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ORIGINAL STUDY

Surgical results of one-stage arthroscopic repair of rotator cuff tears with adhesive capsulitis using anterior or global capsular release

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The purpose of the study is to compare the clinical outcomes and recovery pattern of anterior capsular release and global capsular release for one-stage arthroscopic repair of rotator cuff tears with adhesive capsulitis. Among patients who underwent arthroscopic rotator cuff repairs with a concomitant adhesive capsulitis, 46 patients were treated with either anterior capsular release (group A ; n = 24) or global capsular release (group B ; n = 22). Preoperative mean passive forward flexion was 109º in group A and 107º in group B, whereas external rotation at the side was 27º and 29º, respectively. All patients were evaluated at a minimum 2-year follow-up in terms of visual analog scale for pain, muscle power, range of motion, Constant score, subjective shoulder value, modified American Shoulder and Elbow Surgeons (ASES) shoulder evaluation form, and modified University of California at Los Angeles (UCLA) scores. The mean modified ASES score was 89.3 for group A and 88.9 for group B (*P* = .780). The mean UCLA scores were 34.8 and 33.9, respectively (*P* = .570). The 2 groups showed no significant difference in forward flexion and external rotation postoperatively, as group B recovered more slowly in external rotation. The group A showed a better visual analog scale for pain postoperatively. The global capsular release did not produce better clinical outcomes than anterior capsular release. Overall satisfactory results can be achieved either by anterior capsular release or by global release in a one-stage arthroscopic surgery for rotator cuff tear and adhesive capsulitis. This arthroscopic rotator cuff repair with anterior capsular release might be a reasonable alternative treatment for patients with rotator cuff tear with adhesive capsulitis.

Level of Evidence : Level III, retrospective com-parative study.

Keywords : adhesive capsulitis ; rotator cuff repair ; arthroscopic surgery.

INTRODUCTION

When a patient has a rotator cuff tear with persistent pain, adhesive capsulitis with limited active and passive range of motion (ROM) can be introduced because contracture of the capsule progressively occurs over time *(9,36)*. The ideal

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treatment for rotator cuff tears with adhesive capsulitis remains controversial. Recently, one-stage arthroscopic release of the joint capsule with rotator cuff repair was found to be more favorable than other treatment options for rotator cuff tears with adhesive capsulitis *(7,8,10,21,24,33)*. However, the extent of release remains controversial *(1,6,12, 15,19,23,25,35)*. Arthroscopic global capsular release including anterior, posterior and inferior capsule achieved reasonable results by previous studies *(10,21,33)*. Some complications, including axillary nerve injury, shoulder instability, fluid extravasation, hemarthrosis, and chondrolysis, were also reported *(10,18,21,22,38,40)*. Nevertheless, these complications would potentially affect the healing process after rotator cuff repair.

The pathology of the rotator interval tissue plays a primary role in adhesive capsulitis, and treating the rotator interval pathology is fundamental for resolving adhesive capsulitis *(20,32,37)*. In this study, an anterior capsular release involved resecting all pathological tissues of the rotator interval and restoring full excursion of the subscapularis tendon.

To our knowledge, no reports have been published on the optimal extent of capsular release during treatment of rotator cuff tears with adhesive capsulitis. There are also no known studies that have investigated the effect on anterior capsular release, compared with global capsular release in the same arthroscopic surgery for rotator cuff tears with adhesive capsulitis.

The purpose of this study was to compare the clinical outcomes between 2 capsular release methods for rotator cuff tears with adhesive capsulitis using one stage arthroscopic technique : anterior capsular release and global capsular release. We hypothesized that anterior capsular release would yield better outcomes, as the inferior and posterior capsule would be jeopardized when release was performed during the global capsular release.

PATIENTS AND METHODS

Among 624 patients who underwent arthroscopic rotator cuff repairs from September 2007 to April 2015, 46 consecutive patients with adhesive capsulitis and limited passive ROM (passive forward flexion of 120° and external rotation of 30° in 90° of abduction) under anesthesia were enrolled in our study. Those who had partial or massive (5 cm) rotator cuff tears, subscapularis tendon tears, advanced glenohumeral arthritis, or revision procedures were excluded from the study. Patients were divided into group A (24 patients with anterior capsular release) and group B (22 patients with global capsular release). Assignment of patients to group A or B was not made by standard randomization ; rather, the assignment was made according to the time when patients received surgery. In the initial part of the study period, we used global capsular release. We subsequently postulated that only anterior capsular release would be a less-aggressive way to treat adhesive capsulitis and would also improve excursion of the subscapularis tendon. Thus in the latter half of the study period, we switched to anterior capsular release, preserving other aspects of the capsule intact. Before the operation, we explained to patients the advantages, disadvantages, and technical difficulties of these arthroscopic procedures. All patients agreed to receive these procedures. All operative procedures were performed by a single orthopedic surgeon. After institutional review board approval, the data were retrospectively reviewed.

Patients were evaluated 1 day before the operation, under anesthesia (passive motion), and during the follow-up period. Subjective pain was measured preoperatively, 1 day postoperatively, and at the last follow-up with a visual analog scale (VAS). The VAS was used to measure pain, with 0 indicating no pain and 10 indicating extremely severe pain. Passive shoulder motions, including abduction, forward flexion, external rotation at the side and in 90° of abduction, and internal rotation in 90° of abduction, were measured in each patient 1 day before operation, under anesthesia ; at 2 weeks, 6 weeks, 3 months, 6 months, 12 months, and 24 months postoperatively ; and at the last follow-up. Quantitative strength measurements of the rotator cuff were obtained by manual resistance, and the active motion and strength were graded throughout the ROM on a scale from 0 to 5 according to the Medical Research Council. Abduction strength was

tested with the patient in a seated position with the arm flexed to 90° in the scapular plane *(17)*. External rotation strength and internal rotation strength were tested with the shoulder in a neutral position and the elbow in 90° of flexion. The Constant score, subjective shoulder value (SSV), modified American Shoulder and Elbow Surgeons (ASES) shoulder evaluation form, and modified University of California at Los Angeles (UCLA) score were used for clinical assessment *(11,16,29)*. The primary outcome measure was passive ROM at 24 months postoperatively. Secondary outcomes included quantitative strength measurements, VAS, the Constant, SSV, ASES, and UCLA score.

The patient was positioned in the lateral decubitus position and an examination was performed under anesthesia. Subscapular and axillary nerve block was accomplished by infiltrating a total of 10 mL of 0.5% bupivacaine in divided fractions. A standard posterior viewing portal was created, and the 30° arthroscope was introduced into the glenohumeral joint. A thorough diagnostic arthroscopic examination was then performed. An 18-gauge spinal needle was used to ascertain the precise location for placement of the anterior portal. This portal was created just superior to the lateral half of the subscapularis tendon. With these two portals established, a thorough arthroscopic examination could be performed and the intra-articular pathology could be addressed.

In group A, the tissues between the upper subscapularis and superior glenohumeral ligament were excised using a shaver (ConMed Linvatec, Largo, FL) and a 90° electrocautery probe (Orthopaedic Procedure Electrosurgical System ; Arthrex, Naples, FL). The upper border of the subscapularis tendon was exposed, and this tendon and the medial sling of the biceps (superior glenohumeral and coracohumeral ligaments) were carefully preserved.

With a modified anterior capsular release, four-sided release with respect to the subscapularis tendon was addressed with using 70 degree arthroscope. Posteriorly, the middle glenohumeral ligament (MGHL) was identified. The erythematous, thickening, and hardening MGHL was usually noted and excised using a punch. The inflamed tissue between the glenoid and subscapularis muscles was then resected with a shaver. Anteriorly, the inflamed tissue or fibrotic tissue anterior to subscapularis muscles was also resected with a shaver. The coracoid process was identified. The tissue between the conjoint tendon and humerus were cleared. Medially, the release was extended under the coracoid arch using a shaver or a 30° arthroscopic elevator. Superiorly, the subscapularis tendon was usually covered in hard or inflamed fibrotic tissues. If this fibrotic tissue affected its medial and lateral excursion, it was excised until the glistening subscapularis tendon freely appeared (Figure 1) (Supplementary Material : Video 1)

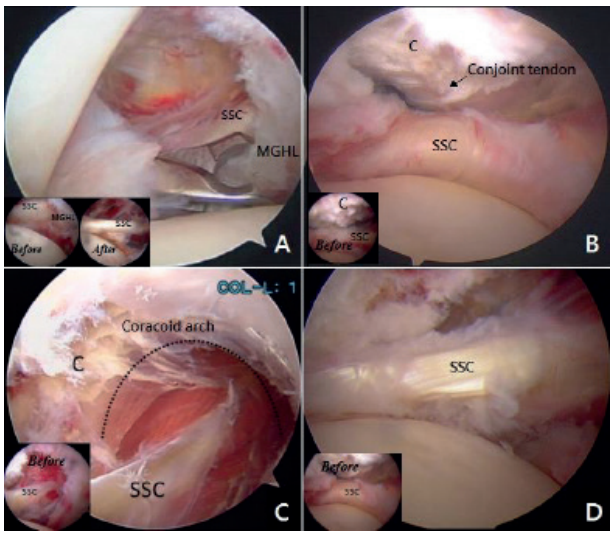

Figure 1. — In group A, anterior capsular release was performed with excision of tissues between the upper subscapularis and the superior glenohumeral ligament. Four-sided release with respect to the subscapularis was performed : (A) Posterior to subscapularis, the middle glenohumeral ligament (MGHL) was excised using a punch. Inflamed tissues between the glenoid and subscapularis muscle were also resected with a shaver. (B) Anterior to subscapularis, the inflamed tissue or fibrotic tissue anterior to subscapularis muscles was also resected with a shaver. The coracoid process was identified. The tissue between the conjoint tendon and humerus were cleared. (C) Medial to subscapularis, the release was extended under the coracoid arch using a shaver or a 30° arthroscopic elevator. (D) Superior to subscapularis, the subscapularis tendon was usually covered in hard or inflamed fibrotic tissues. If this fibrotic tissue affected its medial and lateral excursion, it was excised until the glistening subscapularis tendon freely appeared.
SSC : subscapularis, C : coracoid, MGHL : middle glenohumeral ligament, Dotted line : coracoid arch, Left shoulder, viewing from posterior portal with using of a 70 degree arthroscope

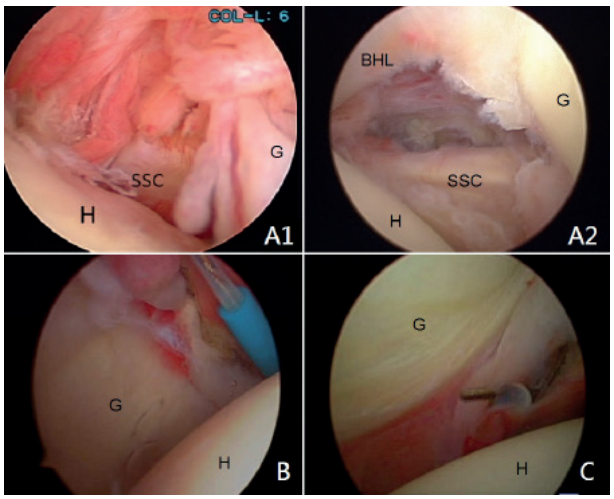

Figure 2. — In group B, arthroscopic global release including anterior, posterior and inferior capsule was performed. (A) Anterior capsule release (left shoulder, viewing form posterior portal). A1 : Inflamed tissue in rotator interval. A2 : After excision of inflamed rotator interval tissue between the upper subscapularis and biceps long head. (B)The posterior capsular release was performed using a pencil-tip electrode from 1 o'clock to 5 o'clock position (left shoulder, viewing from anterior portal). (C)The inferior capsule was also released with a pencil-tip electrode from the 5 o'clock to the 7 o'clock position (left shoulder, viewing from anterior portal).
SSC : subscapularis, H : humeral head, BHL : biceps long head, G : glenoid.

Finally, a dynamic arthroscopic view was obtained with an assistant performing the external and internal rotation of shoulder to confirm recovery of the medial and lateral excursion of the subscapularis tendon.

In group B, rotator interval tissue between the upper subscapularis and the superior glenohumeral ligament was excised by use of a combination of a shaver and a 90° electrocautery probe. The subscapularis tendon and the medial sling of the biceps were carefully preserved. This release of the rotator interval increased external rotation. because it released the anterior capsule, which spanned the rotator interval.

After then, arthroscopic posterior and inferior capsular release was performed. The arthroscope was then placed in the anterior portal, and a pencil-tip electrocautery probe (Arthrex, Naples, FL) was inserted posteriorly. The posterior capsular release was performed from the 1-o'clock position to the 5-o'clock position for a left shoulder or from the 7-o'clock position to the 11-o'clock position for a right shoulder. The posterior release increased internal rotation. The anterior portal also allowed direct visualization of the axillary pouch from the 5-o'clock position to the 7-o'clock position. The inferior capsule was also released with the pencil-tip electrode. In general, the inferior release increased forward elevation (Figure 2).

Video 1.

Anterior capsular release was performed with excision of tissues between the upper subscapularis and the superior glenohumeral ligament. Four-sided release with respect to the subscapularis was performed. Posterior to subscapularis, the middle glenohumeral ligament (MGHL) was excised using a punch. Anterior to subscapularis, the inflamed tissue or fibrotic tissue anterior to subscapularis muscles was also resected with a shaver. The coracoid process was identified. The tissue between the conjoint tendon and humerus were cleared. Medial to subscapularis, the release was extended under the coracoid arch using a shaver. Superior to subscapularis, the subscapularis tendon was covered in hard or inflamed fibrotic tissues. It was excised until the glistening subscapularis tendon freely appeared.

The arthroscope was inserted into the subacromial space through the posterior portal. For alleviating bursitis, a thorough bursectomy was performed with a shaver. Subacromial decompression was performed with a burr (ConMed Linvatec, Largo, FL) through a lateral portal. A flat undersurface to the acromion was created.

Manipulation of the shoulder was performed for both groups after acromioplasty because additional rotator cuff injury could be prevented by widening the subacromial space. All instruments and cannulas were removed. While the arm was positioned at 90° of abduction, the shoulder was externally rotated to 90° and then internally rotated to 30°. Next, the arm was positioned into full combined elevation to 180° while an assistant stabilized the scapula. The shoulder was then manipulated into horizontal abduction.

For the assessment of rotator cuff integrity, a 70° arthroscope was inserted into the posterior portal. The extent of the tear was determined intraoperatively under direct arthroscopic visualization after debridement of the degenerated tendon edges.

Medial-lateral and anterior-posterior tension was tested with a cuff grasper (Arthrex, Naples, FL). To achieve a repair that was as tension free as possible, marginal convergence was performed as needed after the tear pattern was determined. The bone bed of the footprint on the greater tuberosity was prepared with electrocautery, ring curettes, a power shaver, and a burr. The suture anchors (5-mm Corkscrew ; Arthrex) were placed on the bone bed after we determined the number of anchors needed. The suture was passed 8 to 12 mm from the cuff margin with an antegrade suture passer (Viper ; Arthrex). The sutures for each anchor were "tied as you go" from posterior to anterior.

All patients had a sling with a small pillow applied in the operating room. The sling was worn full-time for 6 weeks, except when patients were showering or eating. Patients mainly performed home rehabilitation self-exercises. On the first postoperative day, they were instructed to perform passive stretching including forward elevation by table sliding and external rotation with a cane out to 45°. From the first postoperative day to 6 weeks, this gentle passive stretching program was performed for 15 min every day. At 6 weeks from the date of surgery, patients discontinued use of the sling. At this point, aggressive stretching with forward elevation by door sliding and external rotation using a door was begun. At 6 weeks, strengthening with pushups using a wall was also begun. Progression to using light weights was based on the patient's progress. The return to full, unrestricted activities usually occurred at 3~6 months postoperatively and was based on the initial size of the tear, the strength of the repair, and the patient's rehabilitation progress. Transient medication was only given when a patient occasionally had severe pain.

The Mann-Whitney *U* test was performed to compare results between the groups. The Wilcoxon signed rank test was used to compare preoperative and postoperative results of each group. The level of statistical significance was set as $P < 0.05$.

RESULTS

Forty-two patients (22 in group A and 20 in group B) with complete follow-up documentation for a minimum of 2 years were included in the outcome analyses. Four patients could not complete regular follow-up evaluation, 2 because of financial problems, and 1 because of a move to another city, and 1 because of loss of contact. Patient demographics of those groups with extended anterior capsular release and global capsular release are listed in Table 1.

Table 1. — Patient demographics of two groups

	Group A	Group B
No. of patients	22	20
Sex, male/female	8/14	6/14
Mean age, years (range)	54.7 (46–69)	57.2 (41–70)
Mean follow-up, months (range)	27.8 (24–46)	29.9 (24–56)
Size of tear, small/medium	17/5	15/5

Group A: with extended capsular release; Group B: with global capsular release.

The extent of the tear was determined intraoperatively under direct arthroscopic visualization after debridement of the degenerated tendon edges. According to the classification of DeOrio and Cofield, *(14)* arthroscopic findings of group A included small tears in 17 patients (77.3%), and medium-sized tears in five (22.7%). Group B showed small tears in 15 patients (75.0%), and medium-sized tears in five (25.0%). There was no statistically significant difference in the size of the tear between the two groups ($P = .451$). The mean follow-up period was 27.8 months (range, 24-46 months) for group A, and 29.9 months (range, 24-56 months) for group B. The mean duration of symptoms before surgery was 11.2 months (range, 3-29 months) for group A, and 10.1 months (range, 4-28 months) for group B. The preoperative evaluations are listed in Table 2.

At postoperative day 1, the mean VAS score was 2.9 in group A and 4.8 in group B ($P=.017$). VAS score was significantly better in group A.

Postoperatively, the mean VAS score was 1.1 in group A and 1.2 in group B ($P=.756$) Both groups showed significant improvement from preoperative levels, but there was no statistically significant difference between the two groups. (Tables 3-5).

Postoperatively, passive forward flexion was 172.5° in group A and 168.3° in group B ($P=.120$).

Table 2. — Comparison of preoperative evaluations between the 2 groups

Variable	Group A	Group B	*P* Value
ROM, deg			
FF	109.2	107.1	0.542
ERs	26.8	28.9	0.642
ERab	39.2	40.8	0.584
IRab	6.1	5.8	0.662
Abd	110.5	112.1	0.731
Strength measures, 0–5 (range)			
Abd	3.9	3.9	0.492
ER	4.5	4.3	0.711
IR	4.8	4.9	0.720
VAS, 0–10 (range)	8.5	8.1	0.338
Constant score	44.5	45.9	0.695
Modified ASES score	40.1	40.4	0.560
SSV	33.0	28.1	0.241
Modified UCLA score	14.1	14.3	0.572

ROM : range of motion, IR : internal rotation, ER : external rotation, FF : forward flexion, ERs : external rotation at side, ERab : external rotation in 90º of abduction, Abd : abduction, VAS : visual analog scale, ASES : American Shoulder and Elbow Surgeons, SSV : subjective shoulder value, UCLA : University of California at Los Angeles.

Table 3. — Comparison of postoperative results between two groups

Variable	Group A	Group B	*P*
ROM, deg			
FF	172.5	168.3	0.120
ERs	61.5	58.4	0.501
ERab	93.1	91.8	0.461
IRab	28.3	30.5	0.270
Abd	171.2	169.9	0.618
Strength measures, 0-5 (range)			
Abd	4.7	4.7	0.715
ER	4.8	4.9	0.650
IR	4.8	4.7	0.318
VAS, 0–10 (range) post op	2.9	4.8	0.017
VAS, 0–10 (range) at last f/u	1.1	1.2	0.756
Constant score	92.8	92.2	0.586
modified ASES score	89.3	88.9	0.780
SSV	93.2	91.7	0.560
modified UCLA score	34.8	33.9	0.570

External rotation at the side was 61.5° in group A and 58.4° in group B (*P*=.501), and external rotation in 90º of abduction was 93.1° in group A and 91.8° in group B (*P*=.461). Internal rotation in 90º of abduction was 28.3° in group A and 30.5° in group B (*P*=.270), whereas abduction was 171.2° in group A and 169.9° in group B (*P*=.618). The ROM between the two groups at 2-year follow-up was no significantly different in forward elevation and external rotation.

The gain of motion in group A was not significantly different in forward flexion and external rotation

Table 4. — Comparison of preoperative and postoperative results in group A

Variable	Preoperative	Postoperative	*P*
ROM, degrees			
FF	109.2	172.5	<0.001
ERs	26.8	61.5	<0.001
ERab	39.2	93.1	<0.001
IRab	6.1	28.3	0.002
Abd	110.5	171.2	0.001
Strength measures, 0–5 (range)			
Abd	3.9	4.7	0.018
ER	4.5	4.8	0.212
IR	4.8	4.8	0.481
VAS, 0–10 (range)	8.5	1.1	0.001
Constant score	44.5	92.8	0.001
modified ASES score	40.1	89.3	0.007
SSV	33.0	93.2	0.005
modified UCLA score	14.1	34.8	0.001

Table 5. — Comparison of preoperative and postoperative results in group B

Variable	Preoperative	Postoperative	*P*
ROM, degrees			
FF	107.1	168.3	<0.001
ERs	28.9	58.4	<0.001
ERab	40.8	91.8	<0.001
IRab	5.8	30.5	0.001
Abd	112.1	169.9	0.002
Strength measures, 0–5 (range)			
Abd	3.9	4.7	0.013
ER	4.3	4.9	0.110
IR	4.9	4.7	0.674
VAS, 0–10 (range)	8.1	1.2	0.001
Constant score	45.9	92.2	0.002
modified ASES score	40.4	88.9	0.003
SSV	28.1	91.7	0.005
modified UCLA score	14.3	33.9	0.003

than in group B at 2-year follow-up (*P*=.452). When compared with the preoperative ROM, both groups showed statistically significant recovery of motion (Figures 3).

The mean muscle strength of patients in group A during abduction, external rotation, and internal rotation was measured at 4.7, 4.8, and 4.8 (grade 0-5), postoperatively. The corresponding strength was 4.7, 4.9, and 4.7 for patients in group B. Both groups reported statistically significant improvement in muscle strength in abduction and external rotation, but there was no statistically significant difference between the two groups (*P* =.715, .65, and .318, respectively) (Tables 3-5).

Postoperatively, the Constant score was 92.8 points in group A, and 92.2 points in group B. The subjective shoulder value was 93.2 in group A, and 91.7 in group B. The modified American Shoulder and Elbow Surgeons score was 89.3 in group A and 88.9 in group B. The Shoulder Rating Scale of the University of California at Los Angeles score was 34.8 points in group A, and 33.9 in group

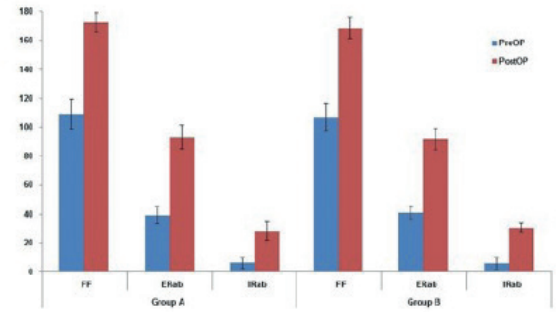

Figure 3. — Gain of range of motion in group A and group B at 2 year follow-up.

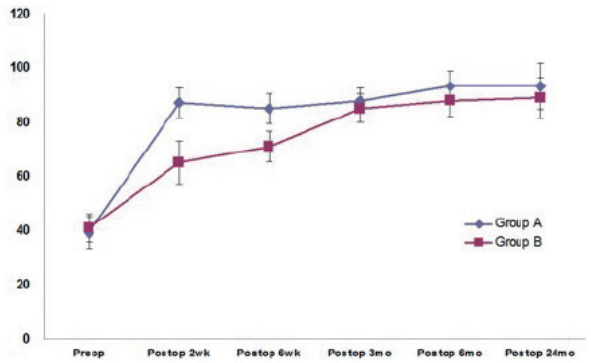

Figure 4. — Group A showed fast recovery in external rotation than did group B with the difference being 22.1° at 2 weeks postoperatively, and 14.0° at 6 weeks. The difference narrowed steadily; there was no statistically significant difference between the two groups at 3 months, 6 months and 2-year follow-up.

B. Both groups reported statistically significant improvement in clinical assessment, but there was no statistically significant difference between the two groups (P = .586, .780, and .57, respectively) (Tables 3-5).

Preoperatively, both groups had severely limited passive ROM in forward flexion, external rotation, and internal rotation. Postoperatively, the ROM recovered gradually in both groups. Group A recovered at a relatively fast pace in external rotation, and there was a no statistically significant difference between the two groups postoperatively.

Group A showed faster recovery in external rotation than did group B with the difference being 22.1° at 2 weeks postoperatively, and 14.0° at 6 weeks. The difference narrowed steadily ; there

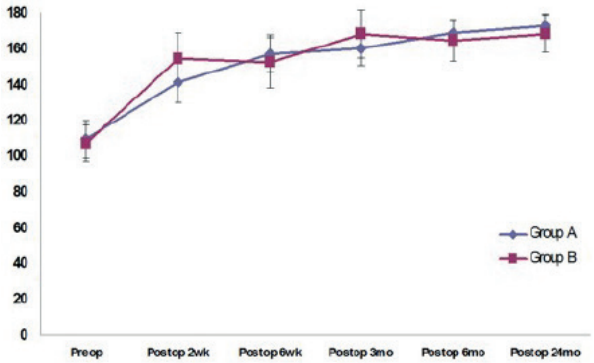

Figure 5. — The difference between the 2 groups was not significant in forward flexion from 2 weeks postoperatively to 2-year follow-up.

was no statistically significant difference between the two groups at 3 months, 6 months and 2-year follow-up (P = .461, .210, and .321, respectively) (Figure 4).

The difference between the 2 groups was not significant in forward flexion from 2 weeks post-operatively to the 2-year follow-up (P = .120, .322, .354, respectively) (Figure 5)

Group B showed faster recovery than group A with the difference in forward flexion being 10.2 at 2 weeks postoperatively, 9.3° at 6 weeks, and 10.1° at 3 months. There was a statistically significant difference between the 2 groups at 6 months and 2-year follow-up (P = .270, .250, .136, respectively).

COMPLICATIONS

Two patients in group B had symptoms of instability. They complained that the joint seemed to be dislocated when they were doing stretching exercises during the first 3 and 6 months, respectively ; however, serial x-rays revealed that the shoulders were not dislocated. As the muscles regained strength, the sensation of instability diminished. Another two patients in group B had transient neuropraxia. They complained of numbness over the lateral aspect of the deltoid, but the sensation diminished after 3 and 6 months of follow-up, respectively. One patient in group A had a postoperative superficial wound infection at the surgical incision site, which resolved after treatment with oral antibiotics for 1 week.

DISCUSSION

In rotator cuff tears with adhesive capsulitis, even though the full restoration of forward elevation, external rotation and internal rotation would be optimal, considering that global capsular release is likely to introduce instability and other complications during the same surgery for rotator cuff repair, we hypothesized that anterior capsular release alone would produce better clinical outcomes than global capsular release. However, contrary to this hypothesis, postoperative clinical outcomes as well as recovery pattern of ROM did not differ significantly between the 2 groups. Transient neuropraxia, the symptom of shoulder instability, early post-operative pain, and slow recovery of external rotation were noted in the group of global capsular release.

Recently, one-stage arthroscopic capsular release and rotator cuff repair became popular for treating rotator cuff tears with adhesive cap-sulitis. The extent of capsular release during this one-stage surgery remains controversial *(7,8,10,12,15,19,21,24,33,35)*. Because the capsular ligament plays a primary role in restraining the glenohumeral joint, any procedure to damage the capsule may compromise shoulder stability *(2,10,18,19,21,38)*. In addition, stability is crucial for tendon-to-bone healing after rotator cuff repair. If global capsular release or 360° capsular release was done with rotator cuff repair, the potential instability would be unfavorable to tendon-bone healing after rotator cuff repair. Moreover, if greater capsular release was done during rotator cuff repair, the painful sensation and fluid extravasation could delay postoperative rehabilitation which is essential for recovery from adhesive capsulitis *(10,21,33,36)*.

Numerous recent studies have supported arthroscopic release to effectively treat refractory adhesive capsulitis. Arthroscopic capsular release allows visually controlled release of the capsule and also allows a different direction of capsular release, control of any potential hemarthrosis, and treatment of associated injuries. Glenohumeral motion loss assessed in cadaveric cutting studies clarified that the regional capsule must be released. Loss of external rotation mandates release of the MGHL, rotator interval, coracohumeral ligament extra-articularly, or intra-articular portion of the subscapularis tendon. Loss of elevation merits the release of the anteroinferior capsule, including the anterior band of the inferior glenohumeral ligament. Loss of internal rotation warrants posterosuperior capsular release *(2,31,41)*.

However, a clinical consensus on the extent of capsular release is lacking ; certain authors recommend 360° capsular release, whereas others suggest relatively conservative release. Arthroscopic capsular release entails some complications. Gobezie et al. reported a case of shoulder dislocation after arthroscopic anterior, posterior, and inferior capsular release, in which the patient was treated with reduction under general anesthesia *(18)*. Jerosch and Aldawoudy reported a catastrophic complication of glenohumeral joint chondrolysis, which was treated with surface replacement surgery *(22)*. Zanotti and Kuhn found average distances of 7.04, 8.2, and 15.9 mm from capsular release to the axillary nerve, posterior circumflex artery, and brachial artery, respectively *(41)*. Warner analyzed the requirement of inferior capsular release, which may affect the axillary nerve, especially when electrocautery or motorized instruments are used *(39)*. Harryman et al. reported transient axillary neuropraxia after inferior capsular release *(19)*. In addition, Wong and Williams reported that 1.4% of their series had postoperative axillary neuropathy, of which 95% exhibited sensory deficits lasting an average of 2.3 months *(40)*. Moreover, arthroscopic capsular release causes other possible complications, such as hemarthrosis or fluid extravasation *(38)*.

Neer described the anterosuperior space between the subscapularis and supraspinatus tendon as the rotator interval. Although definitive roles of rotator interval structures have not been established, they can manifest with adhesive capsulitis. A normal rotator interval contains elastic and membranous tissues, including the biceps long head tendon, superior glenohumeral ligament, MGHL, coracohumeral ligament, and anterior capsule. The rotator interval tissue was critically associated with the development of adhesive capsulitis *(30)*. In adhesive capsulitis, tissues of the rotator interval may become thicken, inflamed, and contracted.

Because the pathological condition of the rotator interval tissue plays a primary role in adhesive capsulitis, release of the rotator interval should be fundamental for treating adhesive capsulitis. Harryman et al. demonstrated an increase in the ranges of flexion, extension, and external rotation by sectioning only the rotator interval capsule in a biomechanical study *(20)*. Ozaki et al. demonstrated that open surgical release of only the rotator interval without using arthroscope in 17 patients with refractory adhesive capsulitis significantly improved pain ; and 16 of 17 patients regained complete ROM in 3 months postoperatively *(32)*.

Anterior capsular release alone has additional advantages. First, it prevents axillary nerve injury. To avoid possible axillary nerve injury, certain studies were extremely cautious regarding inferior capsular release. Second, only anterior capsular release reduces the risk of shoulder instability and dislocation compared to global capsular release. Third, because the bone is the weakest in rotation, the humeral fracture risk is highest during external rotation manipulation. In this study, extended anterior capsular release without posterior or inferior release was sufficient to afford external rotation without excessively forced manipulation. In addition, the visual analog scale for pain is better in group A during early post-operative period, which also facilitated early rehabilitation.

In adhesive capsulitis, a thick fibrotic of inflamed tissue around the intra-articular part of the subscapularis tendon was commonly noted. Several previous studies recommended releasing, cutting, or lengthening the intra-articular subscapularis tendon to restore passive external rotation *(3,27,34)*. The release of a portion of the intra-articular part of the subscapularis was based on a study performed on 10 cadaveric shoulders and 35 patients by Pearsall et al *(34)*. The study mentioned that in addition to the rotator interval, the intra-articular portion of subscapularis tendon contributes to restriction in external rotation. Additionally, in the transverse plane force couple of shoulder joint, the subscapularis anteriorly balanced against the infraspinatus posteriorly *(4,5)*. We believe a balanced force couple affords not only dynamic stability but also a good environment for tendon-to-bone healing during rotator cuff repair. Jeopardizing the subscapularis tendon may cause an unbalanced force couple, thus introducing a worse condition for healing of a rotator cuff repair. In this study, sufficient space for excursion of the subscapularis tendon was created instead of lengthening, releasing, or cutting the subscapularis tendon itself. Particularly in group A with anterior capsular release alone, we emphasized that excursion of the subscapularis tendon is crucial for treating adhesive capsulitis and also restoring a balanced force couple. In this study, 4-sided release with respect to the subscapularis tendon was addressed by anterior capsular release. External and internal rotation was performed to obtain a dynamic arthroscopic view to confirm a full recovery of excursion of subscapularis tendon *(13,28)*.

Our study has acknowledged limitations, the first being a small number of patients. However, rotator cuff tear with adhesive capsulitis is not common and this one-stage arthroscopic capsular release and rotator cuff repair became popular only recently. Second, this was a retrospective comparative study, and the groups were not randomly assigned. Future prospective randomized studies should be conducted to fully evaluate the clinical results. Nevertheless, there was no significant difference in preoperative ROM, muscle strength, or clinical scores between the two groups in this study. Third, the roles of the rotator interval, MGHL, coracoid, and subscapularis tendon are not definite in adhesive capsulitis pathology. Future basic and clinical studies should elucidate this point. Finally, because partial or massive rotator cuff tears were excluded from this study, our data might not apply to patients with a partial or massive tear.

CONCLUSION

The global capsular release did not produce better clinical outcomes than anterior capsular release. Overall satisfactory results can be achieved either by anterior capsular release or by global release in a one-stage arthroscopic surgery for rotator cuff tear with adhesive capsulitis. This arthroscopic rotator cuff repair with anterior capsular release might be a reasonable alternative treatment for patients with rotator cuff tear with adhesive capsulitis.

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