

Assessing injectate spread in ultrasound-guided capsular hydro dilatation for adhesive capsulitis: A comparative MRI study of anterior rotator interval vs. posterior glenohumeral joint approaches

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ABSTRACT

Adhesive capsulitis is a self-limiting condition of the shoulder, characterized by pain and limited range of motion (ROM). Intra-articular steroid injection and hydrodistension of the joint capsule are effective strategies for pain relief and improvement of ROM. Several randomized studies indicate that anterior rotator cuff interval (RCI) injections yield better outcomes than posterior glenohumeral (GH) joint injections. No study has examined the differences in injectate spread patterns between anterior RCI and posterior GH joint approaches. This study involved three patients with adhesive capsulitis who received ultrasound-guided shoulder joint injections with capsular hydrodilatation, utilizing 10 cc, via either the anterior RCI approach or the posterior GH joint approach. The injectate comprised 1 mL (80 mg) methylprednisolone acetate, 4 mL of 2 % lidocaine, and 5 mL of saline mixed with gadolinium contrast. Immediately following the injection, an MRI of the shoulder was performed to evaluate the distribution of the injectate. Injections via the anterior RCI approach exhibited significant intra-capsular spread and vital pathological intra-capsular and pericapsular structures. In contrast, posterior GH joint injections revealed restricted spread, mainly enlarging the joint recess without involvement of the pericapsular ligaments. This study highlights the distribution of injectate following an ultrasound-guided anterior shoulder joint injection, demonstrating that the anterior RCI approach effectively disperses a 10 mL injectate to the intra-capsular synovial lining and key pericapsular structures. The findings suggest that technique selection significantly impacts injectate distribution in adhesive capsulitis, with a 10 mL volume achieving optimal capsular distension without rupture.

1. Introduction

Adhesive capsulitis is a self-limiting inflammatory disorder of the shoulder joint capsule, characterized by pain and restricted range of motion [1]. Characteristic pathologic features include fibrous contraction of joint capsule with reduction of joint volume, thickening of coracohumeral ligament (CHL), and other rotator interval structures, such as intra articular long head of biceps tendon and glenohumeral ligaments [2]. Historically, treatment often begins with physiotherapy and, if necessary, NSAIDs; if these are ineffective, intra-articular (IA) corticosteroid injections (CSI) and manipulation under anesthesia (MUA) have been employed as successful methods to enhance pain relief and range of motion (ROM) [3]. Hydrodistension of the shoulder joint capsule (HUD) was also used as an additional strategy with CSI to promote ROM improvement because the pathophysiology suggests capsular adhesions; however, the results were not consistently meaningfully additive [4,5]. Moreover, there is no agreement on the volume of injectate

sufficient to induce HUD, nor on whether capsule preservation versus capsular rupture influenced therapeutic outcomes [4,6]. The introduction and adoption of point of care ultrasound (POCUS) for musculoskeletal procedures have led to a more frequent utilization of the anterior joint injection technique via the rotator interval, as opposed to the posterior glenohumeral joint approach [7].

Numerous level 1 trials have demonstrated superior outcomes with anterior rotator cuff injections compared to posterior glenohumeral (GH) joint injections [8–10]. A recent cadaveric investigation elucidated the potential causes for improved outcomes with the RCI technique, attributing this to the injectate dispersion including all diseased pericapsular tissues, rather than solely the intra-synovial tissue targeted by the posterior GH joint injection [11]. Nevertheless, there is a lack of study examining the injectate distribution patterns in patients with true pathological adhesive capsulitis.

The objective of this feasibility case series is to identify and compare the injectate spread pattern in ultrasound-guided shoulder joint

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injections via the anterior rotator cuff interval approach with the posterior glenohumeral joint approach.

2. Methods

This study recruited three patients with clinically diagnosed adhesive capsulitis, who were assessed at a tertiary level academic pain clinic over the period of May–September 2023. According to institutional policy, this case series did not require institutional authorization. Consent for publication was received from all the patients. The three patients were referred from primary care providers or other specialists due to symptoms indicative of adhesive capsulitis, in order to have a shoulder joint injection.

The diagnosis of adhesive capsulitis was clinically confirmed based on the criteria established by Codman [12]. These criteria include: 1) experiencing constant shoulder pain that disrupts regular sleep for more than six months, 2) having a decrease in passive external rotation of more than 20° compared to the opposite shoulder (using 45° as a fixed reference point in cases where both shoulders are affected), and 3) having normal conventional shoulder X-rays. Each of these components has to be present in order to establish the diagnosis. All potential alternative shoulder joint disorders, including shoulder impingement syndrome, rotator cuff pathologies, bicipital and labral injuries, and inflammatory arthropathies, were systematically ruled out through clinical evaluation and baseline MRI available for review, which did not reveal any alternative shoulder pathology. All three patients had undergone conservative management, including physiotherapy, active exercises, and pharmacological interventions, without improvement.

Among the three patients, two had an ultrasound guided injection into the glenohumeral (GH) joint using the anterior rotator cuff interval (RCI) method, while one patient received a GH joint injection using the traditional posterior approach. The injectate volume for each treatment was 10 cc. The injectate mixture consisted of 1 cc/80 mg of methyl-prednisolone acetate, 4 cc of 2 % lidocaine, and 5 cc of normal saline that was diluted with Gadolinium contrast (1ml of contrast in 200ml of normal saline). The rotator cuff interval approach and posterior glenohumeral joint approach were performed using specific methods that adhere to the established protocols outlined in prior investigations [11, 13]. The injections were administered exclusively by a highly skilled MSK pain physician who has completed specialized fellowship training and possesses over a decade of expertise.

Shortly after the injection, the patient was promptly transported to an MRI room where a shoulder MRI was conducted by a highly experienced MSK radiologist with over twenty years of expertise. Shoulder MRI arthrogram was performed with a 1.5-T system (Magnetom Sola, Siemens Healthineers). Standard sequences were performed with a dedicated receive only 16-channel shoulder coil with the arm in external rotation. Acquired sequences of the shoulder and the planes included coronal T1-weighted (T1W) fat-saturated (FS) (TR/TE, 520/12), axial T1W FS (TR/TE, 520/9–10), and Sagittal T1W FS (TR/TE, 520/12) imaging. All sequences were performed at 4-mm slice intervals with 0-mm interslice gaps. Patients were assessed for changes in pain and range of motion (ROM) ratings at six weeks and twelve weeks after the GH joint injection procedure.

3. Results

Three patients between the age of 51 yrs. – 68 yrs. were enrolled in this case study. Two of them were female and one was male. All three patients were in the frozen stage of disease, were right hand dominant, The duration of symptoms was six months for two patients and seven months for the third, as shown in Table 1. Two of the patients had non dominant left side disease and one patient had their dominant right side affected. None of the patients had co morbid conditions such as diabetes mellitus or hypothyroidism. The demographic information and initial range of motion (ROM) for all three patients are provided in Table 1.

Table 1

Demographic and clinical characteristics.

S No	Age	Sex	Symptom Duration (months)	Stage of Adhesive capsulitis	Affected side	GHJ Approach
1	51	F	7	Frozen	Right	RCI
2	58	F	6	Frozen	Left	RCI
3	68	M	6	Frozen	Left	Posterior GHJ

In all patients, the gadolinium containing injectate spread extensively to the intra capsular and peri capsular structures. In the patients that underwent anterior RCI injection, excellent intra capsular spread to the inner synovial lining with dilatation of axillary, bicipital and subscapularis recess was visualized. In addition, the spread extended to include superior, middle and inferior glenohumeral ligaments, intra articular portion of long head of biceps tendon, coracohumeral ligament and subscapularis fibres in the rotator interval. In the patient that underwent posterior glenohumeral joint injection, the spread was restricted to the inner synovial lining with excellent dilatation of axillary, bicipital and subscapularis recess. In addition, minimal spread extended to the posterior part of inferior glenohumeral ligament. The distribution of injectate in anterior RCI group and posterior glenohumeral joint group is shown in Figs. 1 and 2.

All three patients experienced nearly 50 % reduction in their average NRS pain scores at three months follow up that continued to improve further by 20 % at six months (Table 2). Similarly, all three patients experienced meaningful improvement in ROM in forward flexion, abduction and external rotation at three and six months follow up.

4. Discussion

This is the first feasibility clinical series to demonstrate that office-based US guided anterior shoulder joint injection using RCI approach in patients with adhesive capsulitis adequately spreads to intra capsular

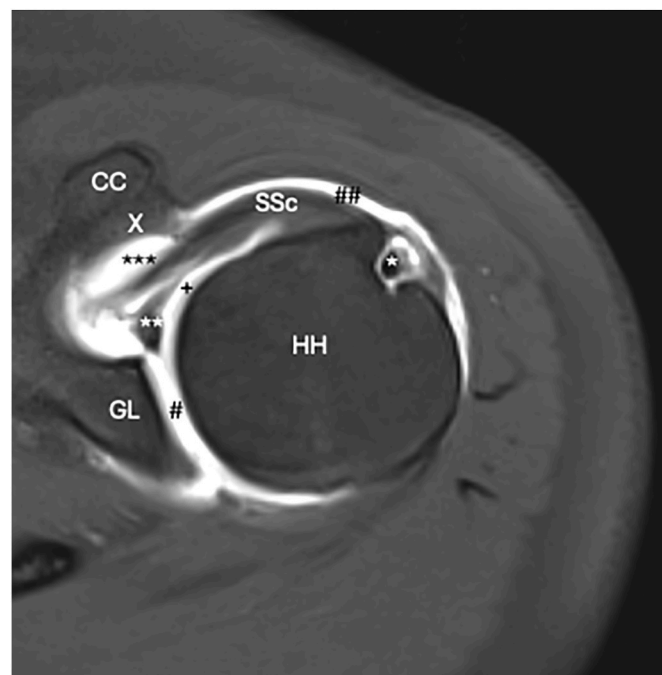


Fig. 1. Anterior RCI approach MRI axial T2 fat sat image - * – Long head of biceps tendon, ** – middle glenohumeral ligament, *** – sub coracoid joint recess, # – intra synovial joint space, ## – sub-acromial sub-deltoid bursa, + – anterior joint - intra synovial joint space.

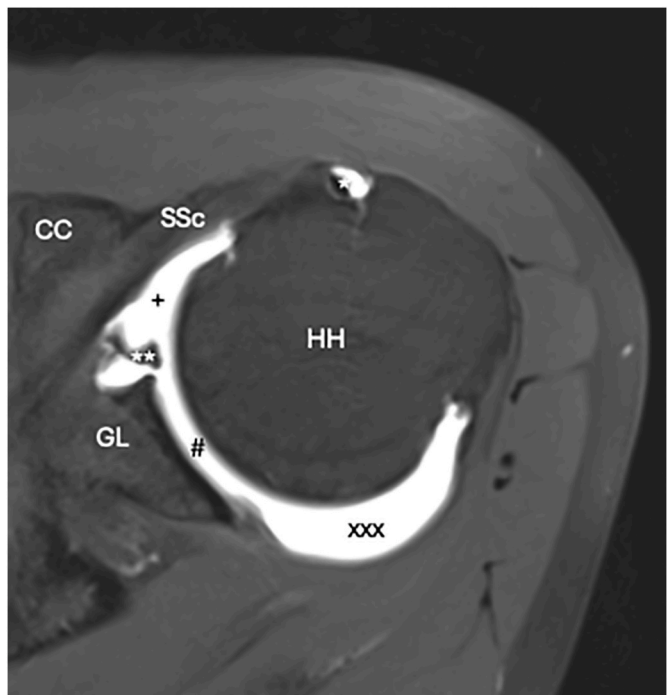


Fig. 2. Posterior Glenohumeral MRI axial T2 fat sat image - * – Long head of biceps tendon, + – anterior joint - intra synovial joint space, **– middle glenohumeral ligament, # - intra synovial joint space, xxx – axillary posterior joint - intra synovial joint space.

Table 2
Pain and range of motion outcomes at baseline, 3 months and 6 months follow up.

Cases	Timepoint	Average Pain NRS	Forward flexion (degrees)	Abduction (degrees)	External rotation (degrees)
1	Baseline	6	90/180	90/180	45/75
1	3-month f/u	3	100/180	100/180	60/75
1	6-month f/u	1–2	150/180	150/180	70/75
2	Baseline	8	95/180	70/180	25/85
2	3-month f/u	4	150/180	100/180	40/85
2	6-month f/u	1	170/180	170/180	60/85
3	Baseline	7	130/180	90/180	15/45
3	3-month f/u	3	160/180	120/180	20/45
3	6-month f/u	2	170/180	170/180	40/45

inner synovial lining and pathological pericapsular structures. In addition, 10 ml of injectate volume exhibited adequate spread to inner synovial lining with excellent distension of axillary, bicapital and subscapularis recess in anterior RCI approach as well as posterior glenohumeral joint approach.

Synovial tissue Inflammation and capsular fibrosis is known to play a role in pathophysiology of adhesive capsulitis resulting in thickening and contracture of the capsule [1]. Previous reviews have established intra and peri articular changes including fibrous contracture of shoulder joint capsule with reduction of joint volume, synovial inflammation, and thickening of pericapsular structures such as CHL, Rotator interval and glenohumeral ligaments as diagnostic pathological structures in

adhesive capsulitis [1,2]. Prior to introduction of MSK US, intra articular shoulder CSI were done using a posterior landmark based approach by majority of providers, and resulted in short term benefits to the patients [3]. On the other side, in some cases fluoroscopic shoulder joint injections were done by radiologists using the anterior RCI joint approach, often combined with hydrodistension, and showed positive outcomes [12,14]. This discrepancy in terms of outcomes between anterior RCI approach and posterior GH approach can likely be explained by the location and spread of injectate.

The anterior RCI approach resulted in preferable deposition of medication specifically targeting the affected anterior shoulder joint's intra- and peri-capsular structures in our sample of patients. This targeted delivery could likely contribute to better outcomes compared to the posterior GH approach. A recent cadaveric study by our group confirmed that US guided anterior shoulder joint injections using the RCI approach results in adequate spread of injectate in the affected intra and peri capsular shoulder joint structures [11]. Further to that, this is the first study on true cases of adhesive capsulitis to show adequate spread to both intra and pericapsular anterior shoulder joint pathological structures such as rotator interval, CHL, glenohumeral ligaments, intra articular portion of LHB and synovium with 10 cc of injectate without capsular rupture.

Distension arthrography/Hydro dilatation (HUD) of the shoulder joint was described as a procedure for additional therapeutic benefit by stretching the shoulder joint capsule [15]. However, there have been inconsistent reports regarding its additive value in pain and ROM improvement [5,16,17]. A Cochrane review in 2008 concluded silver level evidence for HUD with saline and steroids for pain, ROM, and function improvement [17]. Further, a recent JAMA study network meta-analysis found the combination of arthrographic distension and IA CSI to offer highest probability of being the most effective treatment in adhesive capsulitis [3]. In the past, authors have debated about the adequate volume for hydro dilatation of shoulder joint capsule ranging from 10ml to 20–30 ml [8,18]. and there has been significant uncertainty regarding the appropriate adequate volume for shoulder joint capsule distension.

Moreover, integrity of shoulder joint capsule has been recognized as an important variable that affects clinical outcomes [19]. It is hypothesized that injection of large volume of fluid would cause higher hydrostatic pressure resulting in elimination of adhesions and scar tissue. Previous studies have reported on better clinical outcomes with capsular rupture as compared to the capsule preservation [14]. Rupture of the joint capsule in HUD typically occurs at the subscapularis recess, the weakest part of the capsule and the site of least resistance [20]. However, the rupture usually does not occur at the anterior joint capsule or the rotator interval, where the true pathology of adhesive capsulitis originates. In addition, variable low volume of injections without maximizing the capsular distension likely explains the lesser benefit with the capsule preserving approach. On the other hand, recent studies have shown higher benefit with capsular preservation in pain and ROM improvement in both short and medium term as compared to capsule rupture [19]. Although the mean capsular preserving volume in HUD is reported to be 25.1 + 6.9 ml using real time pressure/volume maps, the authors in that study used the posterior GH approach [21]. This is in contrast to the current study findings of adequate capsular distension with 10 cc of injectate. As the pathology in adhesive capsulitis is concentrated in the anterior joint capsule and rotator interval, it is likely that higher pressures would be reached with a lesser volume when injecting fluid using the anterior RCI approach. In the current study, although adequate distension was observed, it is unclear if the maximum distension capacity was reached. In a recent comparative meta-analysis of clinical outcomes between RCI and posterior GH joint approaches that revealed better outcomes with RCI approach, most authors used injectate volumes between 3 ml and 20 ml [8]. The findings of current study suggest that 10 ml of injectate in both anterior RCI and posterior GH joint approaches sufficiently distends the joint capsule and joint recesses

without capsular rupture in people affected by adhesive capsulitis.

Comparative studies of shoulder joint injection using the anterior RCI approach vs the posterior GH joint approach have yielded inconsistent results. Some studies suggest the benefits of anterior RCI injections over glenohumeral GH injections, while others have not [8,22]. A previous study demonstrated a significantly lower success rate in the accuracy of intra-articular shoulder injections using the RCI approach compared to the posterior GH approach [23]. The RCI region has a complex sonoanatomy that requires expertise to accurately identify the target and could potentially affect the accuracy of RCI injections resulting in variable outcomes. In addition, the direction of needle advancement (medial-to-lateral vs. lateral-to-medial) in the RCI injection approach has been shown to affect outcomes, with better distribution to affected structures seen with the lateral-to-medial approach [11]. In the current study, 100 % accurate placement of needle using the lateral to medial RCI approach was identified with an adequate spread of injectate to relevant intra capsular and peri capsular structures. Therefore, the RCI approach requires precise needle placement, ideally in a lateral-to-medial direction, to improve the success rate of the injection.

5. Limitations

A limitation of this study was the sample size. A single physician (N. M.) expert in POCUS who has done more than 1000 RCI injections performed the RCI injections. A larger sample size would allow for better appreciation of the accuracy of anterior RCI approach for adequate spread to relevant pathological structures and the distension of joint capsule. The study was not intended or powered to identify the differences in clinical outcomes between anterior rotator interval and posterior glenohumeral joint approaches.

6. Conclusion

In conclusion, this feasibility case series suggests that choice of US guided injection technique might play a pivotal role in the effectiveness of injectate spread for shoulder joint injections in adhesive capsulitis. The rotator cuff interval approach potentially offers advantages over the posterior approach in terms of better coverage of pathological structures, targeted drug delivery, and potential mechanical benefits with 10ml of injectate. While the posterior approach may be simpler, it seems to lack the precision required to achieve optimal outcomes in cases of adhesive capsulitis. Patients and clinicians alike should consider the benefits of the rotator cuff interval approach when deciding on the most effective treatment strategy for adhesive capsulitis. Further research and clinical trials are warranted to delve deeper into the nuances of these injection techniques and to provide more conclusive evidence on their respective efficacies.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.inpm.2025.100557>.

References

- [1] Ryan V, Brown H, Minns Lowe CJ, Lewis JS. The pathophysiology associated with primary (idiopathic) frozen shoulder: a systematic review. *BMC Musculoskelet Disord* 2016;17:340.
- [2] Tamai K, Akutsu M, Yano Y. Primary frozen shoulder: brief review of pathology and imaging abnormalities. *J Orthop Sci* 2014;19:1–5.
- [3] Chailoumas D, Biddle M, McLean M, Millar NL. Comparison of treatments for frozen shoulder: a systematic review and meta-analysis. *JAMA Netw Open* 2020;3:e2029581.
- [4] Catapano M, Mittal N, Adamich J, Kumbhare D, Sangha H. Hydrodilatation with corticosteroid for the treatment of adhesive capsulitis: a systematic review. *Pm r* 2018;10:623–35.
- [5] Sharma SP, Bærehim A, Moe-Nilssen R, Kvåle A. Adhesive capsulitis of the shoulder, treatment with corticosteroid, corticosteroid with distension or treatment-as-usual; a randomised controlled trial in primary care. *BMC Musculoskelet Disord* 2016;17:232.
- [6] Kim K, Lee KJ, Kim HC, Lee KJ, Kim DK, Chung SG. Capsule preservation improves short-term outcome of hydraulic distension in painful stiff shoulder. *J Orthop Res* 2011;29:1688–94.
- [7] Ricci V, Chang KV, Özçakar L. Ultrasound-guided hydrodilatation of the shoulder capsule at the rotator interval: technical tips and tricks. *Pain Pract* 2020;20:948–9.
- [8] Arrambide-Garza FJ, Guerrero-Zertuche JT, Alvarez-Villalobos NA, Quiroga-Garza A, Espinosa-Urbe A, Vilchez-Cavazos F, Salinas-Alvarez Y, Rivera-Perez JA, Elizondo-Omaña RE. Rotator interval vs posterior approach ultrasound-guided corticosteroid injections in primary frozen shoulder: a meta-analysis of randomized controlled trials. *Arch Phys Med Rehabil* 2024;105(4):760–9. <https://doi.org/10.1016/j.apmr.2023.08.026>. Epub 2023 Sep 9. PMID: 37690742.
- [9] Elnady B, Rageh EM, Hussein MS, et al. In shoulder adhesive capsulitis, ultrasound-guided anterior hydrodilatation in rotator interval is more effective than posterior approach: a randomized controlled study. *Clin Rheumatol* 2020;39:3805–14.
- [10] Sun Y, Liu S, Chen S, Chen J. The effect of corticosteroid injection into rotator interval for early frozen shoulder: a randomized controlled trial. *Am J Sports Med* 2018;46:663–70.
- [11] Kozłowski BJ, Tran J, Peng PWH, Agur AMR, Mittal N. Comparison of the spread pattern of medial-to-lateral and lateral-to-medial rotator interval injections: a cadaveric study. *Interventional Pain Medicine* 2022;1:100164.
- [12] Nicholson JA, Slader B, Martindale A, McKie S, Robinson CM. Distension arthrogram in the treatment of adhesive capsulitis has a low rate of repeat intervention. *Bone Joint Lett J* 2020;102-b:606–10.
- [13] Peng PW, Cheng P. Ultrasound-guided interventional procedures in pain medicine: a review of anatomy, sonoanatomy, and procedures. Part III: shoulder. *Reg Anesth Pain Med* 2011;36:592–605.
- [14] Buchbinder R, Green S, Forbes A, Hall S, Lawler G. Arthrographic joint distension with saline and steroid improves function and reduces pain in patients with painful stiff shoulder: results of a randomised, double blind, placebo controlled trial. *Ann Rheum Dis* 2004;63:302–9.
- [15] van Royen BJ, Pavlov PW. Treatment of frozen shoulder by distension and manipulation under local anaesthesia. *Int Orthop* 1996;20:207–10.
- [16] Paruthikunnan SM, Shastry PN, Kadavigere R, Pandey V, Karegowda LH. Intra-articular steroid for adhesive capsulitis: does hydrodilatation give any additional benefit? A randomized control trial. *Skelet Radiol* 2020;49:795–803.
- [17] Buchbinder R, Green S, Youd JM, Johnston RV, Cumpston M. Arthrographic distension for adhesive capsulitis (frozen shoulder). *Cochrane Database Syst Rev* 2008;(1):Cd007005. <https://doi.org/10.1002/14651858.CD007005>. PMID: 18254123.
- [18] Latzka E, Cali M, Ishii H, Portugal S, Soo Hoo J. Hydrodilatation versus corticosteroid injection in treatment for adhesive capsulitis. *Pm r* 2023;15:1580–7.
- [19] Pimenta M, Vassalou EE, Klontzas ME, Dimitri-Pinheiro S, Ramos I, Karantanias AH. Ultrasound-guided hydrodilatation for adhesive capsulitis: capsule-preserving versus capsule-rupturing technique. *Skelet Radiol* 2024;53:253–61.
- [20] Ibrahim T, Rahbi H, Beiri A, Jeyapalan K, Taylor GJ. Adhesive capsulitis of the shoulder: the rate of manipulation following distension arthrogram. *Rheumatol Int* 2006;27:7–9.
- [21] Lee SY, Lee KJ, Kim W, Chung SG. Relationships between capsular stiffness and clinical features in adhesive capsulitis of the shoulder. *Pm r* 2015;7:1226–34.
- [22] Prestgaard T, Wormgoor MEA, Haugen S, Harstad H, Mowinkel P, Brox JI. Ultrasound-guided intra-articular and rotator interval corticosteroid injections in adhesive capsulitis of the shoulder: a double-blind, sham-controlled randomized study. *Pain* 2015;156:1683–91.
- [23] Cho CH, Kim DH, Kim DH, et al. Comparative efficacy of rotator interval versus posterior capsule approach intraarticular corticosteroid injections for primary frozen shoulder: a single-blind, randomized trial. *Pain Physician* 2022;25:313–21.