Changes in Range of Motion after Intra-Articular Corticosteroid Injection in Frozen Shoulder: A Retrospective 3-Month Follow-Up Study

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Objective: To examine (1) the degree of reduction of passive range of motion (PROM) on the affected side compared to that on the unaffected side and (2) the degree of increase in PROM following intra-articular corticosteroid injection (IACI) in patients with frozen shoulder. Method: The medical records of 120 patients with frozen shoulder were retrospectively reviewed. PROM of the unaffected and affected shoulder (flexion, extension, abduction, internal rotation, external rotation) was compared, and changes in PROM of the affected shoulder after a single IACI (triamcinolone 20 mg) were evaluated after 12 weeks. Results: At the time of diagnosis, PROM of the affected shoulder was most limited in external rotation, followed by internal rotation, abduction, extension, and flexion, compared to that of the unaffected shoulder. Compared to before IACI, PROM of external rotation demonstrated the greatest increase compared to all the other movements after IACI. Conclusion: Limitation in PROM of the frozen shoulder at the time of diagnosis was greatest for external rotation. Moreover, external rotation experienced the greatest improvement after IACI. Our findings should help to further clarify the clinical characteristics of frozen shoulder, aid in its diagnosis, and allow the prediction of the effects of IACI. (Clinical Pain 2019;18:76-81)

Key Words: Frozen shoulder, Intra-articular injection, Corticosteroids, Passive range of motion

INTRODUCTION

Frozen shoulder, also known as adhesive capsulitis, is a long-lasting, painful shoulder disorder. The disorder is caused by progressive fibrosis and eventual contracture of the capsule of the glenohumeral joint, which causes stiffness and pain.1,2 The treatment for frozen shoulder includes rehabilitation exercises and physical modalities, non-steroidal antiinflammatory drugs, intra-articular corticosteroid injection (IACI), capsule distension, and arthroscopic capsular release.1,5

IACI is one of the most common treatments for frozen shoulder. It targets the inflammatory process at the glenohumeral joint. Reports reveal that IACI is effective for the rapid decrease of pain and improvement of passive range of motion (PROM).6,7

Frozen shoulder is provoked by inflammation of the joint capsule and synovium, which eventually results in contracture of the capsule.8 This capsular contracture causes the global limitation of PROM of the glenohumeral joint. Limitation of PROM is an important clinical feature in frozen shoulder because it is an essential diagnostic criterion for this condition.9 Evaluating the changes in PROM after treatment is important for determining the effectiveness of treatment. Some authors have described that limitation of passive external rotation is common in frozen shoulder, but it is still controversial.1,10-12 There are few studies that quantified the degree of reduction of PROM in each plane in the affected side to support their arguments. Moreover, only a few studies have investigated the degree of improvement of PROM of the glenohumeral joint in all planes after IACI.

In the present study, we aimed to examine (1) the degree of reduction in PROM on the affected side compared to that on the unaffected side and (2) the degree of increase in PROM following IACI in patients with frozen shoulder.
MATERIALS AND METHODS

1. Subjects and study design

This study was a retrospective comparative study based on medical records from an outpatient rehabilitation clinic of a university hospital. Informed consent was waived for this retrospective study approved by the institutional review board at the university hospital. Between January 1, 2013 and December 31, 2018, 120 patients with frozen shoulder were reviewed retrospectively. All the patients underwent standardized history taking, physical examination, and shoulder ultrasonography. Evaluations for active range of motion, PROM, and muscle strength, and tests for rotator cuff tendinopathy and impingement were also conducted at the time of initial diagnosis.

The inclusion criteria for the study were as follows: (1) patients who had frozen shoulder with a normal radiography finding of the affected shoulder and restriction of PROM of $> 30^\circ$ in 2 or more planes of movement,9,13 (2) stage 2 frozen shoulder (frozen stage) according to Hannafin and Chiaia,1 and (3) at least 2 months of pain.

Patients were excluded if they had any of the following: secondary frozen shoulder (secondary to other causes including inflammatory, metabolic, or infectious arthritis; cerebrovascular accident; tumor; or fracture), rotator cuff lesion on both physical and ultrasonographic examinations, and full-thickness tear of the rotator cuff on ultrasonographic examination.

2. Intervention

IACI was performed with ultrasound guidance. A mixture of 2 mL of 10 mg/mL triamcinolone acetonide and 4 mL of 1% lidocaine was injected using a 23-gauge 6-cm-long needle behind the shoulder, with the needle positioned parallel to the transducer. After injection, patients received leaflet and were educated by physical therapists to do a home exercise program for increasing the range of motion, including stretching forward and bending down to a desk, and the Codman exercise, wall-climbing exercise, external and internal rotation with bar, and posterior shoulder stretch.14 No nonsteroidal anti-inflammatory drugs, analgesics, or opioids were prescribed after injection.

3. Outcome measurement

PROM in all planes of the shoulder except adduction was measured for both the affected and unaffected sides at the time of initial diagnosis and 12 weeks after injection. To identify the limitation of motion of the affected side compared to the unaffected side at the time of diagnosis, the fraction of PROM of the affected side compared to that of the unaffected side (PROM of the affected side/PROM of the unaffected side) was calculated for each plane. In addition, to examine the changes in PROM of the affected side 12 weeks after injection, PROM change rate (amount of change in PROM after injection/PROM before injection) was calculated. The common follow up interval of the hospital was 4, 8 and 12 weeks. In this study, follow up interval was selected as 12 weeks to see the long-term effect rather than the short-term effect of IACI. PROM for forward flexion, abduction, and external rotation were measured in the supine position using a goniometer. External rotation was measured in 0° abduction of the shoulder and 90° flexion of the elbow.

4. Statistical analysis

All data were analyzed using R 3.5.3 (R Foundation for Statistical Computing, Vienna, Austria). Continuous data are presented as means and SDs, and categorical data are presented as frequencies and percentages. The joint movement with the most severe limitation in PROM was identified using one-way analysis of variance (ANOVA), with the Bonferroni test as the post-hoc test. The degree of improvement in PROM 12 weeks after corticosteroid injection was analyzed with the paired t-test after a test for normality was conducted. The changes in PROM after IACI were evaluated based on the PROM change rate after injection. The plane of joint movement with the greatest improvement was determined by analyzing this change rate with one-way ANOVA and Bonferroni test. Statistical significance was set at $p < 0.05$.

RESULTS

1. Characteristics of patients

A total of 120 patients were enrolled. The mean patient age was 54.1 ± 4.7 years. Thirty-four (28%) of the patients were men and 86 (72%) were women. The dominant
shoulder was affected in 54 patients (45%) and the non-dominant shoulder was affected in 66 patients (55%). The mean duration of pain was 7.01 ± 2.32 months.

2. Limitation in PROM due to frozen shoulder prior to injection

The mean PROM of the unaffected shoulder was 158 ± 14.6º flexion, 54 ± 10.7º extension, 161 ± 17.5º abduction, 79 ± 17.6º internal rotation, and 99 ± 16.7º external rotation. For the affected shoulder, flexion was limited to 84.9% (134 ± 16.4º), extension 61.5% (33 ± 13.2º), abduction 52.9% (85 ± 18.4º), internal rotation 44.0% (34 ± 15.1º), and external rotation to 35.2% (35 ± 16.2º) of the PROM of the unaffected shoulder, showing the significant difference in mean ratio between each planes (p < 0.001, all; Table 1). When comparing the degree of limitation of PROM between each plane, it showed the greatest limitation for external rotation, followed by internal rotation, abduction, extension, and flexion (Table 2).

3. Changes in PROM after IACI

PROM of the affected shoulder was measured 12 weeks after IACI. Compared to that prior to IACI, flexion was improved by 17.7%, extension by 41.6%, abduction by 46.6%, internal rotation by 56.4%, and external rotation by 62.5%. Improvement in PROM was significant in all planes and there was also significant difference in mean ratio between each plane (p < 0.001, all; Table 3). When comparing the superiority of change rate of PROM be-

### Table 1. Passive Range of Motion of the Affected and Unaffected Shoulder

<table>
<thead>
<tr>
<th></th>
<th>Flexion</th>
<th>Extension</th>
<th>Abduction</th>
<th>Internal Rotation</th>
<th>External Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unaffected side (°)</td>
<td>158 ± 14.6</td>
<td>54 ± 10.7</td>
<td>161 ± 17.5</td>
<td>79 ± 17.6</td>
<td>99 ± 16.7</td>
</tr>
<tr>
<td>AFFECTED SIDE (°)</td>
<td>134 ± 16.4</td>
<td>33 ± 13.2</td>
<td>85 ± 18.4</td>
<td>34 ± 15.1</td>
<td>35 ± 16.2</td>
</tr>
<tr>
<td>Ratio (%)†</td>
<td>84.9</td>
<td>61.5</td>
<td>52.9</td>
<td>44.0</td>
<td>35.2</td>
</tr>
<tr>
<td>Mean ratio (%)* †</td>
<td>85.8 ± 14.1</td>
<td>62.4 ± 24.0</td>
<td>53.8 ± 14.4</td>
<td>45.4 ± 21.3</td>
<td>36.3 ± 18.3</td>
</tr>
</tbody>
</table>

Values are presented as mean ± standard deviation or as numbers.†Ratio (%) = PROM of the affected side/PROM of the unaffected side. *Mean ratio (%) = mean value of the raw ratio, compared with one-way analysis of variance.

* p < 0.001.

### Table 2. Post-hoc Test for Limitation in Passive Range of Motion in the Affected Shoulder prior to Intra-articular Corticosteroid Injection

<table>
<thead>
<tr>
<th></th>
<th>External Rotation</th>
<th>Internal Rotation</th>
<th>Abduction</th>
<th>Extension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal rotation</td>
<td>&lt;0.001</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Abduction</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Extension</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>-</td>
</tr>
<tr>
<td>Flexion</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

### Table 3. Changes in Passive Range of Motion of the Affected Shoulder after Intra-articular Corticosteroid Injection

<table>
<thead>
<tr>
<th></th>
<th>Flexion</th>
<th>Extension</th>
<th>Abduction</th>
<th>Internal Rotation</th>
<th>External Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-injection (°)</td>
<td>134 ± 16.4</td>
<td>33 ± 13.2</td>
<td>85 ± 18.4</td>
<td>34 ± 15.1</td>
<td>35 ± 16.2</td>
</tr>
<tr>
<td>Post-injection (°)*</td>
<td>158.1 ± 11.4</td>
<td>47.3 ± 11.6</td>
<td>125.2 ± 25.1</td>
<td>54.4 ± 16.0</td>
<td>57.1 ± 16.8</td>
</tr>
<tr>
<td>Ratio (%)†</td>
<td>17.7</td>
<td>41.6</td>
<td>46.6</td>
<td>56.4</td>
<td>62.5</td>
</tr>
<tr>
<td>Mean ratio (%)* †</td>
<td>19.2 ± 15.4</td>
<td>56.6 ± 51.9</td>
<td>54.1 ± 50.5</td>
<td>80.1 ± 83.0</td>
<td>108 ± 172.9</td>
</tr>
</tbody>
</table>

Values are presented as mean ± standard deviation or as numbers.†Ratio (%) = amount of change in PROM after injection/PROM before injection. *Mean ratio (%): mean value of the raw ratio, compared with one-way analysis of variance.

* p < 0.001.


**Table 4. Post-hoc Test for Change Rate in Passive Range of Motion in the Affected Shoulder after Intra-articular Corticosteroid Injection**

<table>
<thead>
<tr>
<th></th>
<th>External rotation</th>
<th>Internal rotation</th>
<th>Abduction</th>
<th>Extension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal rotation</td>
<td>0.18</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Abduction</td>
<td>&lt;0.001</td>
<td>0.29</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Extension</td>
<td>&lt;0.001</td>
<td>0.48</td>
<td>&gt;0.99</td>
<td>-</td>
</tr>
<tr>
<td>Flexion</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>0.03</td>
<td>0.02</td>
</tr>
</tbody>
</table>


tween each plane, external rotation was more significantly improved than extension, flexion, and abduction. However, the degree of improvement was not significantly different from that for internal rotation. There was significantly less improvement in flexion compared to all other planes (Table 4).

**DISCUSSION**

To our knowledge, our study is the first to quantify and compare the degree of improvement in PROM in each plane following IACI among patients with frozen shoulder. This study showed that (1) limitation in PROM of the affected shoulder at the time of diagnosis was greatest for external rotation, followed by internal rotation, abduction, extension, and flexion and that (2) PROM of external rotation was improved the most after IACI.

The marked limitation in PROM noted for external rotation at the time of diagnosis seems related to the contracture of the anterior capsule. Although fibroplasia of the entire capsule causes global limitation, the limitation in external rotation is known to be particularly severe because the contracture of the anterior capsule is more severe compared to that of other capsule regions. Contracture particularly occurs in the coracohumeral ligament at the rotator interval, and some studies showed that anterior capsular release improves PROM of external rotation in patients with refractory frozen shoulder.

Currently, there are several clinical diagnostic criteria for frozen shoulder due to the lack of a clear consensus on the degree of limitation of PROM for the diagnosis of frozen shoulder. Regarding diagnostic criteria, some authors used a limitation of external rotation, while many others did not. Frozen shoulder is characterized by global limitation, but in the present study, we showed that the limitation in external rotation caused by anterior capsule contracture was the most characteristic feature with specific supporting data. Although the limitation of external rotation was the most important characteristic, it is currently not included in most diagnostic criteria. We strongly suggest that the limitation in external rotation should be included in the diagnostic criteria for frozen shoulder.

Despite our findings, few studies show the specific data that a limited external rotation is the most common limitation in PROM of the shoulder. Neviaser et al. described that early loss of external rotation is a hallmark of frozen shoulder. Likewise, Hannafin et al. reported that external rotation is the most limited plane in frozen shoulder. But there is no specific supporting data in both of them. In one study that quantified the degree of PROM in 30 patients with frozen shoulder, the authors showed that external rotation of the affected shoulder was significantly limited compared to internal rotation and abduction, and this is consistent with our findings. However, their study had a small sample and only examined 3 planes of shoulder joint movement (external rotation, internal rotation, and abduction).

Passive external rotation was more significantly improved after IACI compared to the other planes, with the exception of internal rotation. This is because the limitation in external rotation is more related to localized inflammation and consequently to the contracture of the anterior capsule, as opposed to the contracture of the global capsule. For this reason, the anti-inflammatory effect of IACI would have been effective for improving PROM of external rotation. In one meta-analysis study about the effects of IACI in patients with frozen shoulder showed that PROM in all planes was significant improved after IACI. However, when reviewing the individual studies, none of them calculated the rate of improvement of the degree and compared the superiority between each planes. Not only did our study quantify the degree of improvement after IACI, but it also compared the superiority between each plane.

Our study analyzed the degree of improvement of PROM after IACI using the change rate of PROM. When analyzing with the amount of change of PROM, abduction was the most improved plane. Differences in the results of the two methods might be the limitation for this study.
However, since the normal values of PROM of each plane are all different, using the amount of change of PROM may produce the unstandardized results. Our study was intended to obtain standardized results using the change rate of PROM.

The fact that we examined changes in PROM after injection in the present study has the following clinical implications. First, because external rotation is most noticeably limited in frozen shoulder, IACI can be selected from various treatment methods as the most effective therapy for improving PROM of external rotation. Second, the degree of improvement in PROM after IACI can be predicted.

One strength of this study is that it presented evidence supporting previous arguments that external rotation is the most limited movement in frozen shoulder and that PROM of external rotation is the most improved after IACI. However, our study has some limitations. First, it is limited by its retrospective design. Second, after IACI, patients were educated by physical therapists to do a home exercise program including stretching exercise and could not verify that all patients had carried out what they had been educated. This might have affected the measured PROM. Further study that considers such limitation will be needed in the future.

CONCLUSION

Limitation in PROM of frozen shoulder at the time of diagnosis was greatest for external rotation, followed by internal rotation, abduction, extension, and flexion. Moreover, external rotation demonstrated the greatest improvement after IACI. The findings of this study should help clarify the clinical characteristics of frozen shoulder, aid in its diagnosis, and allow the prediction of the effects of IACI.

REFERENCES

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