Prospective Study

Comparative Efficacy of Rotator Interval Versus Posterior Capsule Approach Intraarticular Corticosteroid Injections for Primary Frozen Shoulder: A Single-blind, Randomized Trial

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Background: Intraarticular (IA) corticosteroid injection is commonly performed in patients with primary frozen shoulder (PFS). However, the best administration site remains controversial.

Objectives: To compare the efficacy of rotator interval (RI) vs posterior capsule (PC) approach for ultrasound-guided corticosteroid injections into the glenohumeral joint of patients with PFS.

Study Design: A randomized, exploratory, prospective study.

Setting: A single fellowship training institution in Daegu, Republic of Korea.

Methods: This study was approved by the Institutional Review Board (2019-04-047-001). Ninety patients with PFS were randomly assigned to either RI approach (RI group, n = 43) or PC approach (PC group, n = 45) for ultrasound-guided IA corticosteroid injection. Fluoroscopic images to assess the accuracy of the injection were obtained immediately after injection by a shoulder specialist. Visual Analog Scale for pain, the American Shoulder and Elbow Surgeons score, the subjective shoulder value, and range of motion (ROM) were used to assess clinical outcomes for all patients at the time of presentation, and at 3, 6, and 12 weeks after injection.

Results: The accuracy of injection was 76.7% (33/43) and 93.3% (42/45) in the RI and PC groups, respectively; the between-group difference was statistically significant ($P = .028$). Significant improvements were observed in both groups in terms of all clinical scores and ROMs throughout follow-up until 12 weeks after the injection (all $P < .001$). At 12 weeks, better improvements in forward flexion and abduction ($P = .049$ and .044) were observed in the RI group than in the PC group. No adverse effect related to injection was observed in either group.

Limitations: This study had no control group receiving placebo injections and limited follow-up time.

Conclusions: Both groups showed significant pain reduction and functional improvement until 12 weeks after injection. Although no significant differences were observed in pain and functional scores between the 2 groups, the RI group showed better improvement of ROM than the PC group. These results indicate that the RI and anterior structures are a major site in the pathogenesis and treatment target of PFS.

Key words: Frozen shoulder, injection, corticosteroid, rotator interval, prospective study, ultrasonography, range of motion, pain

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Primary frozen shoulder (PFS) is a painful restriction of the glenohumeral (GH) joint, caused by an inflammatory fibrotic contracture of the joint capsule (1,2). This condition is characterized by progressive and insidious pain and loss of range of motions (ROMs) in the GH joint (3-5). The primary pathology in PFS is an inflamed appearance and a congested and thickened capsule, especially around the rotator interval (RI), with a thickened coracohumeral ligament around the anterior GH joint (3). Therefore, the anterior structures around the RI of the GH joint play an important role in the diagnosis and treatment of PFS.

Intraarticular (IA) corticosteroid injection is one of the most effective treatments for PFS (1,4,5). The injection reduces synovial inflammation, leading to reduction of pain and disability of patients with PFS, particularly in the inflammatory phase (1,2). A posterior capsule (PC) approach is used in a safe and accurate technique for ultrasound-guided IA injection into the GH joint (6). Some clinicians have administered corticosteroid injection via RI as the primary pathology for management of PFS symptoms (7-10). However, the effect of an RI approach injection is not consistent with the results of their studies. To date, debate persists regarding the proper administration site of IA corticosteroid injection for treatment of PFS (3,11,12). Research on the comparative effectiveness of RI and PC approaches is still lacking. In addition, accurate IA corticosteroid injection is also important in the clinical field. Inaccurate corticosteroid injections not only have less effective outcomes, but also several side effects, such as fat atrophy, skin discoloration, and weakness of tendons or ligaments caused by leakage of drugs into surrounding soft tissues (13). Despite the importance of accuracy in corticosteroid injection, no study on the effect according to the accuracy of the RI approach IA injection has been reported.

The aim of this study was to compare the efficacy and accuracy between the RI approach and the PC approach for ultrasound-guided IA corticosteroid injection into the GH joint in patients with PFS. The authors hypothesized that the RI approach would be superior to the PC approach in improving clinical outcomes, including ROMs and function.

Methods

Study Design and Patients

Our institutional review board approved this study (IRB No: 2019-04-047-001), which was registered with the Clinical Research Information Service (http://cris.nih.go.kr; registration number KCT0006418) and followed the CONSORT (Consolidated Standards of Reporting Trials) guidelines (Fig. 1). The research was done in accordance with the Ethical Principles for Medical Research Involving Human Subjects, outlined in the World Medical Association's Declaration of Helsinki (revised in 2013). Informed consent was obtained from all patients. Between May 16, 2019 to December 31, 2020, 102 patients diagnosed with PFS were enrolled at a single fellowship training institution. The inclusion criteria were shoulder pain with limitation of passive motion of greater than 30° in 2 or more movement planes at the time of presentation. Prior to enrollment, patients underwent plain radiography and magnetic resonance imaging for detection of secondary causes of painful stiffness. The exclusion criteria were as follows: 1) secondary frozen shoulder, such as that due to rotator cuff tear, 2) calcific tendinitis, 3) osteoarthritis, 4) infection, 5) rheumatic diseases, 6) history of high-energy trauma, 7) previous shoulder surgery, 8) neurological symptoms or abnormal neurological findings in the affected arm, 9) previous corticosteroid injection on the affected shoulder within 3 months, and 10) poor cognitive function and psychological problems. After the exclusion of 12 patients who met the exclusion criteria or refused to provide informed consent, 90 patients were randomly recruited to 1 of 2 groups using a computer-generated blocked-randomization number taken from a sealed envelope. Group allocations were performed by an independent researcher, and the assigned numbers presented to the specialist at the time the injection was administered. The patients were randomly allocated to 2 groups: 45 patients in the RI group (GH joint injection via RI approach) or 45 patients in the PC group (GH joint injection via PC approach). During the study period, 2 patients dropped out of the RI group because they withdrew participation in this study.

Procedures

For both groups, the 10 mL injection mixture consisted of 1 mL of 40 mg triamcinolone acetonide, 3 mL of 1% lidocaine, 3 mL of water soluble unionized contrast, and 3 mL of normal saline. The RI approach injection was performed with the patient in the supine position on the affected arm with external rotation and slight abduction. A linear 5- to 12-MHz probe (HD15 ultrasound system; Philips) under US guidance was placed across the long biceps

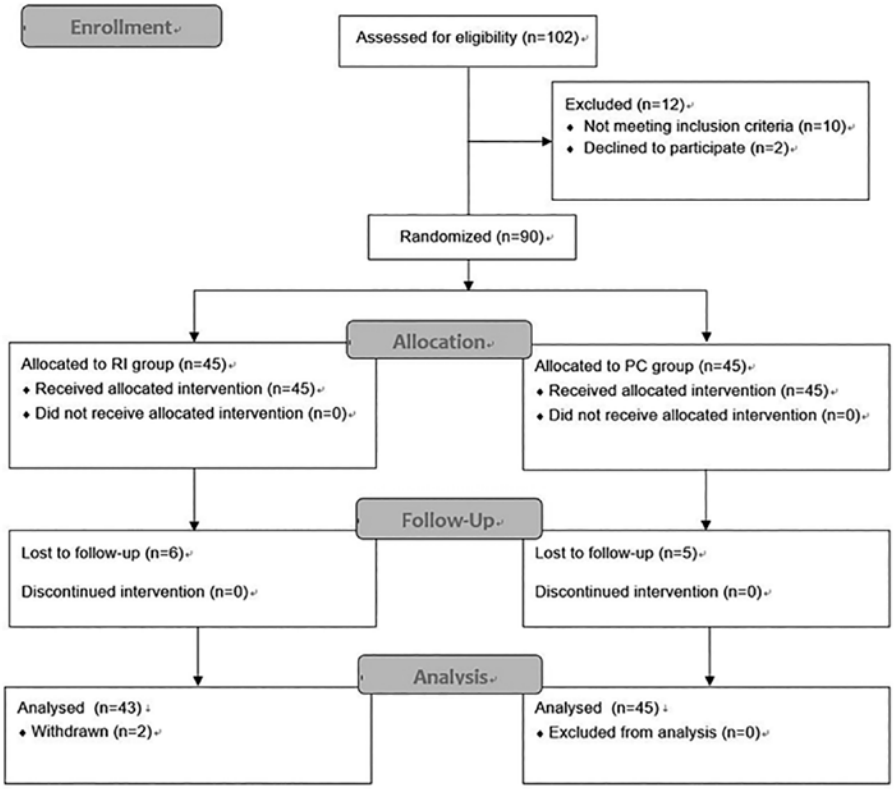

Fig. 1. *CONSORT guideline flow diagram.*
CONSORT, Consolidated Standards of Reporting Trials.

tendon for visualization of the IA course between the supraspinatus and subscapularis tendons. The needle was introduced medially to laterally with visualization of the needle shaft, and reached the RI between the long biceps tendon and the subscapularis tendon (Fig. 2) (10). The PC approach injection was performed with the patient in the semilateral decubitus position on the unaffected side with 45° anterior tilting of the affected side. The needle was advanced laterally to medially with visualization of the needle shaft under US guidance, and reached the GH joint space between the posterior humeral head and glenoid labrum. Once the needle had made contact with the humeral head, the needle was slightly withdrawn and followed by administration of the injection mixture in a resistance-free position (Fig. 3) (6,14). All procedures were performed by a single shoulder-intervention specialist (DHK) with 15 years of experience in the field. After the injection, anteroposterior and axillary fluoroscopic images were

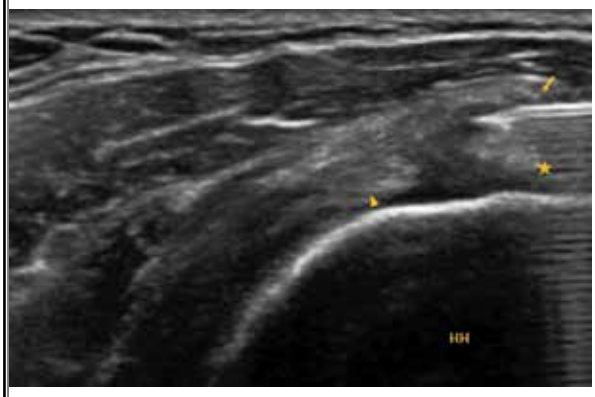

Fig. 2. *Transverse ultrasound view of the RI approach injection. The needle tip (arrow) is positioned in the RI between the long biceps tendon (arrow head) and the subscapularis tendon (asterisk).*

RI, rotator interval; HH, humeral head

captured to assess the accuracy of injection. Localization of the contrast medium within the GH joint was classified as a success (Fig. 4A). When leakage was observed in surrounding soft tissue or subacromial space, it was considered a failure (Fig. 4B) (14).

All pretreatment and follow-up assessments were performed by the same evaluator, who did not participate in administration of treatment. Pain intensity using the Visual Analog Scale (VAS) score, the American Shoulder and Elbow Surgeons (ASES) score, the subjective shoulder value (SSV), and passive ROMs was assessed prospectively before the injection and at 3, 6, and 12 weeks after the injection. A goniometer was used for assessment of the ROMs, which included forward flexion, abduction, external rotation, and internal rotation with the patient in the sitting position. Degrees of forward flexion and abduction were evaluated, including the scapulohumeral motion. For measurement of the range of internal rotation, the scratch test was performed by recording the vertebral level reached with the tip of the thumb. This level was then converted into a serial number as follows: T1-T12 into 1-12, respectively; L1-L5 into 13-17, respectively; sacrum into 18; coccyx into 19; and buttock into 20 (14,15).

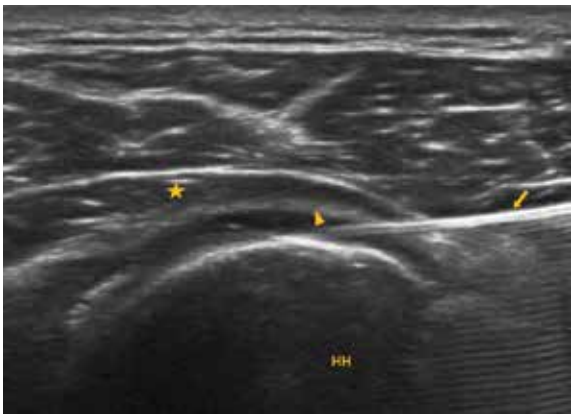

Fig. 3. *Transverse ultrasound view of the PC approach injection. The needle tip (arrow) is positioned in the PC (arrow head) of GH joint under the infraspinatus tendon (asterisk).*

PC, posterior capsule; GH, glenohumeral; HH, humeral head

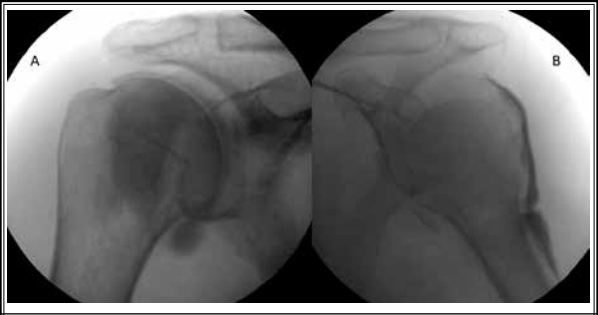

Fig. 4. *Fluoroscopic findings after injection.* (A) *Success; injection material is localized only within the GH joint.* (B) *Failure; injection material is visualized outside the GH joint.*
GH, glenohumeral.

All patients were instructed on a home-based exercise program to increase ROM and were allowed to perform a home-based exercise 3 times a day (15 minutes each round) (14,15). The home exercise program included pendulum exercises, wall-climbing exercises, and gentle ROM exercises using a bar. During this exercise program, patients were asked to refrain from provoking post-mobilization soreness with self-feedback. Patients were instructed not to undergo acupuncture or additional injections from other hospitals.

Statistical Analysis

Results of a power analysis indicated that sample sizes of 36 patients in each group would be required to demonstrate significant differences in ASES scores with a mean difference of 8 points and a standard deviation of 12 points at an α level of 0.05 and a β value of 0.20 (16). Considering a potential dropout rate of 20%, a minimum of 45 patients per group were enrolled. The data analysis was performed on an intention-to-treat basis. The independent-samples t test, the chi-square test, or one-way analysis of variance (ANOVA) was used for comparison of demographic factors at baseline between the 2 groups. For both groups, ANOVA was used to determine whether each outcome had a time effect after injection, and post hoc comparisons between the differences of the adjacent week's values were performed using the Bonferroni method. The independent-samples t test was used for comparison of potential differences between the outcomes of 2 groups at each point according to the normality of data. Differences between the success and failure subgroups in the RI group at each point were compared using the Friedman test with repeated measurements. A *P* value of < 0.05 was considered significant. SPSS, Version 26.0, IBM Corporation, Armonk, NY, United States was used for statistical analysis.

Results

At baseline, there were no significant differences in age, gender, the affected side, the presence of diabetes, body mass index, duration of symptoms, and clinical scores between the 2 groups with PFS ($P > 0.05$). The success rate of injection into the GH joint was 76.7% (33/43) and 93.3% (42/45) in the RI group and PC group, respectively, and the difference between the 2 groups was statistically significant ($P < 0.05$) (Table 1).

Table 1. *Baseline demographics of patients with PFS.*

Variable	RI Group	PC Group	*P* value
Number of Patients	43	45	
Age*	54.14 ± 8.87	55.44 ± 9.93	0.518
Men:Women (no)	25:18	20:25	0.199
Right:Left (no)	19:24	28:17	0.090
Diabetes (no)	7	7	0.926
Body Mass Index (kg/m2)	23.63 ± 2.98	23.69 ± 2.55	0.923
Duration of Symptoms (mo)*	9.35 ± 14.74	10.00 ± 11.26	0.816
Initial Clinical Score*			
VAS	6.81 ± 2.48	6.56 ± 2.15	0.602
ASES	40.23 ± 21.00	39.96 ± 16.25	0.946
SSV	43.02 ± 20.18	41.33 ± 18.01	0.679
Initial ROM*			
Forward Flexion	118.37 ± 23.60	115.11 ± 24.23	0.524
Abduction	101.05 ± 25.90	101.56 ± 27.22	0.929
External Rotation	41.74 ± 18.61	40.89 ± 20.84	0.840
Internal Rotation	17.74 ± 2.01	18.04 ± 2.28	0.515

*The values are given as the mean and SD.
Abbreviations: PFS, primary frozen shoulder; RI, rotator interval approach; PC, posterior capsule approach; VAS, Visual Analog Scale; ASES, American Shoulder and Elbow Surgeons; SSV, subjective shoulder value; ROM, range of motion; SD, standard deviation.

Significant improvements were observed in all outcome measures ($P < .001$ for all parameters) when compared to baseline, including VAS score, ASES scores, SSVs, and ROMs through 12 weeks in both the RI and PC groups. These results indicated that all outcome measures were significantly improved at 3, 6, and 12 weeks after the injection in both groups. The improvements of ROMs were maximized at 12 weeks after the injection in both groups. The improvements of pain score and functional scores were maximized at 6 weeks in both groups. No significant differences in VAS score, ASES scores, and SSVs were observed between the RI and PC groups at 3, 6, and 12 weeks after injection. Similarly, no significant differences in terms of the external and internal rotation in ROMs were observed between the 2 groups. A significantly higher degree of forward flexion and abduction was observed in the RI group than in the PC group at 12 weeks (Table 2).

We analyzed differences in outcomes between the success and failure subgroups depending on the results of the postinjection fluoroscopic image in the RI group. Significant improvements in all outcome measures ($P < .001$ for all parameters) including VAS score, ASES scores, SSVs, and ROMs through 12 weeks were observed in both the success (n = 33) and failure subgroups (n = 10). No significant differences in all outcome measures were observed between the 2 subgroups; however, the failure subgroup showed a significantly higher improvement of the degree of abduction in ROMs compared to the success subgroup at 3 weeks after injection ($P = 0.048$) (Table 3).

No patients reported serious adverse effects, such as infections, necrosis, vasovagal syncope, systemic toxicity of the local anesthetic, or anaphylactic response to contrast medium.

Discussion

The findings of the current study show that all injections intended to be administered into the GH joint led to significant improvements in pain relief, functional status, and ROMs at each time point after the injections. The clinical effect of these procedures was sustained for at least 12 weeks after the injection. Better improvements in the degree of forward flexion and abduction in ROMs were observed in the RI group compared to the PC group at 12 weeks after injection. However, no significant differences in the external and internal rotation in ROMs were observed between the 2 groups. The RI group showed a significantly lower success rate than the PC group in the accuracy of IA injection for the PFS treatment.

The anterior structures of the GH joint play an important role in the diagnosis and treatment of PFS. The RI is a triangular cylinder-shaped space in the anteromedial aspect of the shoulder (10,17,18). The coracohumeral ligament is an irregular trapezoidal structure, which forms the roof of the RI (9,19,20). The predominant pathological site in PFS is the RI, axillary recess, and the anterior capsules with a thickened coracohumeral ligament (3,21). PFS presents with pain due to inflammation of the joint capsule, which progresses to fibrosis and hypertrophy and causes contracture

Table 2. *Serial changes and statistical analysis of outcome measures between the RI group and the PC group at each time point.*

Variables	Baseline	3 Weeks	6 Weeks	12 Weeks
VAS				
RI Group	6.92 ± 2.54	2.46 ± 1.27	2.13 ± 1.26	2.59 ± 2.22
PC Group	6.41 ± 2.27	2.51 ± 1.15	1.89 ± 1.05	2.35 ± 1.58
P value	0.352	0.852	0.378	0.594
ASES				
RI Group	39.62 ± 21.39	75.00 ± 11.17	80.47 ± 10.46	77.39 ± 19.01
PC Group	41.04 ± 16.78	75.90 ± 9.33	80.99 ± 9.25	77.75 ± 12.61
P value	0.749	0.705	0.819	0.924
SSV				
RI Group	41.79 ± 20.76	68.97 ± 15.85	77.31 ± 13.42	74.49 ± 18.69
PC Group	42.97 ± 18.35	72.68 ± 12.22	77.14 ± 11.47	74.46 ± 12.90
P value	0.794	0.260	0.952	0.994
Forward Flexion				
RI Group	119.10 ± 23.81	144.36 ± 17.55	152.44 ± 15.93	156.15 ± 16.95
PC Group	112.97 ± 24.42	139.73 ± 17.28	147.30 ± 17.22	148.51 ± 16.24
P value	0.272	0.251	0.181	0.049*
Abduction				
RI Group	100.38 ± 26.52	130.26 ± 22.77	139.74 ± 20.84	144.74 ± 22.85
PC Group	98.65 ± 26.79	125.95 ± 19.22	133.11 ± 20.25	134.46 ± 20.88
P value	0.777	0.377	0.164	0.044*
External Rotation				
RI Group	41.41 ± 18.92	59.87 ± 13.10	65.26 ± 12.19	66.67 ± 14.57
PC Group	39.19 ± 20.57	55.95 ± 12.74	60.95 ± 13.84	62.16 ± 13.36
P value	0.625	0.190	0.153	0.165
Internal Rotation				
RI Group	17.74 ± 2.07	13.44 ± 2.49	11.74 ± 3.07	11.59 ± 3.18
PC Group	18.11 ± 2.26	13.59 ± 2.81	12.76 ± 2.67	12.49 ± 3.08
P value	0.466	0.795	0.130	0.216

*Statistically significant.
Abbreviations: RI, rotator interval approach; PC, posterior capsule approach; VAS, Visual Analog Scale; ASES, American Shoulder and Elbow Surgeons; SSV, subjective shoulder value.

of the shoulder (2,22). The IA corticosteroid injection is intended to diminish synovial inflammation for reduction or prevention of capsular fibrosis and yields an improvement in clinical symptoms (22,23). The injection is more useful to patients with PFS during the early period of painful or freezing stages, when fibrous contracture is not apparent (1,4,30). In this study, we injected a total of 10 mL fluid mixture with corticosteroid for both groups. Excessive injected IA volume (over 18 mL) could rupture the GH joint capsule in PFS patients, consequently causing adverse effects, such as atrophy of adipose tissue and weakening of tendons or ligaments, due to corticosteroid leaking into the surrounding soft tissues (22).

Few studies (7,8,24) on the comparative effect of RI injection and other approaches as a treatment for patients with PFS have been reported. In 2015, Prestgaard et al (8) reported on differences in the outcome of corticosteroid injection using the posterior IA approach vs combined PC and RI approaches in patients with PFS in the freezing stage. They found no differences in pain, function, and ROMs between the injection sites at any time up to 6 weeks. In 2018, Sun et al (7) injected corticosteroid into RI, PC, and subacromial space, respectively, for treatment of PFS and compared their clinical effect with each injection. The authors suggested that injection into the RI yielded better effects than into PC or subacromial space for patients with PFS in the freezing stage. In 2020, Elnady et al (24) used a hydrodilation (17 mL was injected) RI approach and compared its effects with PC approach hydrodilation in patients with PFS. Greater clinical effects were observed in patients who underwent hydrodilation via RI in the frozen stage. However, these comparisons on the effect of RI injection and other approaches are not consistent across the results of their studies. Additionally, the accuracy of RI injection was not evaluated in previous research. To the best of our knowledge, this is the first study comparing the efficacy and accuracy of RI vs PC approaches with ultrasound-guided IA corticosteroid injections for treatment of PFS. The findings of our study demonstrated that both injections were effective in patients with PFS and that the RI approach injection provided better ROM increments than the PC approach in patients with PFS, despite the difficulty of a precise procedure.

In clinical practice, posterior joint space of the GH joint is available as an accurate and safe IA injection site (6). However, in our research, greater improvement of forward flexion and abduction in ROMs was observed in the RI group than in the PC group at 12 weeks after the injection (Table 2). Although there was no statistical significance, the improvement of external and internal rotation also tended to be higher in the RI group than

Table 3. *Serial changes and statistical analysis of outcome measures between the success subgroup and the failure subgroup depending on the results in the RI group at each time point.*

Variables	Baseline	3 Weeks	6 Weeks	12 Weeks
VAS				
Success Subgroup	6.97 ± 2.62	2.43 ± 1.14	2.17 ± 1.32	2.87 ± 2.32
Failure Subgroup	6.78 ± 2.39	2.56 ± 1.74	2.00 ± 1.12	1.67 ± 1.66
P value	0.848	0.805	0.733	0.158
ASES				
Success Subgroup	39.56 ± 21.56	74.61 ± 9.93	79.94 ± 11.23	74.89 ± 19.95
Failure Subgroup	39.81 ± 22.09	76.30 ± 15.27	82.22 ± 7.64	85.74 ± 13.15
P value	0.975	0.697	0.574	0.135
SSV				
Success Subgroup	43.67 ± 20.59	67.33 ± 16.63	76.83 ± 13.74	71.9 ± 19.18
Failure Subgroup	35.56 ± 21.28	74.44 ± 12.10	78.89 ± 12.94	83.11 ± 14.73
P value	0.310	0.243	0.692	0.116
Forward Flexion				
Success Subgroup	115.17 ± 23.17	141.50 ± 17.38	150.67 ± 16.12	154.5 ± 17.14
Failure Subgroup	132.22 ± 22.24	153.89 ± 15.37	158.33 ± 14.58	161.67 ± 16.01
P value	0.058	0.062	0.210	0.272
Abduction				
Success Subgroup	98.00 ± 24.62	126.33 ± 22.82	137.67 ± 21.61	142.5 ± 23.22
Failure Subgroup	108.33 ± 32.40	143.33 ± 18.03	146.67 ± 17.32	152.22 ± 21.08
P value	0.312	0.048*	0.261	0.269
External Rotation				
Success Subgroup	40.17 ± 17.98	57.83 ± 12.3	64.83 ± 12.35	65.33 ± 14.79
Failure Subgroup	45.56 ± 22.42	66.67 ± 14.14	66.67 ± 12.25	71.11 ± 13.64
P value	0.461	0.076	0.698	0.303
Internal Rotation				
Success Subgroup	17.83 ± 2.12	13.63 ± 2.66	11.77 ± 3.27	11.93 ± 3.24
Failure Subgroup	17.44 ± 2.01	12.78 ± 1.79	11.67 ± 2.45	10.44 ± 2.83
P value	0.628	0.373	0.933	0.222

*Statistically significant.
Abbreviations: RI, rotator interval approach; VAS, Visual Analog Scale; ASES, American Shoulder and Elbow Surgeons; SSV, subjective shoulder value.

in the PC group. However, the injection procedure via RI can increase the local corticosteroid concentration at the RI, the anterior joint capsule, and the coracohumeral ligament, as the site of main pathology. Moreover, the procedure can aim efficiently at the anterior fibrotic structures and may loosen the adhesions with micro tear by needle. Therefore, injection using the RI approach may have the advantage of being able to deliver corticosteroid directly to the site of main pathology for management of PFS.

As the progression of localized contracture in anterior structures, the global stiffness of the entire joint capsule caused multidirectional limitation of motion in the shoulder with PFS (22). The coracohumeral ligament, which is usually the first structure to be affected in PFS, restricts mainly external rotation and additionally internal rotation of the shoulder joint (9,25,26). The external rotation of the shoulder is usually the first affected ROM in the early stage of PFS (2,3). In our study, the duration of symptoms in the 2 groups is applicable to the freezing or frozen stage of PFS. Contracture of the coracohumeral ligament might have already progressed at the time of injections. Therefore, external and internal rotation, directly affected by the coracohumeral ligament, may have been less effective than forward flexion and abduction in the improvement of ROMs.

In the current study, the successful rate of the RI group was lower at a level of 76.7% than the PC group with 93.3%. All the injections were performed by one shoulder specialist, different from the physician who measured ROMs and functional scores of the patients. The success rate of ultrasound-guided IA injection into the PC of the GH joint was reported to be quite high at 90% and 100%, respectively, between the 2 groups. The rate of accuracy in the PC group was within the range reported in the literature (14,27). The targeting of the RI, which is rather smaller in extent and volume, could be considered technically trickier than a relatively large joint space, such as a posterior joint capsule (10,28). In addition, the anatomy of the RI varies between patients because it was split or variously inserted into surrounding structures in a cadaver study (19). These

factors cause difficulty in performing IA injection using the RI approach. Despite the expected difficulty, good outcomes have been achieved using the RI approach technique with no severe adverse effects. The subacromial bursa and the subcoracoid bursa is located around the coracohumeral ligament (19); biceps tenosynovitis frequently occurs along with PFS (29). In case of failed RI injection, the injection drugs out of the GH joint cavity may spread into the soft tissues of the RI, as well as the adjacent bursa and tendon sheath (14,17). The coexisting bursitis or tenosynovitis could be treated due to the injection spreading into the adjacent pathologies, as well as PFS. Some previous studies (1,30) reported that corticosteroid injection into the subacromial bursa had an effect in patients with PFS. A recent clinical trial (11) also reported that multisite corticosteroid injection targeting the GH joint, PC, subacromial bursa, biceps long head, and coracohumeral ligament had better clinical effect than IA injection using the posterior approach in the treatment of PFS. Therefore, these results suggested that the bursa, tendon sheath, and soft tissues near the RI may be a potential pathologic lesion in PFS.

This study has several limitations. First, sham-controlled groups receiving placebo injections were not included, as the rate of dissatisfaction and dropout in the control group was expected to be high. However, the efficacy of the IA corticosteroid injection in patients with PFS has already been proven. Second, long-term effects were not evaluated. Considering pharmacokinetics, we presumed that the IA corticosteroid injection mainly has a short-term effect. Third, a double-blind study was not possible because the posture of the patients during the procedure was different according to the approach. Fourth, the sample size was too small to evaluate the effect of IA corticosteroid injection according to the success or failure of the procedure. Moreover, the statistical power of this study was too low to make a conclusion of the comparative efficacy of the RI vs PC approach IA corticosteroid injection for PFS patients.

Further research is needed to evaluate the effect of IA corticosteroid injection using the RI approach according to the success or failure of the procedure. Finally, compliance with home exercise was not assessed even though exercise could affect the outcomes (15,16).

Conclusions

Both IA corticosteroid injections resulted in significant pain reduction and functional improvement until 12 weeks after injection in the treatment of PFS. Although no significant differences in pain and functional scores were observed between the 2 injection techniques, the RI injection yielded better ROM improvement than the PC injection. Thus, IA corticosteroid injection via RI can be a useful treatment method for management of PFS, particularly in patients who are in the early stages. As a future study, evaluation of the comparative effect of IA corticosteroid injection using the RI approach according to the accuracy of the procedure in patients with PFS would be relevant. To achieve a definite conclusion on the effect of IA injection using the RI approach, a 3-arm, sham-controlled, randomized trial would be necessary. High-quality prospective clinical trials should be performed to compare IA injection options available to clinicians for treating PFS.

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