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Does the timing of surgical intervention impact the clinical outcomes and overall duration of symptoms in frozen shoulder?

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Background: The optimal timing of arthroscopic capsular release in patients with frozen shoulder is controversial. Some surgeons delay surgery in the belief that early surgical intervention results in a poorer prognosis. However, whether early surgical intervention causes inferior clinical outcomes and a longer duration of symptoms in frozen shoulder remains unclear. The objective of this study was to compare the clinical outcomes and overall duration of symptoms in frozen shoulder between patients who underwent early surgical intervention and those subjected to late surgical intervention. Our hypotheses were that (1) early surgical intervention would provide significant improvement in symptoms but inferior clinical outcomes because of more severe synovitis compared with late surgical intervention and (2) early surgical intervention would shorten the overall duration of symptoms compared with late surgical intervention.
Methods: We reviewed 60 consecutive patients with frozen shoulder who underwent arthroscopic capsular release. We compared clinical outcomes and the overall duration of symptoms between 2 groups: Group I comprised 27 patients who underwent surgery <6 months after onset (mean, 3.8 months), whereas group II comprised 33 patients who underwent surgery ≥6 months after onset (mean, 11.1 months). The severity of glenohumeral synovitis at the time of surgery was evaluated. Patient-reported pain, shoulder function, and range of motion, as well as the presence of sleep disturbance, were assessed preoperatively and at 3 and 6 months after surgery.
Results: Both groups showed significant improvements in the visual analog scale pain score, Japanese Orthopaedic Association score, American Shoulder and Elbow Surgeons score, and prevalence of sleep disturbance after surgery ($P < .001$), although the glenohumeral synovitis score was significantly higher in group I than in group II ($P < .0001$). Forward flexion at 6 months after surgery was significantly greater in group I than in group II ($P = .007$). The overall duration of symptoms was shorter in group I than in group II ($P < .0001$). Neither the pain score, functional score, prevalence of sleep disturbance, nor postoperative recovery time differed between groups.
Conclusions: Arthroscopic capsular release provided significant pain relief and improvement in shoulder function in patients with frozen shoulder regardless of the timing of surgery. Early surgical intervention might shorten the overall duration of symptoms in frozen shoulder and is not associated with inferior clinical outcomes when compared with late surgical intervention. Surgeons do not need to delay surgical intervention for patients who have intolerable pain and/or nocturnal pain with sleep disturbance.
Level of evidence: Level III; Retrospective Cohort Comparison; Treatment Study

Keywords: Arthroscopic capsular release; clinical outcome; duration of symptoms; frozen shoulder; nocturnal pain; timing of surgery

The study protocol was approved by the Institutional Review Board at Osaka Medical College (no. 2783).

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The term "frozen shoulder" was first described by Codman[8] in 1934 as a condition that is characterized by pain and reduced range of motion (ROM) of the affected shoulder with no previous findings in terms of patient history, physical examination, or imaging. Frozen shoulder is defined as an idiopathic stiff shoulder.[21] It is a common disease with a prevalence of 2%-5% in the general population.[3,5,19] The etiology of the condition remains unknown. Women are more commonly affected than men,[39] as are smokers and patients with diabetes and thyroid disorders.[21,30]

The natural course of frozen shoulder can be divided into 3 phases.[36] The first is the "freezing phase," which is characterized by the onset of severe pain and gradually increasing stiffness and lasts 2-9 months. In the second phase, the "frozen phase," pain usually subsides while shoulder stiffness becomes substantial. This phase usually lasts 4-12 months. In the third phase, the "thawing phase," function is gradually restored and pain is resolved. This phase lasts a further 5-26 months. During the natural course of the disease, some patients may regain full use of their shoulder within 12-18 months whereas others may experience persistent pain and dysfunction for additional months.[21]

Management of frozen shoulder involves several different nonoperative treatments, such as oral steroids, intra-articular steroid injections, physical therapy, and supervised neglect, as well as operative treatment options, such as open release, manipulation under anesthesia, and arthroscopic capsular release.[4,11,13,16,20,35] Although nonoperative treatment is successful in about 90% of patients, a smaller fraction of patients have severe pain and restriction of shoulder ROM requiring surgical intervention.[17,25] Operative treatment can be offered to patients with refractory cases of frozen shoulder, even though the first choice of treatment should be conservative therapy. Some authors have speculated that arthroscopic capsular release is safer than manipulation under anesthesia because of the controlled nature of the capsular release.[15,16] Previous studies have reported good to excellent short- and long-term outcomes after arthroscopic capsular release.[18,20,24,27]

The optimal timing of arthroscopic capsular release in patients with frozen shoulder is currently a matter of controversy. Traditionally, surgeons would only offer surgical intervention after failure of conservative measures for a minimum of 6 months considering the natural course.[12,14,21,33,34] Some surgeons delay surgical intervention in the belief that surgery in the early stages of frozen shoulder results in a poorer prognosis; however, there is no evidence as to whether early surgical intervention causes inferior clinical outcomes compared with delayed surgical intervention. In addition, it is unclear whether early surgical intervention would prolong or shorten the duration of symptoms in frozen shoulder.

Hence, the objective of this study was to compare clinical outcomes after arthroscopic capsular release and the overall duration of symptoms in frozen shoulder between patients who underwent early intervention and those subjected to late surgical intervention. Our hypotheses were that (1) early surgical intervention would provide significant improvement in symptoms but inferior clinical outcomes because of more severe synovitis compared with late surgical intervention and (2) early surgical intervention would shorten the overall duration of symptoms compared with late surgical intervention.

Materials and methods

Patient selection

We retrospectively reviewed our prospectively collected database of frozen shoulder cases. The inclusion criteria were patients who had a clinical diagnosis of frozen shoulder (idiopathic stiff shoulder), defined as a painful, stiff shoulder with no identifiable cause; underwent arthroscopic capsular release at our institutions; and had a minimum of 6 months' follow-up. The exclusion criteria were patients whose affected shoulder had a history of trauma or surgery or the presence of a rotator cuff tear, glenohumeral arthritis, or calcific tendinitis or those with <6 months' follow-up. Surgery was indicated in patients with frozen shoulder after failure of conservative treatment, such as oral nonsteroidal anti-inflammatory drugs, a home therapy program, and outpatient physical therapy, or those who refused to continue conservative treatment because of severe pain and/or sleep disturbance after the failure of conservative treatment at other clinics.

We initially included 71 consecutive patients who had undergone arthroscopic capsular release performed by 1 of 2 experienced shoulder surgeons (T.M. or K.F.) at our institutions between 2013 and 2018. Of these 71 patients, 7 had post-traumatic stiff shoulder, 1 had a history of rotator cuff repair, and 3 were lost to follow-up. Thus, 60 shoulders in 60 patients (35 women and 25 men; mean age, 60.1 years; age range, 37-78 years) were included in this study. The mean follow-up period was 13.1 months (range, 6-47 months). To investigate whether the timing of arthroscopic capsular release had an impact on the clinical outcome and the overall duration of symptoms, all patients were assigned to 1 of 2 groups according to the interval between the onset of symptoms and surgical intervention. Group I comprised 27 patients who underwent arthroscopic capsular release <6 months after disease onset, whereas group II comprised 33 patients who underwent surgery ≥6 months after onset. The onset of symptoms was defined based on the patient's report at the initial visit to our clinic.

Surgical procedure

All procedures were performed with the patients under general anesthesia following an interscalene regional block in the lateral decubitus position. The shoulder ROM was examined with the patients under general anesthesia. We established a posterior

portal for initial arthroscopic assessment of the glenohumeral joint. Next, we established an anterior portal through the rotator interval as the working portal. After careful synovectomy of the anterior capsule and débridement of labral fraying, a radiofrequency wand (CoVac 50 ArthroWand; ArthroCare, Austin, TX, USA) was introduced through the anterior portal to perform the capsular release. The tissues in the rotator cuff interval were released with the radiofrequency wand, and the capsule was then cut immediately lateral to the glenoid labrum. Starting at the 1-o'clock position (for a right shoulder), the capsular release was performed in the superior-to-inferior direction to the 6-o'clock position and involved takedown of the superior, middle, and anterior bands of the inferior glenohumeral ligament. Next, the release was continued on the posterior side after the arthroscope was switched to the anterior portal with the radiofrequency wand in the posterior portal. The posterior release was performed in the same fashion as the anterior procedure. During arthroscopic inferior capsular release between the 5- and 7-o'clock positions, care was taken to release the glenoid capsular insertion close to the labrum and to release only the capsular layer to avoid any iatrogenic injury to the axillary nerve. After the complete 360° capsular release, the arthroscope was removed from the glenohumeral joint and was redirected into the subacromial space. If synovitis, bursal adhesion, hypertrophy, or fraying of the coracoacromial ligament was observed during examination of the subacromial space, resection of the bursal tissues or coracoacromial ligament was performed. Next, the arm was taken out of the arm holder, and gentle manipulation was performed. Finally, we reinserted the arthroscope into the glenohumeral joint and the subacromial space to confirm that no iatrogenic injuries had occurred.

Postoperative protocol

Intravenous patient-controlled analgesia was used for postoperative pain control. Patients were admitted to the hospital and received an intravenous infusion of fentanyl, 10 μg/mL administered at a rate of 1-3 mL/h, for several days. The day after the surgical procedure, a postoperative physical therapy program, which consisted of passive ROM exercises performed 2 or 3 times a day, was initiated. Physical therapists assisted all patients with their exercises. Patients were discharged between the seventh and 14th postoperative day and were instructed to try to use their shoulder for activities of daily living. Continued outpatient physical therapy for 2 or 3 days per week was recommended until the patient fully recovered the ability to perform daily activities.

Evaluation of glenohumeral synovitis

A fellowship-trained shoulder surgeon with 7 years' experience in shoulder surgery (A.H.) reviewed all shoulder arthroscopic videos to evaluate glenohumeral synovitis at the time of surgery. The surgeon did not have access to clinical data or patient information before the evaluation. The validated scoring system introduced by Davis et al[9] was used to evaluate the severity of glenohumeral synovitis. In brief, scores were determined for the color of the capsule (pale, 0; pink, 1; red, 2), villous projections (none, 0; few, 1; extensive, 2), capillaries of the capsule (scattered, 0; hypertrophied, 1), and axillary recess (normal, 0; contracted, 1), and the total score was calculated. A previous study reported that this scoring system showed good reliability (interclass correlation coefficient of 0.68 and 100% power with 19 surgeons reviewing 20 videos twice).[9]

Outcome assessment

To compare the clinical outcomes, recovery times, and overall duration of symptoms between the 2 groups, we evaluated the (1) visual analog scale (VAS) pain score (0-100), (2) Japanese Orthopaedic Association (JOA) score, (3) American Shoulder and Elbow Surgeons (ASES) shoulder score, (4) passive shoulder ROM, (5) presence or absence of nocturnal pain with sleep disturbance, (6) time needed for rehabilitation after surgery, and (7) overall duration of symptoms (defined as the time interval from the onset of symptoms to full recovery of patients' ability to perform daily activities). The VAS pain, JOA, and ASES scores were evaluated preoperatively and 6 months after surgery. Shoulder ROM and the presence or absence of nocturnal pain with sleep disturbance were recorded preoperatively and 3 and 6 months after surgery.

Statistical analyses

Descriptive statistics were used to report basic measures. Values were given as mean and standard deviation or range where appropriate. The Mann-Whitney *U* test was used to compare the glenohumeral synovitis score and clinical outcomes between the 2 groups. The unpaired *t* test was used to compare the ROM between the 2 groups. The paired *t* test was used to compare the preoperative and postoperative clinical outcome measures. The Fisher exact test was used to compare all categorical variables between groups. For comparison of the prevalence of nocturnal pain with sleep disturbance at different time points, the McNemar test was used. Statistical significance was defined as $P < .05$. All statistical analyses were performed using JMP Pro software (version 14.0; SAS Institute, Cary, NC, USA).

We used the G*Power package (version 3) to perform a power analysis after data collection. We calculated the power $(1 - \beta)$ of comparison between group I and group II by defining the sample sizes as 27 (for group I) and 33 (for group II); defining the threshold of significance (α) as .05; and defining the effect size as 1.27 for the glenohumeral synovitis score, 0.85 for forward flexion, 1.37 for the interval between onset and surgery, and 1.27 for the overall duration of symptoms.

Results

According to the power analysis, the comparison between groups I and II had a power of 0.99 for the glenohumeral synovitis score, 0.90 for forward flexion, 1.0 for the interval between onset and surgery, and 1.0 for the overall duration of symptoms. The patient demographic characteristics are shown in Table I. There were no statistically significant differences in age; sex; and the prevalence of diabetes mellitus, thyroid disorders, and smoking habits between groups I and II. The interval between disease onset and

Table I Patient demographic characteristics

	Group I (n = 27)	Group II (n = 33)	*P* value
Age, yr	61.2 ± 10.0	59.2 ± 11.8	.47
Sex, n	13 M and 14 F	12 M and 21 F	.43
DM	2 of 27 (7.4)	9 of 33 (27.3)	.09
Thyroid disorder	1 of 27 (3.7)	4 of 33 (12.1)	.37
Smoking	6 of 27 (22.2)	6 of 33 (19.3)	>.999
Interval between onset and surgery, mo	3.8 ± 0.9	11.1 ± 7.5	<.0001*

M, male; *F*, female; *DM*, diabetes mellitus.
Data are presented as prevalence of patients (percentage) or mean ± standard deviation unless otherwise indicated.
* Statistically significant at $P < .0001$.

surgical intervention was significantly shorter in group I (3.8 ± 0.9 months) than in group II (11.1 ± 7.5 months, $P < .0001$). The cumulative glenohumeral synovitis score was significantly higher in group I (4.9 ± 1.0) than in group II (3.5 ± 1.2, $P < .0001$) (Table II). In terms of the score's individual categories, group I had more severe capsule color, villous projection, and capillary scores than group II. Representative arthroscopic images of shoulders in groups I and II are shown in Figure 1.

The VAS pain score improved significantly 6 months after surgery in both group I (from 79.8 to 5.3) and group II (from 71.1 to 9.0) (both $P < .0001$). Similarly, the JOA score improved significantly after surgery in both group I (from 49.0 to 91.4) and group II (from 50.1 to 87.9) (both $P < .0001$). The ASES score also improved significantly after surgery in groups I (from 34.8 to 88.6) and II (from 39.8 to 89.4) (both $P < .0001$) (Table III). No significant differences in the VAS pain score, JOA score, and ASES score were found between groups I and II preoperatively and at 6 months after surgery (Table III).

Shoulder ROM was significantly increased after surgery in both groups (Table IV). Forward flexion at 6 months after surgery was significantly larger in group I than in group II ($P = .007$). There was no significant difference in abduction, external rotation, and internal rotation between groups I and II at each time point.

The prevalence of nocturnal pain with sleep disturbance was significantly decreased after surgery in both group I (from 81.5% preoperatively to 29.6% at 3 months and 14.8% at 6 months after surgery) and group II (from 75.8% preoperatively to 18.2% at 3 months and 15.2% at 6 months after surgery) (all $P < .001$). There was no significant difference in the prevalence of nocturnal pain with sleep disturbance between groups I and II at each time point (Table V).

The time needed for postoperative rehabilitation did not differ between groups I (6.5 ± 3.5 months) and II (6.9 ± 3.8 months, $P = .82$) (Table VI). The overall duration of symptoms was significantly shorter in group I (10.3 ± 3.3 months) than in group II (18.1 ± 8.0 months, $P < .0001$) (Table VI). Finally, there were no intraoperative or postoperative complications, including fracture, dislocation, iatrogenic instability, axial nerve injury, recurrence, or infection, in either group.

Discussion

We hypothesized that early (<6 months) surgical intervention would provide inferior clinical outcome because of more severe synovitis compared with late (≥6 months) intervention; however, our hypothesis was rejected. Our results showed that early surgical intervention did not provide inferior clinical outcomes compared with later surgical intervention, despite the fact that patients who underwent early surgical intervention had more severe glenohumeral synovitis. In this study, arthroscopic capsular release provided significant pain relief and improvement in shoulder function in patients with frozen shoulder regardless of the timing of surgery. Several previous studies have documented the substantial impact of arthroscopic capsular release for frozen shoulder on pain and ROM.[2,20,37] The short-term clinical outcomes in both groups in our study were comparable with those in previous reports.[2,20,37]

Another important finding was that the overall duration of symptoms in patients who underwent early surgical intervention was significantly shorter than that in patients subjected to late surgical intervention, although there was no significant difference in the time needed for postoperative rehabilitation between the 2 groups. To date, it is still unclear whether early surgical intervention would shorten the recovery time and overall duration of symptoms. In this study, we found that the overall symptom duration in patients with early intervention was shorter than that in patients with late intervention; this result suggests that early surgical intervention might shorten the overall duration of symptoms. In addition, we found that at 6 months after surgery, patients who underwent early surgical intervention had significantly greater forward flexion than those subjected to late surgical intervention. A possible explanation is that patients with a prolonged interval between disease onset and surgical intervention might have

Table II Glenohumeral synovitis score at time of surgery

	Group I	Group II	*P* value
Color of capsule	1.4 ± 0.5	1.0 ± 0.5	.003*
Villous projections	1.6 ± 0.5	1.2 ± 0.5	.002*
Capillaries of capsule	0.9 ± 0.3	0.4 ± 0.5	.0001*
Contracture of axillary recess	1.0 ± 0.0	1.0 ± 0.2	.38
Summed score	4.9 ± 1.0	3.5 ± 1.2	<.0001*

Data are presented as mean ± standard deviation.
* Statistically significant at $P < .01$.

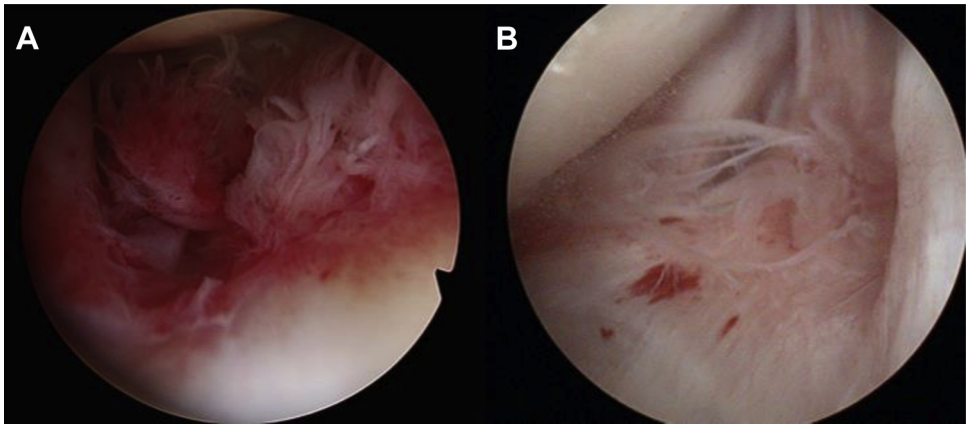

Figure 1 Arthroscopic images of representative cases. **(A)** The right shoulder of a 52-year-old male patient in group I (early surgical intervention) shows formation of red villi with extensive villous projections and hypertrophied capillaries. **(B)** The left shoulder of a 55-year-old male patient in group II (later surgical intervention) shows formation of pink villi with few villous projections and scattered capillaries.

Table III Preoperative and postoperative shoulder scores

	Group I	Group II	*P* value (group I vs. group II)
VAS pain score			
Preoperative	79.8 ± 20.9	71.1 ± 19.2	.07
6 mo after surgery	5.3 ± 7.6	9.0 ± 11.7	.31
P value (preoperative vs. postoperative)	<.0001*	<.0001*	
JOA score			
Preoperative	49.0 ± 12.6	50.1 ± 12.6	.53
6 mo after surgery	91.4 ± 6.5	87.9 ± 7.9	.16
P value (preoperative vs. postoperative)	<.0001*	<.0001*	
ASES score			
Preoperative	34.8 ± 18.6	39.8 ± 20.0	.36
6 mo after surgery	88.6 ± 11.0	89.4 ± 8.7	.92
P value(preoperative vs. postoperative)	<.0001*	<.0001*	

VAS, visual analog scale; *JOA*, Japanese Orthopaedic Association; *ASES*, American Shoulder and Elbow Surgeons.
Data are presented as mean ± standard deviation.
* Statistically significant at $P < .0001$.

experienced more muscle disuse with subsequent atrophy, muscle imbalance, or severe fibrosis.[10,28,32] During the course of the natural history of frozen shoulder, it is thought that inflammation occurs at an early stage of the disease whereas fibrosis occurs at a later stage.[6,32] Reeves[36] reported that the longer the stiffness stage, the longer the recovery stage. Therefore, surgical intervention for frozen shoulder during the early stage of the disease may

Table IV Preoperative and postoperative passive range of motion

	Preoperative	3 mo after surgery	6 mo after surgery	*P* value		
				Preoperative vs. 3 mo	Preoperative vs. 6 mo	3 mo vs. 6 mo
Forward flexion, °						
Group I	92.6 ± 31.4	156.1 ± 13.0	160.7 ± 9.6	<.0001	<.0001	.0003
Group II	89.4 ± 21.5	149.8 ± 16.0	152.7 ± 9.2	<.0001	<.0001	.026
P value (group I vs. group II)	.56	.07	.007*			
Abduction, °						
Group I	60.2 ± 18.6	140.7 ± 23.9	147.8 ± 18.0	<.0001	<.0001	.011
Group II	64.2 ± 18.6	133.5 ± 28.1	142.3 ± 21.6	<.0001	<.0001	<.0001
P value (group I vs. group II)	.33	.31	.44			
External rotation, °						
Group I	12.4 ± 11.3	43.1 ± 15.1	45.2 ± 14.3	<.0001	<.0001	.23
Group II	12.6 ± 12.1	40.0 ± 16.9	43.8 ± 16.4	<.0001	<.0001	.0002
P value (group I vs. group II)	.95	.49	.72			
Internal rotation, mean (range)						
Group I	Buttock (buttock-L5)	L2 (buttock-T7)	L1 (sacrum-T7)	<.0001	<.0001	.012
Group II	Sacrum (buttock-L4)	L2 (buttock-T6)	L2 (sacrum-T5)	<.0001	<.0001	.0011
P value (group I vs. group II)	.47	.52	.44			

Data are presented as mean ± standard deviation unless otherwise indicated.
* Statistically significant at $P < .01$.

Table V Preoperative and postoperative nocturnal pain with sleep disturbance

	Preoperative	3 mo after surgery	6 mo after surgery	*P* value		
				Preoperative vs. 3 mo	Preoperative vs. 6 mo	3 mo vs. 6 mo
Group I	22 of 27 (81.5)	8 of 27 (29.6)	4 of 27 (14.8)	.0002*	<.0001*	.10
Group II	25 of 33 (75.8)	6 of 33 (18.2)	5 of 33 (15.2)	<.0001*	<.0001*	>.999
P value (group I vs. group II)	.76	.36	.97			

Data are presented as prevalence of nocturnal pain with sleep disturbance (percentage).
* Statistically significant at $P < .001$.

Table VI Time needed for postoperative rehabilitation and overall duration of symptoms

	Group I	Group II	*P* value
Time needed for postoperative rehabilitation, mo	6.5 ± 3.5	6.9 ± 3.8	.82
Overall duration of symptoms, mo	10.3 ± 3.3	18.1 ± 8.0	<.0001*

Data are presented as mean ± standard deviation.
* Statistically significant at $P < .0001$.

potentially shorten the duration of the stiffness stage and time for recovery of shoulder function.

Another notable finding was that arthroscopic capsular release could reduce nocturnal pain with sleep disturbance at 3 months after surgery regardless of the timing of surgery. Nocturnal pain associated with sleep disturbance is a common finding in patients with frozen shoulder, particularly during the freezing phase.[23,31] It is likely that sleep interruption secondary to shoulder discomfort has a negative impact on a patient's quality of life and may increase his or her depression and anxiety.[7] Cho et al[7] suggested that shoulder pain for $\geq$3 months places patients at great risk of the development of depression and anxiety. The reason for an increased nocturnal pain level in patients with shoulder disease remains unclear, although nocturnal pain is associated with synovial inflammation at the glenohumeral joint and subacromial space in patients with frozen shoulder.[26,32] Furthermore, several studies have demonstrated that frozen shoulder is associated with elevated levels of proinflammatory and pain-related cytokines at the glenohumeral joint.[6,22,38] In our study, we found moderate to severe glenohumeral synovitis and a high prevalence of sleep disturbance in both groups. Thus, the therapeutic effects of arthroscopic capsular release combined with synovectomy and irrigation may involve reduction in the levels of proinflammatory and pain-related cytokines, resulting in improvement in nocturnal pain. Our results suggest that the surgical intervention is beneficial for patients with frozen shoulder experiencing excruciating nocturnal pain with sleep disturbance even if they are still in the early stage of disease and have severe synovitis.

Arthroscopic capsular release provides precise and controlled release of the capsule and ligaments, reducing the risk of traumatic complications after forceful manipulation.[1,29] In this study, we observed no postoperative iatrogenic instability, axial nerve injury, recurrence, or infection, in accordance with the low rates of complications reported by previous studies.[20,24,27] Therefore, we believe that arthroscopic capsular release is a safe and reliable option to treat refractory cases of frozen shoulder regardless of the timing of surgery.

A major strength of this study was that we compared the overall duration of symptoms as well as short-term clinical outcomes. These comparisons enabled us to identify the clinical implications of shortening the overall disease course of frozen shoulder by early surgical intervention. In addition, we evaluated glenohumeral synovitis at the time of the operation. This evaluation allowed us to show that arthroscopic capsular release is beneficial in the earliest phase of frozen shoulder, that is, the freezing phrase, which is characterized by severe synovitis. Moreover, in this study, all surgical procedures and postoperative protocols were standardized and carried out in the same manner.

There are a few limitations to this study. First, the follow-up period was relatively short. However, previous studies have reported that good to excellent short-term outcomes of arthroscopic capsular release last for 7 years (range, 2-13 years).[20,24] Therefore, we believe the comparison of short-term outcomes in this study is beneficial. Second, there was no control group in this study; thus, we were unable to directly compare the clinical outcomes and overall duration of symptoms of patients who underwent arthroscopic capsular release vs. those who followed the natural course. Finally, all patients in this study were hospitalized for 7-14 days and subsequently underwent a postoperative rehabilitation program assisted by physical therapists until the recovery of the ability to perform activities of daily living. Thus, it remains unclear whether similar results would be obtained in a day-surgery setting and with a shorter period of postoperative outpatient physical therapy or no such therapy. Further studies are warranted to address this issue.

Conclusion

Arthroscopic capsular release provided significant pain relief and improvement in shoulder function in patients with frozen shoulder regardless of the timing of surgery. Early surgical intervention might shorten the overall duration of symptoms in frozen shoulder and is not associated with inferior clinical outcomes when compared with late surgical intervention. Surgeons do not need to delay surgical intervention for patients who have intolerable pain and/or nocturnal pain with sleep disturbance.

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References

1. Amir-Us-Saqlain H, Zubairi A, Taufiq I. Functional outcome of frozen shoulder after manipulation under anaesthesia. J Pak Med Assoc 2007;57:181-5.
2. Barnes CP, Lam PH, Murrell GA. Short-term outcomes after arthroscopic capsular release for adhesive capsulitis. J Shoulder Elbow Surg 2016;25:e256-64. https://doi.org/10.1016/j.jse.2015.12.025

3. Bridgman JF. Periarthritis of the shoulder and diabetes mellitus. Ann Rheum Dis 1972;31:69-71.
4. Buchbinder R, Green S, Youd JM, Johnston RV. Oral steroids for adhesive capsulitis. Cochrane Database Syst Rev 2006:CD006189. https://doi.org/10.1002/14651858.CD006189
5. Bunker TD. Frozen shoulder: unravelling the enigma. Ann R Coll Surg Engl 1997;79:210-3.
6. Bunker TD, Reilly J, Baird KS, Hamblen DL. Expression of growth factors, cytokines and matrix metalloproteinases in frozen shoulder. J Bone Joint Surg Br 2000;82:768-73.
7. Cho CH, Jung SW, Park JY, Song KS, Yu KI. Is shoulder pain for three months or longer correlated with depression, anxiety, and sleep disturbance? J Shoulder Elbow Surg 2013;22:222-8. https://doi.org/10.1016/j.jse.2012.04.001
8. Codman EA. The shoulder: rupture of the supraspinatus tendon and other lesions in and about the subacromial bursa. Malabar, FL: R.E. Krieger; 1934.
9. Davis DE, Maltenfort M, Abboud JA, Getz C, Rothman Institute Shoulder Consortium Group and the Association of Clinical Elbow and Shoulder Surgeons. Classifying glenohumeral synovitis: a novel intraoperative scoring system. J Shoulder Elbow Surg 2017;26:2047-53. https://doi.org/10.1016/j.jse.2017.06.003
10. DePalma AF. The classic. Loss of scapulohumeral motion (frozen shoulder). Ann Surg. 1952;135:193-204. Clin Orthop Relat Res 2008;466:552-60. https://doi.org/10.1007/s11999-007-0101-7
11. Diercks RL, Stevens M. Gentle thawing of the frozen shoulder: a prospective study of supervised neglect versus intensive physical therapy in seventy-seven patients with frozen shoulder syndrome followed up for two years. J Shoulder Elbow Surg 2004;13:499-502. https://doi.org/10.1016/j.jse.2004.03.002
12. Elhassan B, Ozbaydar M, Massimini D, Higgins L, Warner JJ. Arthroscopic capsular release for refractory shoulder stiffness: a critical analysis of effectiveness in specific etiologies. J Shoulder Elbow Surg 2010;19:580-7. https://doi.org/10.1016/j.jse.2009.08.004
13. Farrell CM, Sperling JW, Cofield RH. Manipulation for frozen shoulder: long-term results. J Shoulder Elbow Surg 2005;14:480-4. https://doi.org/10.1016/j.jse.2005.02.012
14. Fernandes MR. Arthroscopic capsular release for refractory shoulder stiffness. Rev Assoc Med Bras (1992) 2013;59:347-53. https://doi.org/10.1016/j.ramb.2013.02.004
15. Grant JA, Schroeder N, Miller BS, Carpenter JE. Comparison of manipulation and arthroscopic capsular release for adhesive capsulitis: a systematic review. J Shoulder Elbow Surg 2013;22:1135-45. https://doi.org/10.1016/j.jse.2013.01.010
16. Griesser MJ, Harris JD, Campbell JE, Jones GL. Adhesive capsulitis of the shoulder: a systematic review of the effectiveness of intra-articular corticosteroid injections. J Bone Joint Surg Am 2011;93:1727-33. https://doi.org/10.2106/JBJS.J.01275
17. Griggs SM, Ahn A, Green A. Idiopathic adhesive capsulitis. A prospective functional outcome study of nonoperative treatment. J Bone Joint Surg Am 2000;82:1398-407.
18. Hand C, Clipsham K, Rees JL, Carr AJ. Long-term outcome of frozen shoulder. J Shoulder Elbow Surg 2008;17:231-6. https://doi.org/10.1016/j.jse.2007.05.009
19. Hannafin JA, Chiaia TA. Adhesive capsulitis. A treatment approach. Clin Orthop Relat Res 2000:95-109.
20. Ide J, Takagi K. Early and long-term results of arthroscopic treatment for shoulder stiffness. J Shoulder Elbow Surg 2004;13:174-9. https://doi.org/10.1016/j.jse.2003.11.001
21. Itoi E, Arce G, Bain GI, Diercks RL, Guttmann D, Imhoff AB, et al. Shoulder stiffness: current concepts and concerns. Arthroscopy 2016;32:1402-14. https://doi.org/10.1016/j.arthro.2016.03.024
22. Kabbabe B, Ramkumar S, Richardson M. Cytogenetic analysis of the pathology of frozen shoulder. Int J Shoulder Surg 2010;4:75-8. https://doi.org/10.4103/0973-6042.76966
23. Kelley MJ, Shaffer MA, Kuhn JE, Michener LA, Seitz AL, Uhl TL, et al. Shoulder pain and mobility deficits: adhesive capsulitis. J Orthop Sports Phys Ther 2013;43:A1-31. https://doi.org/10.2519/jospt.2013.0302
24. Le Lievre HM, Murrell GA. Long-term outcomes after arthroscopic capsular release for idiopathic adhesive capsulitis. J Bone Joint Surg Am 2012;94:1208-16. https://doi.org/10.2106/JBJS.J.00952
25. Levine WN, Kashyap CP, Bak SF, Ahmad CS, Blaine TA, Bigliani LU. Nonoperative management of idiopathic adhesive capsulitis. J Shoulder Elbow Surg 2007;16:569-73. https://doi.org/10.1016/j.jse.2006.12.007
26. Lho YM, Ha E, Cho CH, Song KS, Min BW, Bae KC, et al. Inflammatory cytokines are overexpressed in the subacromial bursa of frozen shoulder. J Shoulder Elbow Surg 2013;22:666-72. https://doi.org/10.1016/j.jse.2012.06.014
27. Liem D, Meier F, Thorwesten L, Marquardt B, Steinbeck J, Poetzl W. The influence of arthroscopic subscapularis tendon and capsule release on internal rotation strength in treatment of frozen shoulder. Am J Sports Med 2008;36:921-6. https://doi.org/10.1177/0363546507313090
28. Lin JJ, Wu YT, Wang SF, Chen SY. Trapezius muscle imbalance in individuals suffering from frozen shoulder syndrome. Clin Rheumatol 2005;24:569-75. https://doi.org/10.1007/s10067-005-1105-x
29. Loew M, Heichel TO, Lehner B. Intraarticular lesions in primary frozen shoulder after manipulation under general anesthesia. J Shoulder Elbow Surg 2005;14:16-21. https://doi.org/10.1016/j.jse.2004.04.004
30. Milgrom C, Novack V, Weil Y, Jaber S, Radeva-Petrova DR, Finestone A. Risk factors for idiopathic frozen shoulder. Isr Med Assoc J 2008;10:361-4.
31. Mulligan EP, Brunette M, Shirley Z, Khazzam M. Sleep quality and nocturnal pain in patients with shoulder disorders. J Shoulder Elbow Surg 2015;24:1452-7. https://doi.org/10.1016/j.jse.2015.02.013
32. Neviaser AS, Hannafin JA. Adhesive capsulitis: a review of current treatment. Am J Sports Med 2010;38:2346-56. https://doi.org/10.1177/0363546509348048
33. Neviaser AS, Neviaser RJ. Adhesive capsulitis of the shoulder. J Am Acad Orthop Surg 2011;19:536-42. https://doi.org/10.5435/00124635-201109000-00004
34. Neviaser RJ, Neviaser TJ. The frozen shoulder. Diagnosis and management. Clin Orthop Relat Res 1987:59-64.
35. Omari A, Bunker TD. Open surgical release for frozen shoulder: surgical findings and results of the release. J Shoulder Elbow Surg 2001;10:353-7.
36. Reeves B. The natural history of the frozen shoulder syndrome. Scand J Rheumatol 1975;4:193-6.
37. Rizvi SM, Harisha AJ, Lam PH, Murrell GAC. Factors affecting the outcomes of arthroscopic capsular release for idiopathic adhesive capsulitis. Orthop J Sports Med 2019;7:2325967119867621. https://doi.org/10.1177/2325967119867621
38. Rodeo SA, Hannafin JA, Tom J, Warren RF, Wickiewicz TL. Immunolocalization of cytokines and their receptors in adhesive capsulitis of the shoulder. J Orthop Res 1997;15:427-36.
39. White D, Choi H, Peloquin C, Zhu Y, Zhang Y. Secular trend of adhesive capsulitis. Arthritis Care Res (Hoboken) 2011;63:1571-5. https://doi.org/10.1002/acr.20590