JSES International 4 (2020) 826–832

Contents lists available at ScienceDirect

JSES International

journal homepage: www.jsesinternational.org

Clinical outcomes of arthroscopic pan-capsular release with or without entire coracohumeral ligament release for patients with frozen shoulder

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ARTICLE INFO

Keywords:
Frozen shoulder
arthroscopic capsular release
range of motion
coracohumeral ligament
joint capsule
clinical outcome

Level of evidence: Level III; Retrospective Cohort Comparison; Treatment Study

Background: We aimed to retrospectively determine the effects of arthroscopic pan-capsular release with or without entire coracohumeral ligament (CHL) release and diabetes mellitus (DM) in patients with frozen shoulder (FS).

Methods: The study included 34 patients (20 male and 14 female patients) who underwent arthroscopic pan-capsular release without entire CHL release (group 1) and 26 patients (6 male and 20 female patients) who underwent entire CHL release for FS (group 2). Patients with a minimum of 12 months of follow-up were included, and range of motion (ROM) and the shoulder rating scale of the University of California at Los Angeles (UCLA) scoring system were evaluated.

Results: In group 2, external rotation and hand-behind-the-back (HBB) ROMs were significantly increased compared with group 1 at the final follow-up (external rotation, $53.1° \pm 15.2°$ vs. $41.3° \pm 20.5°$ [$P = .044$]; HBB level, T6 [interquartile range, T5-T9] vs. T11 [interquartile range, T8-L4] [$P < .001$]). Total UCLA scores and UCLA scores for pain (9.2 ± 1.5 vs. 10.0, $P = .003$), function (8.5 ± 1.4 vs. 10.0, $P < .001$), and active forward flexion (4.6 ± 0.6 vs. 4.9 ± 0.2, $P < .011$) were significantly greater in group 2 at the final follow-up. Patients without DM tended to have greater recovery of forward flexion and HBB ROMs and better total, pain, and function UCLA scores compared with those with DM. In group 2, there were no significant differences in ROMs and UCLA scores between the patients with DM and those without DM.

Conclusion: Arthroscopic entire CHL release is an essential treatment option for FS patients to regain ROMs and function and to reduce pain.

Frozen shoulder (FS) is characterized by painful restriction of both active and passive ranges of motion (ROMs).[25] The prevalence rate of FS is 2%-5%, and FS occurs more commonly in women.[28] Although the natural history of FS is considered self-limited,[10] some patients show little or no improvement, with residual limited ROM and continuing symptoms, even after a few years of conservative treatment.[17,31] For such situations, arthroscopic capsular release, which mainly targets the thickened joint capsule, is a reliable treatment option with many advantages over open surgery.[8,16]

One of the main purposes of treatment of FS is to reduce pain and recover shoulder ROMs. Evaluating shoulder ROM has been accepted as a means of summarizing the ROM of the glenohumeral and other joints including the humerus, scapula, clavicle, and thorax. Furthermore, the muscles around the shoulder girdle also connect the bones and may impact their motions and the posture.[4]

This study was approved by the Institutional Review Boards of Funabashi Orthopaedic Clinic (approval no. 2014005) and Tohoku University School of Medicine (approval no. 2015-1-483). All procedures were performed in accordance with the ethical standards of the institutional and/or national research committee and with the Declaration of Helsinki. All patients provided written informed consent to participate in the study and undergo study procedures.

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https://doi.org/10.1016/j.jseint.2020.08.019

However, considering that arthroscopic capsular release focuses on the joint capsule, to evaluate the true glenohumeral motion, the scapula must be fixed by an examiner with one hand such that the scapula is immobile and motions should be measured to exclude scapulothoracic motion.[12,14] Although there are a few reports regarding the true glenohumeral ROM of FS patients under general anesthesia,[15] no studies have examined the evaluation of ROMs at an outpatient clinic in a conscious patient.

A thickened coracohumeral ligament (CHL), which forms the anterosuperior part of the joint capsule at the rotator interval (RI), is the most specific manifestation[18] and the primary restraint against external rotation (ER) in FS.[19,24,27] However, during the true glenohumeral ROM evaluation, the CHL restricts the ROM in various directions other than ER.[15] Furthermore, for recurrent anterior shoulder instability, the obliteration of the subcoracoid fat triangle and the thickness of the CHL are positively correlated with ROM restriction (forward flexion [FF],[6] ER with the arm at the side [ER1], and hand-behind-the-back [HBB] level, which are measured by asking the patient to place the thumb on the highest spinal vertebra he or she can possibly reach[20]). The thickened CHL is a manifestation of FS and of other shoulder disorders. In addition, there are no data regarding the mid- to long-term clinical results of entire CHL release for FS.

Patients with diabetes mellitus (DM) have a higher prevalence of FS and a diminished response to treatment, including surgical intervention, compared with the general population.[11] A higher hemoglobin A_{1c} level is associated with the development of FS in patients with DM.[7] Furthermore, patients with DM who received steroid injections before surgery had reduced ROM in FF and reported experiencing pain according to their University of California at Los Angeles (UCLA) scores after arthroscopic pan-capsular release without entire CHL release.[16] Patients with FS and DM may have reduced clinical results after adequate treatment options, but there are no clinical results on the effects of arthroscopic pan-capsular release with entire CHL release.

The HBB movement is a combination of adduction and extension of the glenohumeral joint. HBB ROM limitation is refractory despite restoration of the other ROMs and causes distress to patients with FS and to physicians if the ROM limitation occurs over a long period. Tightness of the posterior band of the inferior glenohumeral ligament,[29] as well as poor shoulder motor control,[23] can induce HBB ROM limitation. Compared with before surgery, FS patients could gain significant improvement in HBB ROM after arthroscopic pan-capsular release without entire CHL release,[16] but a recovery to the lower thoracic spine level was not sufficient for daily life activities, such as putting on or taking off clothing and scratching one's back. Although the pathologies in the shoulder joint that lead to an HBB limitation are not fully understood, the CHL could be a candidate.[20]

To recover normal daily activities, regaining ROMs, including HBB ROM, that are similar to ROMs on the unaffected side is quite important for patients with FS. However, there are no published data regarding the mid- to long-term effects of arthroscopic pan-capsular release with entire release of the CHL for patients with FS. The purpose of this study was to retrospectively determine the effects of arthroscopic pan-capsular release with or without entire CHL release and DM on ROMs in patients with FS.

Materials and methods

Inclusion and exclusion criteria

This retrospective study included 34 patients with FS who underwent arthroscopic pan-capsular release without entire CHL release between May 2000 and December 2010 (group 1)[16] and 26 patients with FS who underwent arthroscopic pan-capsular release with entire CHL release between April 2016 and April 2018 (group 2). FS was diagnosed based on (1) a history of shoulder pain and difficulty performing activities of daily living due to loss of ROM for >1 month after an initial visit to 1 of 2 outpatient clinics according to the type of surgery; (2) limited passive shoulder motion of $\leq 100^\circ$ of FF, $\leq 20^\circ$ of ER1, and HBB ROM to the fifth lumbar vertebra or lower; and (3) a normal radiologic appearance of the shoulder.[3,15,31] Patients were excluded based on radiographic evidence of abnormalities indicating glenohumeral osteoarthritis, calcific tendinitis, a superiorly migrated humeral head, osteonecrosis of the humeral head, or a rotator cuff tear visualized on magnetic resonance imaging. Patients with a history of fractures around the shoulder, shoulder dislocation, thyroid disorders, or post-traumatic FS were also excluded.

Preoperative treatment

A mixture of 4 mg of dexamethasone and 10 mL of 1% lidocaine was injected using ultrasonography until the symptoms were relieved (in total, ≤ 2 times, once per week). Stretching of the muscles around the shoulder girdle, thorax, spine, trunk, and hip joints was performed every week until symptoms were relieved.[12] If a patient's symptoms continued after ≥ 1 month of physiotherapy performed in our clinics, arthroscopic pan-capsular release was recommended.[12,15]

ROM measurements

Conventional ROM measurements including glenohumeral and scapulothoracic motion were applied in patients in the outpatient clinic. However, to evaluate the true glenohumeral ROM and exclude scapulothoracic motion, the scapula was first fixed by an examiner with one hand (without palpating the scapular motion) and the following motions were measured with a goniometer with the patient in a standing position: passive ROM of FF1, lateral elevation (LE) with scapular fixation, ER1, ER at 90° of abduction, internal rotation (IR) at 90° of abduction, horizontal flexion (HF) with scapular fixation, ER at 90° of FF, and IR at 90° of FF,[14,15] which was applied in group 2. In patients who had difficulty achieving 90° of FF and LE, ROM was evaluated at the maximum degrees of FF and LE. After the true glenohumeral ROM was evaluated, conventional combined ROMs including scapulothoracic motion were also measured in FF and LE in the same manner as those in group 1. Conventional ROMs in FF, LE, and HF were defined as forward flexion without scapular fixation (FF2), LE without scapular fixation, and HF without scapular fixation, respectively. Because FF2, ER1, and HBB level were recorded in group 1, these ROMs were compared with those in group 2. Reliability and validation of the goniometer methods could not be evaluated because of time limitations.

Surgical procedure

The joint capsule was released in a sequential order as follows: (1) RI, (2) CHL, (3) superior capsule, (4) middle glenohumeral ligament, (5) anterior inferior glenohumeral ligament, and (6) posterior inferior glenohumeral ligament.[12,14,15] The RI and middle glenohumeral ligament were dissected with forceps (Oval Punches Straight; Smith & Nephew, Andover, MA, USA) or a shaver (Dyonics Powermax Elite Handpiece and Dyonics Incisor Plus Platinum; Smith & Nephew) until a clear view of the CHL, conjoint tendon, and subscapularis tendon or muscle could be obtained, along with

Table I
Demographic data of patients

Participants	Total (N = 60)		CHL release				P value
			Partial (n = 34)		Entire (n = 26)		
	Mean (SD)	n (%)	Mean (SD)	n (%)	Mean (SD)	n (%)	
Age, yr	57.4 (7.4)		56.3 (7.6)		58.8 (7.0)		.33
Sex							
Male		25 (41.7)		19 (55.9)		6 (23.1)	.011
Female		35 (58.3)		15 (44.1)		20 (76.9)	
Follow-up, mo	16.7 (7.1)		19.9 (8.0)		12.6 (1.6)		<.001
Affected side							
Right		20 (33.3)		15 (44.1)		5 (19.2)	.043
Left		40 (66.7)		19 (55.9)		21 (80.8)	
DM							
Present		18 (30.0)		13 (38.2)		5 (19.2)	.11
Absent		42 (70.0)		21 (61.8)		21 (80.8)	

CHL, coracohumeral ligament; *SD*, standard deviation; *DM*, diabetes mellitus.

release of the superior glenohumeral ligament and a part of the CHL. In group 2, the remaining CHL under the coracoid process to the subscapularis tendon or muscle and the base of the coracoid process to the supraspinatus tendon, as well as adhesions between the subscapularis and conjoint tendon or glenoid neck, were also dissected with forceps and a shaver. The superomedial capsule, just above the long head of the biceps, was dissected with a radiofrequency device (VAPR Angled Side Effect; DePuy Mitek, Raynham, MA, USA) to the base of the coracoid process until a clear view of the posterior margin of the coracoacromial ligament was obtained. Furthermore, the CHL that was connected to the supraspinatus tendon, along with the posterior margin of the coracoacromial ligament, was resected with forceps and a shaver, which allowed visualization of the acromioclavicular joint, indicating completion of the entire CHL release. A single surgeon (H.S.) performed all surgical procedures and ROM measurements in group 1; likewise, a single surgeon (Y.H.) performed all surgical procedures and ROM measurements in group 2. Subacromial decompression was not performed in either group. There were no complications during or after surgery, and rotator cuff abnormalities did not occur in any patients.

Statistical analyses

Continuous variables were presented as means and standard deviations or medians and interquartile ranges (IQRs). Categorical variables were reported as numbers and percentages. Because most values were not normally distributed, nonparametric procedures were performed for analysis. The Mann-Whitney *U* test and χ^2 test were used to compare the groups. Because the presence of DM affected the clinical results of FS patients,[16] the ROMs and UCLA scores were compared between the participants with and without DM in the same manner. The Wilcoxon signed rank test was used to compare the scores and ROMs before surgery and at the final follow-up. All statistical analyses were performed using SPSS software (version 24.0; SPSS Japan, Tokyo, Japan). All tests were 2-tailed, and $P < .05$ was considered statistically significant.

Table II
Changes in ranges of motion after arthroscopic pan-capsular release with or without entire coracohumeral ligament release

ROM	CHL release		P value*
	Partial (n = 34)	Entire (n = 26)	
FF2, °			
Before surgery	90.3 (9.0)	88.1 (19.7)	.98
Final follow-up	156.3 (18.8)	164.0 (13.1)	.161
Change	66.0 (22.7)	76.0 (23.3)	.172
ER1, °			
Before surgery	−2.7 (7.6)	−5.6 (19.5)	.72
Final follow-up	41.3 (20.5)	53.1 (15.2)	.044
Change	44.0 (20.0)	58.7 (17.0)	.005
HBB level†			
Before surgery	B (L5-B)	B (L5-B)	.94
Final follow-up	T11 (T8-L4)	T6 (T5-T9)	<.001
Change‡	7.0 (3.0-10.0)	11.5 (9.0-13.0)	<.001

CHL, coracohumeral ligament; *FF2*, forward flexion without scapular fixation; *ER1*, external rotation with arm at side; *HBB*, hand behind back; *B*, buttock; *L*, lumbar spine; *T*, thoracic spine; *ROM*, ranges of motion.
Data are presented as mean (standard deviation) unless otherwise indicated.
* *P* value adjusting for sex, age, and diabetes mellitus.
† Median (interquartile range).
‡ Number of vertebrae.

Table III
Changes in scores of shoulder rating scale of UCLA scoring system after arthroscopic pan-capsular release with or without entire coracohumeral ligament release

UCLA score	CHL release		P value*
	Partial (n = 34)	Entire (n = 26)	
Total			
Before surgery	13.8 (3.4)	13.1 (3.5)	.484
Final follow-up	32.4 (3.1)	34.9 (0.2)	<.001
Change	18.5 (4.0)	21.9 (3.5)	.001
Pain			
Before surgery	3.6 (2.5)	2.7 (1.8)	.168
Final follow-up	9.2 (1.5)	10.0 (0.0)	.003
Change	5.6 (2.4)	7.3 (1.8)	.002
Function			
Before surgery	2.9 (1.3)	2.9 (1.5)	.663
Final follow-up	8.5 (1.4)	10.0 (0.0)	<.001
Change	5.6 (1.9)	7.1 (1.5)	.002
Active FF			
Before surgery	2.4 (0.6)	2.7 (0.8)	.036
Final follow-up	4.6 (0.6)	4.9 (0.2)	.011
Change	2.3 (0.9)	2.3 (0.8)	.625
Strength			
Before surgery	4.9 (0.3)	4.8 (1.0)	.479
Final follow-up	5.0 (0.0)	5.0 (0.0)	>.999
Change	0.1 (0.3)	0.2 (1.0)	.479
Satisfaction			
Before surgery	0.0 (0.0)	0.0 (0.0)	>.999
Final follow-up	5.0 (0.0)	5.0 (0.0)	>.999
Change	5.0 (0.0)	5.0 (0.0)	>.999

UCLA, University of California at Los Angeles; *CHL*, coracohumeral ligament; *FF*, forward flexion.
Data are presented as mean (standard deviation).
* *P* value adjusting for sex, age, and diabetes mellitus.

Table IV
Demographic data of patients with or without DM

Participants	DM				*P* value
	Present (n = 18)		Absent (n = 42)		
	Mean (SD)	n (%)	Mean (SD)	n (%)	
Age, yr	57.3 (7.4)		57.6 (4.3)		.663
Sex					
Male		12 (66.7)		13 (31.0)	.01
Female		6 (33.3)		29 (69.0)	
Follow-up, mo	16.1 (6.3)		18.3 (8.6)		.249
Affected side					
Right		8 (44.4)		12 (28.6)	.232
Left		10 (55.6)		30 (71.4)	

DM, diabetes mellitus; *SD*, standard deviation.

Results

The demographic data of the 2 groups are listed in Table I. No significant differences in age or the presence of DM were found between the 2 groups. However, the ratios of female patients and left-side dominance were significantly increased whereas the follow-up period was significantly decreased in group 2 (Table I). All of the ROMs after surgery were significantly greater than those before surgery in group 2 (Supplementary Table S1). There were no significant differences in the ROM values and amount of change for FF2; however, the values for ER1 (41.3° ± 20.5° vs. 53.1° ± 15.2°, P = .044) and HBB level (T11 [IQR, T8-L4] vs. T6 [IQR, T5-T9], P < .001) were significantly greater in group 2 at the final follow-up (Table II). We found no significant differences in strength and satisfaction according to the UCLA scores before surgery and at final follow-up, as well as the amount of change. Moreover, no significant differences in the preoperative total, pain, and function UCLA scores were observed between the 2 groups. However, the total (32.4 ± 3.1 vs. 34.9 ± 0.2, P < .001), pain (9.2 ± 1.5 vs. 10.0, P = .003), and function (8.5 ± 1.4 vs. 10.0, P < .001) UCLA scores at the final follow-up, as well as the amount of change in these scores, were significantly greater in group 2. UCLA scores for active FF preoperatively and active FF at the final follow-up (4.6 ± 0.6 vs. 4.9 ± 0.2, P < .001) were significantly greater in group 2. There were no significant differences in the amount of change in the UCLA scores for strength between the 2 groups (Table III).

Table V
Changes in ranges of motion after arthroscopic pan-capsular release in patients with or without DM

ROM	DM		*P* value*
	Present (n = 18)	Absent (n = 42)	
FF2, °			
Before surgery	93.1 (9.1)	87.7 (16.2)	.075
Final follow-up	152.8 (23.1)	162.6 (10.9)	.14
Change	59.7 (28.4)	74.9 (19.4)	.036
ER1, °			
Before surgery	−2.2 (10.6)	−4.7 (15.2)	.671
Final follow-up	42.2 (25.9)	48.2 (15.5)	.233
Change	44.4 (25.9)	53.0 (16.6)	.257
HBB level			
Before surgery	B (L5-B)	B (L5-B)	.899
Final follow-up	L1 (T8-L4)	T8 (T6-T11)	.008
Change†	6.0 (3.0-11.0)	9.5 (7.0-12.0)	.009

DM, diabetes mellitus; *FF2*, forward flexion without scapular fixation; *ER1*, external rotation with arm at side; *HBB*, hand behind back; *B*, buttock; *L*, lumbar spine; *T*, thoracic spine; *ROM*, ranges of motion.
Data are presented as mean (standard deviation) or median (interquartile range).
* *P* value adjusting for sex, age, and coracohumeral ligament release.
† Number of vertebrae.

Table VI
Changes in scores of shoulder rating scale of UCLA scoring system after arthroscopic pan-capsular release in patients with or without DM

UCLA score	DM		*P* value
	Present (n = 18)	Absent (n = 42)	
Total			
Before surgery	12.7 (2.2)	13.9 (3.8)	.241
Final follow-up	32.2 (3.7)	34.0 (1.9)	.026
Change	19.5 (4.5)	20.2 (4.0)	.846
Pain			
Before surgery	2.3 (1.2)	3.6 (2.5)	.092
Final follow-up	9.0 (1.7)	9.8 (0.8)	.023
Change	6.7 (2.0)	6.1 (2.4)	.455
Function			
Before surgery	2.8 (1.5)	3.0 (1.4)	.684
Final follow-up	8.6 (1.5)	9.4 (1.1)	.015
Change	5.7 (2.1)	6.4 (1.8)	.172
Active FF			
Before surgery	2.6 (0.6)	2.5 (0.7)	.443
Final follow-up	4.6 (0.7)	4.9 (0.4)	.171
Change	2.0 (1.0)	2.4 (0.8)	.204
Strength			
Before surgery	4.9 (0.2)	4.8 (0.8)	.808
Final follow-up	5.0 (0.0)	5.0 (0.0)	>.999
Change	0.1 (0.2)	0.2 (0.8)	.808
Satisfaction			
Before surgery	0.0 (0.0)	0.0 (0.0)	>.999
Final follow-up	5.0 (0.0)	5.0 (0.0)	>.999
Change	5.0 (0.0)	5.0 (0.0)	>.999

UCLA, University of California at Los Angeles; *DM*, diabetes mellitus; *FF*, forward flexion.
Data are presented as mean (standard deviation).

The demographic data of the patients with or without DM regardless of entire CHL release are shown in Table IV. The ratio of men was greater in patients with DM. There were no significant differences in the preoperative and final follow-up values of ER1. Although no significant differences in the preoperative and final follow-up values of FF2 were observed, the amount of change in FF2 (59.7° ± 28.4° vs. 74.9° ± 19.4°, P = .036) was greater in patients without DM. We found no significant differences in the preoperative HBB values, but the HBB values at the final follow-up (L1 [T8-L4] vs. T8 [T6-T11], P = .008) and the amount of change (6.0 [3.0-11.0] vs. 9.5 [7.0-12.0], P = .009) were significantly greater in patients without DM (Table V). There were no significant differences in the preoperative or final follow-up UCLA scores for active FF, strength, and satisfaction or in the amount of change in these scores between the 2 groups. Although the total, pain, and function UCLA scores before surgery and the amount of change in these scores were not significantly different between the 2 groups, these scores were significantly greater at the final follow-up in patients without DM (total, 32.2 ± 3.7 vs. 34.0 ± 1.9 [P = .026]; pain, 9.0 ± 1.7 vs. 9.8 ± 0.8 [P = .023]; and function, 8.6 ± 1.5 vs. 9.4 ± 1.1 [P = .015]) (Table VI). In group 2, there were no significant differences in the demographic data, ROMs, and UCLA scores between the patients with DM and those without DM (Supplementary Table S2, Tables VII and VIII).

Discussion

The most important findings of this study were that arthroscopic pan-capsular release with entire CHL release had greater effects on ER1 and HBB ROMs and the total, pain, and function UCLA scores than in patients without entire CHL release. Patients with FS and DM had a reduced recovery of FF2 and HBB ROMs after surgery; however, there were no significant differences in ROMs and UCLA scores for FS patients treated with entire CHL release regardless of DM.

Table VII
Changes in ranges of motion after arthroscopic pan-capsular release with entire coracohumeral ligament release in patients with or without DM

ROM	Total (n = 26)	DM		*P* value
		Present (n = 5)	Absent (n = 21)	
FF1, °				
Before surgery	70.2 (17.0)	72.0 (2.7)	69.8 (18.9)	.34
Final follow-up	145.0 (15.7)	145.0 (15.0)	145.0 (16.2)	.9
Change	74.8 (23.6)	73.0 (13.5)	75.2 (25.7)	.95
FF2, °				
Before surgery	88.1 (19.7)	92.0 (7.6)	87.1 (21.7)	.34
Final follow-up	164.0 (10.2)	164.0 (12.5)	164.1 (10.0)	.66
Change	76.0 (23.3)	72.0 (18.2)	76.9 (24.7)	.45
LE1, °				
Before surgery	56.2 (16.3)	60.0 (16.2)	55.2 (16.5)	.8
Final follow-up	154.4 (13.1)	155.0 (9.4)	154.3 (14.0)	.66
Change	98.3 (19.2)	95.0 (17.0)	99.0 (20.0)	.66
LE2, °				
Before surgery	74.6 (22.1)	79.0 (14.3)	73.6 (23.8)	.31
Final follow-up	171.0 (7.9)	171.0 (5.5)	171.0 (8.5)	.9
Change	96.3 (25.2)	92.0 (16.0)	97.4 (27.2)	.53
ER1, °				
Before surgery	−5.7 (19.5)	−2.0 (17.2)	−6.5 (20.3)	.61
Final follow-up	53.1 (15.2)	63.0 (20.5)	50.7 (13.3)	.11
Change	58.7 (17.0)	65.0 (16.2)	57.2 (17.2)	.31
ER2, °				
Before surgery	50.6 (10.9)	52.0 (9.1)	50.2 (11.5)	.75
Final follow-up	92.5 (6.0)	94.0 (4.2)	92.1 (6.4)	.61
Change	41.9 (11.4)	42.0 (10.4)	41.9 (11.9)	.9
IR2, °				
Before surgery	−35.1 (19.0)	−41.0 (6.5)	−33.7 (20.8)	.71
Final follow-up	8.9 (10.3)	10.0 (10.0)	8.6 (10.6)	.71
Change	44.0 (24.0)	51.0 (12.9)	42.3 (25.9)	.66
HBB level*				
Before surgery	B (L5-B)	B (L5-B)	B (L5-B)	.95
Final follow-up	T6 (T5-T9)	T6 (T6-L1)	T6 (T5-T8)	.28
Change†	8 (6.0-8.0)	11 (6.5-12.0)	12 (9-14)	.22
HF1, °				
Before surgery	−14.6 (26.2)	−7.0 (24.9)	−16.4 (26.8)	.34
Final follow-up	48.9 (5.2)	46.0 (4.2)	49.5 (5.2)	.16
Change	63.5 (28.7)	53.0 (25.4)	65.9 (29.4)	.34
HF2, °				
Before surgery	5.1 (20.4)	10.0 (12.2)	3.9 (21.9)	.53
Final follow-up	59.2 (6.7)	56.0 (5.5)	60.0 (6.9)	.28
Change	54.2 (21.8)	46.0 (13.4)	56.1 (23.2)	.25
ER3, °				
Before surgery	54.8 (27.0)	62.0 (12.0)	53.1 (29.4)	.45
Final follow-up	91.2 (4.5)	94.0 (5.5)	90.5 (4.2)	.34
Change	36.3 (27.3)	32.0 (13.0)	37.4 (29.9)	.75
IR3, °				
Before surgery	−45.8 (8.4)	−48.0 (6.7)	−45.2 (8.9)	.61
Final follow-up	1.2 (3.3)	0.0 (0.0)	1.4 (3.6)	.66
Change	46.9 (9.0)	48.0 (6.7)	46.7 (9.5)	.9

DM, diabetes mellitus; *FF1*, forward flexion with scapular fixation; *FF2*, forward flexion without scapular fixation; *LE1*, lateral elevation with scapular fixation; *LE2*, lateral elevation without scapular fixation; *ER1*, external rotation with arm at side; *ER2*, external rotation at 90° of lateral elevation; *IR2*, internal rotation at 90° of lateral elevation; *HBB*, hand behind back; *B*, buttock; *L*, lumbar spine; *T*, thoracic spine; *HF1*, horizontal flexion with scapular fixation; *HF2*, horizontal flexion without scapular fixation, *ER3*, external rotation at 90° of forward flexion; *IR3*, internal rotation at 90° of forward flexion; *ROM*, ranges of motion.
Data are presented as mean (standard deviation) unless otherwise indicated.
* Median (interquartile range).
† Number of vertebrae.

A thickened CHL has been reported as one of the most specific manifestations[18] and the primary restraint against ER in FS patients.[19,24,27] However, the CHL restricted the ROMs of LE with scapular fixation, ER1, ER at 90° of FF, and IR at 90° of FF, and entire release of the CHL resulted in a recovery of the ROMs to the same levels as the unaffected sides.[15] Entire CHL release can promote movement of the supraspinatus and infraspinatus tendons smoothly around the base of the coracoid process, as well as the glenoid neck. Furthermore, a release of the CHL under the coracoid process can promote smooth movement of the subscapularis tendon.[12] Considering that the CHL originates from the base and the horizontal limb of the coracoid process and encloses the subscapularis, supraspinatus, and infraspinatus tendons,[9] after the release, it is reasonable to regain ROMs in various directions. In this study, entire CHL release improved ER1 significantly compared with that in patients without entire release at the final follow-up.

For patients with FS, it is difficult to regain HBB ROM to levels similar to those on the unaffected side with conventional treatment options.[2,16,21] Establishing a treatment strategy for HBB restriction is mandatory not only for patients with FS but also for patients with other shoulder disorders. Although the pathology is different from recurrent anterior instability, this study demonstrated a significant recovery of HBB ROM with entire CHL release in patients with FS regardless of DM vs. that in patients without entire CHL release. Furthermore, the HBB level recovered with entire CHL release reached the middle thoracic spine, which allows for the

Table VIII
Changes in scores of shoulder rating scale of UCLA scoring system after arthroscopic pan-capsular release with or without entire coracohumeral ligament release

UCLA score	Total (n = 26)	DM		*P* value
		Present (n = 5)	Absent (n = 21)	
Total				
Before surgery	13.1 (3.5)	11.8 (0.8)	13.4 (3.8)	.31
Final follow-up	34.9 (0.2)	35.0 (0.0)	34.9 (0.2)	.9
Change	21.9 (3.5)	23.2 (0.8)	21.6 (3.8)	.31
Pain				
Before surgery	2.7 (1.8)	1.8 (0.4)	2.9 (1.9)	.37
Final follow-up	10.0 (0.0)	10.0 (0.0)	10.0 (0.0)	>.99
Change	7.3 (1.8)	8.2 (0.4)	7.1 (1.9)	.37
Function				
Before surgery	2.9 (1.5)	2.2 (1.1)	3.0 (1.6)	.34
Final follow-up	10.0 (0.0)	10.0 (0.0)	10.0 (0.0)	>.99
Change	7.1 (1.5)	7.8 (1.1)	7.0 (1.6)	.34
Active FF				
Before surgery	2.7 (0.8)	2.8 (0.4)	2.7 (0.9)	.71
Final follow-up	4.9 (0.2)	5.0 (0.0)	4.9 (0.2)	.9
Change	2.3 (0.8)	2.2 (0.4)	2.3 (0.9)	.8
Strength				
Before surgery	4.8 (1.0)	5.0 (0.0)	4.8 (1.1)	.9
Final follow-up	5.0 (0.0)	5.0 (0.0)	5.0 (0.0)	>.99
Change	0.2 (1.0)			.9
Satisfaction				
Before surgery	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	>.99
Final follow-up	5.0 (0.0)	5.0 (0.0)	5.0 (0.0)	>.99
Change	5.0 (0.0)	5.0 (0.0)	5.0 (0.0)	>.99

UCLA, University of California at Los Angeles; *DM*, diabetes mellitus; *FF*, forward flexion.
Data are presented as mean (standard deviation).

performance of daily activities such as putting on or taking off clothing and scratching one's back. The sliding mechanism of the supraspinatus, infraspinatus, and subscapularis tendons is quite important to alter the rotational center between the glenoid cavity and the humeral head. Further biomechanical studies are needed to clarify this motion effect. Arthroscopic pan-capsular release with entire CHL release is a necessary surgical procedure for patients with FS to recover HBB ROM similar to the unaffected side.

Pain is one of the other manifestations of FS in patients. Inflammation in the joint capsule could be one of the main sources of pain in FS patients.[1,13,18,34] The RI is the area most affected by angiogenesis as revealed by arthroscopic findings,[33] which has been confirmed by histologic studies[13,35] and dynamic magnetic resonance imaging.[30] Furthermore, transcatheter arterial embolization for abnormal neovessels at the RI can relieve pain and restore function.[26] Arthroscopic findings have revealed abundant angiogenesis, especially in the RI area, and excision of the tissues results in rapid pain relief.[5] During arthroscopic entire CHL release, abnormal vessels and excessive bleeding were prominent around the base of the coracoid process in group 2, which could have contributed to pain relief after surgery in this study. Further studies are needed to clarify the relationship between abnormal vessels and pain in patients with FS.

To evaluate the joint capsular effects on ROMs, the true glenohumeral ROM evaluation with scapular fixation is ideal for FS patients under general anesthesia,[14,15] which can reflect faint changes of the joint capsule. However, it is difficult to evaluate HBB ROM during arthroscopic surgery with patients in both the lateral decubitus and beach-chair positions. Because we adopted this ROM evaluation procedure in 2014, it was difficult to compare the results with those in group 1. However, all of the ROMs in group 2 had significantly recovered to almost normal levels regardless of DM. This finding indicates that evaluation of the true ROM of the glenohumeral joint with scapular fixation is a reliable method during surgery, as well as in the outpatient clinic.[12]

Patients with DM are more likely to have FS develop and to require operative management.[32] Having inadequate glycemic control and undergoing treatment for retinopathy are associated with worsening shoulder pain and disability.[22] Furthermore, patients with DM and FS have a significantly higher prevalence of microvascular conditions such as neuropathy, nephropathy, and retinopathy than those without DM.[35] Considering the combined data of the 2 groups in this study, DM patients had reduced FF2 ROM, HBB ROM, and total, pain, and function UCLA scores vs. those without DM, although the significance disappeared after adjustments. However, there were no significant differences in ROMs and UCLA scores regardless of DM in group 2, which indicated that arthroscopic entire CHL release could affect the results of the combined data. Further studies are needed to clarify the effects of arthroscopic entire CHL release in patients with DM.

This study has some limitations. First, surgery was performed and ROMs were evaluated by a single surgeon for each group, and reliability and validation of ROMs were not evaluated. Additional research should include reliability tests, such as inter-rater reliability. Furthermore, although the surgeon who treated group 2 was a former fellow of the surgeon who treated group 1 and had adopted a similar surgical technique for group 2, it was difficult to exclude the technical differences in these results. Second, because the visits to both clinics were the final visits for the patients, it was difficult to determine the exact time of onset. There were no patients with symptom onset that began <3 months before visiting our clinics. Third, a retrospective study design was adopted. Consequently, there might be some potential confounding factors. Fourth, medical history of DM was not evaluated. Fifth, the long-term clinical outcomes of arthroscopic capsular release with entire CHL release were not evaluated. Finally, the sample size, especially for patients with DM, was small. Larger studies that include reliability tests, preoperative and postoperative ROM evaluations, and evaluation of long-term clinical outcomes are necessary in the future.

Conclusion

Arthroscopic pan-capsular release with entire CHL release improved ROM, especially HBB level, and UCLA scores in patients with FS regardless of DM. Arthroscopic entire CHL release is an essential treatment option for patients with FS to regain ROMs and to reduce pain after surgery.

Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jseint.2020.08.019.

Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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