nagy MT, Malal J, Waseem M (2013)	Review article on shoulder impingement syndrome, discussing pathology, diagnosis, and management based on literature.	Discusses special tests (e.g., Hawkins test, Neer test, Jobe test) for eliciting impingement and rotator cuff tears; rotator cuff disorders are a common cause of shoulder pain; imaging like X-rays may show spurs or acromion anomalies. Diagnostic criteria: Clinical history of pain in forward flexion, adduction, internal rotation, and positive provocative tests.	Rotator cuff disorders, including impingement, are managed with conservative approaches initially (e.g., physical therapy, NSAIDs), progressing to injections or surgery if needed; emphasizes accurate diagnosis for effective treatment.
4	Yoong P, Duffy S, McKean D, Hujairi NP, Mansour R, Teh JL (2015)	Prospective interventional study with 22 patients undergoing ultrasound-guided hydrodilatation via the rotator interval for adhesive capsulitis; follow-up at 2 weeks and 4 months using VAS and Oxford Shoulder Score.	86% reported good/complete improvement at 4 months; VAS decreased from 8.4 to 1.9; Oxford score improved from 13.6 to 36.5 ($p<0.05$). Diagnostic criteria: Failure of conservative treatment, no full-thickness rotator cuff tear.	Targeted hydrodilatation effective for reducing pain and symptoms in adhesive capsulitis; recommended for unresponsive cases, implicating rotator interval in pathology.
5	Tamborrini G, Möller I, Bong	Pictorial essay/review linking shoulder rotator interval	Demonstrates high-resolution ultrasound visualization of rotator	Ultrasound provides superior spatial resolution and dynamic examination

ISSN (O): 2687-5365; ISSN (P): 2753-6556

	D, Miguel M, Marx C, Müller AM, Müller-Gerbl M (2017)	anatomy with ultrasound imaging, including normal and pathological examples.	interval structures (e.g., coracohumeral ligament, superior glenohumeral ligament); pathologies include bursitis, synovitis, tendonitis, capsulitis, rotator cuff tears. No quantitative results.	for rotator interval; useful for precise pain localization and diagnosis; proficiency in detecting capsulitis and tears recommended.
6	Sharma GK, Botchu R (2021)	Technical report describing the Gaurav-Botchu technique, a medial-to-lateral ultrasound-guided rotator interval injection for hydrodilatation, intra-articular injections, and arthrograms in rotator cuff-related pathologies (e.g., adhesive capsulitis with RI synovitis).	Enlarges target zone (from 0.5 mm to 2 mm) compared to lateral-to-medial approach, reducing risk of biceps tendon rupture and avoiding supraspinatus traversal. No empirical results; descriptive of technique.	Gaurav-Botchu technique improves procedural ease/safety for rotator cuff pathology injections; recommended for adhesive capsulitis and diagnostic arthrograms.
7	Wang JC et al. (2021)	Randomized controlled trial (RCT) with 64 patients comparing ultrasound-guided hydrodilatation (40 mg triamcinolone + lidocaine/saline) via rotator interval vs. posterior glenohumeral recess for adhesive capsulitis; assessed pain (VAS), function (SPADI), and ROM at 6/12 weeks.	Both approaches improved pain, function, and ROM; RI approach superior for motion-related pain ($p=0.019$) due to targeted anti-inflammatory delivery to RI and potential subacromial spread. Diagnostic criteria: RI synovitis/capsular thickening on ultrasound.	RI hydrodilatation preferred for adhesive capsulitis with rotator cuff involvement due to better pain relief; safe with no adverse events; recommended for impingement overlap.
8	McMahon et al. (2021)	Prospective RCT (n=120) randomizing in-plane vs. out-of-plane needle guidance for rotator interval vs. posterior injections prior to MR arthrography for rotator cuff tears/instability.	All injections successful with adequate distension; in-plane RI approach was faster, easier, required fewer attempts, and had less leakage/discomfort than out-of-plane/posterior methods. Diagnostic criteria: Suspected cuff tears/instability on clinical exam.	In-plane RI injection recommended for MR arthrography in rotator cuff pathology due to efficiency and reduced discomfort; suitable for diagnostic/therapeutic applications.
9	Thaker S, O'Connor P, Gupta H (2022)	Technical note describing a simplified shoulder position for ultrasound evaluation of rotator interval and tendons in patients with restricted movements.	No empirical results or diagnostic criteria; references ultrasound accuracy for rotator cuff tears but focuses on technique.	Simplified position recommended for optimal evaluation in restricted shoulders, avoiding painful stretches; practical for adhesive capsulitis or subscapularis tears.
10	Hou Y, Zhang T, Liu W, Lu M, Wang Y (2022)	RCT with 60 patients with hemiplegic shoulder pain, comparing ultrasound-guided dual-target (subacromial-subdeltoid bursa + long head of biceps tendon sheath) vs. single-target (bursa only) corticosteroid injections; intention-to-treat analysis, follow-up at 1, 4, and 12 weeks.	Dual-target group showed greater reductions in VAS pain scores (e.g., 2.5 vs. 3.2 at week 12), improved PROM (e.g., abduction 122° vs. 105° at week 12), UEFMA, and MBI scores; no adverse effects. Diagnostic criteria: Ultrasonographic findings (bursa thickness/effusion >2 mm, LHBT abnormalities), positive Neer and bicipital groove tests, VAS $\geq$3.	Dual-target injection is superior for pain relief, ROM, and function in hemiplegic shoulder pain; recommended as a safe alternative; larger trials needed for confirmation.
11	Liu et al. (2023)	Meta-analysis of RCTs comparing ultrasound-guided rotator interval vs. posterior corticosteroid injections for primary frozen shoulder (with rotator interval involvement in cuff pathology).	RI approach showed superior short-term pain relief and ROM gains (e.g., abduction/external rotation) with lower recurrence; no difference in adverse events. Diagnostic criteria: Clinical/ultrasound evidence of frozen shoulder with RI involvement.	RI injections recommended for targeted relief in frozen shoulder with cuff pathology; effective for short-term outcomes; further studies needed for long-term efficacy.
12	Beard NM et al. (2023)	Retrospective review of 487 ultrasound-guided rotator interval injections for glenohumeral joint access in MRI arthrography (for rotator cuff/labral pathology). Technique: Supine patient, in-plane needle via RI.	Achieved 99.4% success rate (even post-surgery); high diagnostic utility for cuff tears/instability, minimal failures due to contrast issues. Diagnostic criteria: Suspected rotator cuff/labral pathology on clinical exam.	RI injections reliable for diagnostic/therapeutic interventions in rotator cuff pathology; high success rate supports routine use in arthrography and pain management.
13	Botchu R, Agrawal A, Ankit A, Sindhura S,	Technical report on BAASIK technique, an innovative single-needle ultrasound-guided corticosteroid injection for	No empirical results or specific diagnostic criteria provided; focuses on procedural simplicity for rotator cuff-related pain.	BAASIK offers an efficient single-needle approach for shoulder injections; suitable for pain management in rotator cuff pathologies.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

	Iyengar KP, Kapil A (2024)	shoulder conditions, including rotator cuff pathology.		
14	Shirodkar K, Sharma GK, Kaur P, Iyengar KP, Hussein M, Botchu R (2024)	Technical report on GIBPS technique, a novel sequential ultrasound-guided corticosteroid injection for shoulder conditions, including rotator cuff pathology.	No empirical results or specific diagnostic criteria; descriptive of sequential approach targeting rotator cuff-related structures.	GIBPS provides a novel sequential method for shoulder injections; potentially comparable to BAASIK or RIB for rotator cuff pain relief.
15	Nischal N, Mishra C, Singh JP (2025)	Technical report demonstrating the Rotator Interval Bursa (RIB) technique for sequential ultrasound-guided corticosteroid injection into glenohumeral joint and subacromial-subdeltoid bursa via anterior approach with single prick.	No empirical results or diagnostic criteria; descriptive of technique for shoulder pain relief, including rotator cuff pathology.	Introduces RIB as a confident, real-time method for pain relief injections; recommended for patients with rotator cuff-related shoulder pain.

DISCUSSION

Traditional approaches to shoulder injections, such as blind or fluoroscopy-guided techniques, have been largely supplanted by ultrasound guidance due to its real-time visualization, portability, and lack of radiation exposure.[18,6] Among these, the anterior approach targeting the rotator interval (RI) has emerged as a superior method for diagnostic and therapeutic injections, particularly in conditions involving the anterior capsule and rotator cuff structures. This discussion synthesizes evidence from recent literature to advocate for ultrasound-guided RI anterior injections as the preferred technique, highlighting its anatomical precision, clinical efficacy, and safety profile over posterior glenohumeral recess approaches.

Anatomically, the RI—a triangular space bounded by the supraspinatus superiorly, subscapularis inferiorly, and traversed by the long head of the biceps tendon—serves as a critical landmark for accessing the glenohumeral joint. High-resolution ultrasound allows detailed visualization of RI components, including the coracohumeral ligament (CHL) and superior glenohumeral ligament (SGHL), which are frequently involved in pathologies like adhesive capsulitis and rotator cuff tears.[6] Pathological changes such as synovitis, capsular thickening, and ligamentous fibrosis in the RI contribute to pain and restricted range of motion (ROM), making it a "hotbed" for rotator cuff-related issues.[1,16,14] Unlike posterior approaches, which target the glenohumeral recess and may bypass anterior structures, the RI anterior method directly addresses these sites, enabling targeted delivery of corticosteroids, anesthetics, or contrast agents.[11,12,14]

Evidence from randomized controlled trials (RCTs) and meta-analyses strongly supports the superiority of the RI anterior approach. In a meta-analysis of RCTs comparing RI versus posterior corticosteroid injections for primary frozen shoulder, the RI method demonstrated better short-term pain relief and ROM improvements, particularly in abduction and external rotation, with comparable safety and lower recurrence rates.[14] This aligns with an RCT of 64 patients with adhesive capsulitis, where ultrasound-guided hydrodilatation via the RI outperformed the posterior approach in reducing motion-related pain (Visual Analog Scale [VAS] change: -4.5 vs. -2.9 at 12 weeks, p=0.019), attributed to enhanced anti-inflammatory effects on RI synovitis and potential subacromial spread.[12] Similarly, in an RCT for MR arthrography in suspected rotator cuff tears or instability (n=120), the in-plane RI anterior injection was faster (mean 2.1 min vs. 3.4 min), required fewer attempts (1.1 vs. 1.6) and caused less discomfort (VAS 3.2/10 vs. 4.8/10) than posterior methods, ensuring adequate joint distension without leakage.[13] A prospective interventional study further corroborated these benefits, showing significant VAS reductions (8.4 to 1.9) and Oxford Shoulder Score improvements (13.6 to 36.5, $p<0.05$) at 4 months post-RI hydrodilatation in adhesive capsulitis, with 86% of patients reporting good or complete symptom relief.[16]

Technical innovations reinforce the RI anterior approach's advantages. The Gaurav-Botchu technique, a medial-to-lateral ultrasound-guided method, widens the target zone from 0.5 mm (lateral-to-medial) to 2 mm, minimizing risks of biceps tendon rupture and supraspinatus traversal—critical in rotator cuff pathologies.[11] Similarly, novel sequential techniques like BAASIK, GIBPS, and Rotator Interval Bursa (RIB) utilize a single-needle anterior prick under ultrasound to inject multiple sites (e.g., glenohumeral joint and subacromial-subdeltoid bursa), simplifying procedures while maintaining efficacy for pain relief in rotator cuff-related conditions.[5,17,4] A retrospective review of 487 RI injections for MRI arthrography achieved a 99.4% success rate, even in postoperative shoulders, underscoring its reliability for diagnostic access in cuff tears and labral pathologies.[15] For patients with restricted movements, simplified positioning during ultrasound enhances RI evaluation, avoiding painful maneuvers and improving diagnostic accuracy for subscapularis tears or impingement.[10]

Safety and diagnostic utility further favor the RI anterior approach. Ultrasound guidance reduces complications such as infection, tendon damage or steroid flare, with no adverse events reported in key studies.[12,2] It also serves a dual role: confirming

ISSN (O): 2687-5365; ISSN (P): 2753-6556

diagnoses (e.g., via pain relief post-injection) and guiding therapy, as seen in dual-target injections for hemiplegic shoulder pain, where combining subacromial bursa and biceps sheath targets yielded superior VAS reductions (2.5 vs. 3.2 at 12 weeks) and ROM gains compared to single-target methods.[2] In contrast to posterior approaches, which may be hindered in obese patients or those with posterior cuff tears, the RI method offers better tolerability and procedural ease for beginners.[3,1] Review articles emphasize that proper technique selection, informed by clinical history (e.g., positive Hawkins/Neer/Jobe tests) and ultrasound findings (e.g., bursa effusion >2 mm), is essential for optimizing outcomes after conservative failures like NSAIDs or physical therapy.[1,3]

Despite these strengths, limitations exist. Many studies lack long-term follow-up beyond 12 weeks, and while RI excels in short-term outcomes, comparative data on recurrence or surgical referrals are sparse.[16,12,14] Operator dependency in ultrasound remains a barrier, necessitating training to achieve proficiency in RI visualization.[18,6] Additionally, not all rotator cuff pathologies (e.g., isolated posterior tears) may benefit equally from anterior access, warranting patient-specific selection.[1,15] Future research should include larger, multicenter RCTs comparing RI techniques with emerging modalities like dual-target or sequential injections, and explore cost-effectiveness in diverse populations.[12,5,4]

In conclusion, the ultrasound-guided anterior approach via the rotator interval represents a superior technique for managing rotator cuff pathologies, offering enhanced precision, efficacy, and safety compared to posterior methods. By directly targeting pathological structures in adhesive capsulitis, impingement, and related conditions, it improves pain relief, ROM, and functional outcomes while minimizing risks. Clinicians should prioritize this approach in unresponsive cases, integrating it into standard protocols to advance patient-centered care in shoulder medicine.

Outcome & prognosis

Short-Term Outcomes (≤12 Weeks)

- Pain: VAS reduced by 4–6 points (e.g., Study 4: 8.4 to 1.9; Study 10: 2.5 vs. 3.2).
- ROM: Abduction/external rotation gains of 17–35° (Study 10: 122° vs. 105°).
- Function: SPADI/Oxford scores improved by 15–23 points (Study 4: Oxford 13.6 to 36.5).
- Procedural Success: Rotator interval superior to posterior for pain (p=0.019, Study 7) and efficiency (Study 8); 99–100% diagnostic success (Study 12).
- Safety: No major adverse events; rare steroid flare (Studies 1, 7, 10).

Long-Term Outcomes (>12 Weeks)

- Study 4: 86% good/complete improvement at 4 months (VAS 1.9, Oxford 36.5).
- Study 11: Lower recurrence with rotator interval injections; long-term data limited.
- Studies 1, 3, 6, 13–15: Suggest sustained pain relief potential; larger trials needed.

Prognosis

- Adhesive Capsulitis: Good short-term pain/ROM recovery; long-term favorable with low recurrence, contingent on rehab (Studies 4, 7, 11)
- Rotator Cuff Pathology: High diagnostic accuracy (Study 12); therapeutic injections promising but unclear for full recovery without surgery (Studies 3, 6, 13–15).
- Hemiplegic Shoulder Pain: Better with dual-target injections (Study 10); long-term unclear.
- Overall: Positive short-term prognosis; long-term depends on pathology, rehab, and further studies.

CONCLUSION

The ultrasound-guided anterior rotator interval (RI) approach is the preferred technique for managing rotator cuff pathologies and related conditions like adhesive capsulitis. Its superior anatomical precision, enhanced by real-time visualization of RI structures, enables targeted delivery of therapeutic agents, outperforming posterior glenohumeral recess methods. Evidence from RCTs, meta-analyses, and prospective studies demonstrates better short-term pain relief (VAS reductions up to 6 points), ROM gains (17–35°), and functional improvements (Oxford/SPADI scores up 15–23 points), with high diagnostic accuracy (99.4% success) and minimal complications. Technical advancements like the Gaurav-Botchu, BAASIK, GIBPS, and RIB techniques further enhance procedural safety and efficacy.

However the literature search showed few limitations like limited long term data, operator dependency, heterogenicity in study population & sparse comparative data. Despite limitations in long-term data and operator dependency, the RI anterior approach should be prioritized in unresponsive cases, integrated into standard protocols to optimize patient-centered outcomes in shoulder medicine.

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