

Factors Affecting the Outcomes of Arthroscopic Capsular Release for Idiopathic Adhesive Capsulitis

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Background: Arthroscopic capsular release has been shown to provide excellent short- and long-term outcomes in patients with idiopathic frozen shoulder. Some surgeons delay surgery in the belief that operating in the early stages of adhesive capsulitis results in a poorer prognosis. However, it is unclear which factors, particularly the stage of the disorder, affect the surgical outcome of this procedure.

Hypothesis: Patients who undergo capsular release during the early symptomatic stage of idiopathic adhesive capsulitis would have less improvement in range of motion compared with those who undergo surgery at a later stage.

Study Design: Cohort study; Level of evidence, 3.

Methods: A total of 189 shoulders with idiopathic adhesive capsulitis that underwent arthroscopic capsular release were evaluated. All patients completed a L'Insalata questionnaire and had their range of motion and strength tested prior to surgery and at 1, 6, and 12 weeks and 6 months post-capsular release. Post hoc, patients were grouped by whether they had symptoms lasting <10 months (shorter symptoms group; n = 131) or ≥10 months (longer symptoms group; n = 38). Multiple linear regression analysis was performed to determine which preoperative factors were independently associated with a favorable outcome.

Results: Patients in the shorter symptoms group were more restricted prior to surgery than were those in the longer symptoms group (mean ± SEM: external rotation, 17° ± 2° vs 27° ± 4° [*P* = .04]; abduction, 78° ± 3° vs 92° ± 6° [*P* = .04]; internal rotation, S3 ± 1 vs S1 ± 1 [*P* = .03]). The shorter symptoms group had greater postoperative improvement in internal rotation (from S3 ± 1 preoperatively to T12 ± 1 vertebral levels) compared with the longer symptoms cohort (from S1 ± 1 to L2 ± 1) (*P* = .02).

Conclusion: Patients with a frozen shoulder and a duration of symptoms <10 months made greater improvements in internal rotation and had similar final results for flexion, abduction, and external rotation following arthroscopic capsular release when compared with patients who had a longer duration of symptoms, so there is no reason to delay surgery.

Keywords: idiopathic adhesive capsulitis; frozen shoulder; arthroscopic capsular release; stiffness; freezing phase; frozen phase

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Ethical approval for this study was obtained from the South East Sydney Local Health District Human Research Ethics Committee (14/STG/013).

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Idiopathic adhesive capsulitis, or frozen shoulder, is a condition characterized by the onset of pain and limited global range of motion in the shoulder.^{2,5,15} There is an estimated prevalence of 2% to 5% in outpatient clinics,⁸ with peak onset at between 50 and 55 years. Women are commonly more affected than men at a ratio of 1.4 to 1, and frozen shoulder is more common in patients with diabetes and thyroid disorders.¹³

Many authors have divided the timeline of adhesive capsulitis into 3 phases. The first phase, or freezing phase, is characterized by severe pain in the affected shoulder and typically lasts 2 to 9 months. The second phase, or frozen phase, involves improving pain but continual stiffness and typically lasts 4 to 9 months. The final phase, or thawing phase, involves gradual resolution and improvement in range of motion, which may last from 5 to 26 months. The

entire course of disease can take up to 2 to 3 years to resolve, and symptoms may persist long term.¹²

Treatment of adhesive capsulitis has included nonsurgical interventions such as nonsteroidal anti-inflammatory administration, physical therapy, intra-articular steroid injections, and surgical interventions, such as open release, manipulation under anesthesia, or arthroscopic capsular release. While nonoperative treatment is usually successful, some patients seeking a quicker resolution of stiffness are willing to undergo surgery, despite its risks.³ We previously showed that arthroscopic capsular release for idiopathic adhesive capsulitis provides significant reduction of pain severity and frequency and increased range of motion in the short term and up to 10 years after the operation.^{1,12} However, it is unclear at which of the 3 phases of adhesive capsulitis the capsular release is most beneficial with regard to surgical outcomes. To our knowledge, there have not been any studies exploring whether there is a relationship between timing of capsular release and functional outcomes.

The purpose of this study was to identify if arthroscopic capsular release is beneficial in the earliest phase of idiopathic adhesive capsulitis and to assess which subsets of patients benefit most from this operation. Our hypothesis was that capsular release undertaken during the early symptomatic stage of idiopathic adhesive capsulitis would provide less reduction in stiffness compared with surgery at a later stage.

METHODS

Study Design

Following ethics committee approval, a retrospective study was performed on patients who had undergone arthroscopic capsular release for adhesive capsulitis by the senior author (G.A.C.M.) between January 2001 and December 2015.

Inclusion and Exclusion Criteria

Patients were included in the study if a clinical diagnosis of idiopathic adhesive capsulitis was made (defined as a painful, stiff shoulder with no other identifiable cause^{4,6,7}). Excluded were those whose affected shoulder had a prior fracture, a previous rotator cuff tear, glenohumeral arthritis (grade II or greater), calcific tendinitis, previous infection in the shoulder joint, previous surgery, or other concurrent procedures. Other comorbidities were not recorded.

Operative Procedures and Rehabilitation

Arthroscopic capsular release was carried out in a day surgical setting. Patients undergoing the procedure underwent interscalene regional anesthesia and were positioned in the beach-chair position. An examination under anesthesia was performed, and intraoperative shoulder range of motion was noted and documented. The patient was prepared and draped, and a posterior portal

was made for glenohumeral arthroscopy. After the joint was examined with the arthroscope, a spinal needle was introduced to create an anterior portal, just lateral to the coracoid process. The spinal needle was positioned to ensure access for the instruments to the posterior and inferior aspects of the capsule. The anterior portal was made superior to the upper border of the subscapularis tendon.

Through the anterior portal, the tissues in the rotator cuff interval—from the anterior border of the long head of the biceps to the coracoid—were released with a radiofrequency wand (CoVac 50 ArthroWand; ArthroCare). The intra-articular segment of the subscapularis tendon was also released. The capsule was then cut anterior-inferiorly, just lateral to the glenoid labrum. The spinal needle was used again to establish a posterior-inferior portal, which facilitated release of the posterior-inferior capsule. The result was a 360° capsular release. The shoulder was then manipulated and the new range of motion recorded. Depo-Medrol (10 mL) with lidocaine (40 mg/mL of methylprednisolone acetate and 10 mg/mL of lidocaine hydrochloride with 0.9% m/v benzyl alcohol) was introduced into the joint. The portals were sutured, and a soft, bulky dressing was then applied. The patient was not provided a sling, to encourage the postoperative rehabilitation regimen.

The patient met with a physical therapist the next day and at least twice a week for 6 weeks, with the intention of maintaining active and passive shoulder motion. From day 1 postsurgery, the patient was advised to perform pendular reach, shoulder flexion, and shoulder extension exercises 3 times per day. The patient was also instructed to stretch the shoulder 3 times per day. From day 6 postsurgery, patients were advised to begin at least 3 sets of rotator cuff strengthening exercises every day using a TheraBand (Hygenic). Patients were advised to carry out this routine 3 times per day for 12 weeks.

Outcome Assessment

The primary outcome measures were (1) change in passive external rotation of the shoulder at 6 months following the capsular release, (2) change in patient-ranked stiffness scores, and (3) change in patient-reported overall shoulder satisfaction.

At each clinical visit, passive range of motion (abduction, external rotation, forward flexion, internal rotation) was measured visually, and strength (adduction, external rotation, internal rotation, subscapularis, supraspinatus) was evaluated with a handheld force gauge (HFG 110; Transducer Techniques) with previously validated protocols.⁹

Patient-reported outcomes of shoulder function and pain were assessed via a modified L'Insalata Shoulder Rating Questionnaire preoperatively and 1 week, 6 weeks, 12 weeks, and 6 months postoperatively.¹¹ The questionnaire used a 5-point Likert scale to answer questions regarding the frequency of sleep pain, pain during activities, and extreme pain (always, daily, weekly, monthly, or never) and the degree of shoulder stiffness, overall shoulder satisfaction, pain during sleep, pain in overhead activities, and pain at rest (very severe, severe, moderate, mild, or none).

Statistical Analysis

For statistical purposes, we measured internal rotation range of motion according to the number of vertebrae below T1. Outcomes with parametric data were analyzed by using 2-way unpaired Student tests and nonparametric data with the use of Wilcoxon signed-rank tests and Mann-Whitney rank-sum tests (GraphPad Prism, v 50.0; GraphPad Software). Spearman rank correlation tests were also performed to assess the relationship between the distributions. Results were considered significant if $P \leq .05$. Multiple linear regression analyses were performed with SigmaPlot (v 12.0; Systat Software).

RESULTS

Patient Demographics

From January 2001 to December 2015, the senior author performed 297 arthroscopic capsular releases for adhesive capsulitis of the shoulder in 280 patients. Of these 297 capsular releases, 15 operations were excluded owing to simultaneous rotator cuff repair surgery; 63 patient records had insufficient data; and 30 patients failed to attend at least 1 follow-up clinic at 6 months postsurgery. Eight patients had capsular release on both shoulders at separate times. The initial study cohort thus comprised 189 procedures.

The study cohort consisted of 120 women (63%) and 69 men (37%) with a mean \pm SEM age of 55 ± 1 year (range, 24-80 years). The mean duration of symptoms was 10 months (range, 1-364 months). Of the 189 operations, 105 (56%) were on the left side and 84 (44%) were on the right. The mean operative time was 30 minutes (range, 3-120 minutes).

The length of the patients' symptoms was recorded based on their recollection. Of the 189 patients, 20 failed to specify the length of their symptoms and were excluded. A total of 131 patients indicated their duration of symptoms to be <10 months before surgery; this cohort formed the shorter symptoms group, based on the timeline of adhesive capsulitis outlined by Wong and Tan.¹⁷ Seventeen patients indicated their duration of symptoms to be between 10 and 16 months before surgery, and 21 indicated their symptoms to have lasted >16 months before surgery. These 38 patients whose symptoms lasted ≥ 10 months comprised the longer symptoms group.

The shorter symptoms group, with 131 patients, consisted of 79 (60%) women and 52 (40%) men, with a mean age of 56 ± 1 year and a mean duration of symptoms of 4 ± 2 months (range, 1-9 months). The longer symptoms group, with 38 patients, consisted of 27 (71%) women and 11 (29%) men, with a mean age of 55 ± 1 year and a mean duration of symptoms of 23 ± 14 months (range, 10-64 months). There were no significant differences with regard to sex ($P = .22$) or age ($P = .85$) between the groups.

Preoperative Comparison: Time of Surgery

Range of motion was analyzed intraoperatively, with the patients under anesthesia. In general, there were

no preoperative strength differences between the groups; however, the shorter symptoms cohort demonstrated more restriction in range of motion compared with the longer symptoms cohort. Mean \pm SEM external rotation was reduced in the shorter symptoms cohort at $17^\circ \pm 2^\circ$, as opposed to $27^\circ \pm 4^\circ$ in the second cohort ($P = .04$). The shorter symptoms cohort was also more restricted before surgery in abduction than the longer symptoms cohort ($78^\circ \pm 3^\circ$ vs $92^\circ \pm 6^\circ$; $P = .04$) as well as in internal rotation ($S3 \pm 1$ vs $S1 \pm 1$; $P = .03$). Furthermore, forward flexion appeared more restricted in the shorter symptoms cohort but did not reach statistical significance ($88^\circ \pm 2^\circ$ vs $101^\circ \pm 6^\circ$; $P = .06$).

Postoperative Comparison

Both cohorts demonstrated improvements in range of motion and strength at 1 week, 6 weeks, 12 weeks, 24 weeks, and 6 months postsurgery.

The overall change in mean \pm SEM internal rotation from preoperative assessment to 6 months postoperatively was markedly improved in the shorter symptoms cohort (from $S3 \pm 1$ preoperatively to $T12 \pm 1$ vertebral levels) compared with the longer symptoms cohort (from $S1 \pm 1$ to $L2 \pm 1$; $P = .03$) (Figure 1A). Although preoperative external rotation (Figure 1B) and preoperative abduction (Figure 1C) were significantly more restricted in the shorter symptoms group, its range of motion improved noticeably postoperatively, and by 6 months, there were no significant differences between the groups. There were no differences between the groups for forward flexion (Figure 1D).

External rotation strength in the shorter symptoms cohort was higher than that in the longer symptoms cohort at 6 weeks postoperatively (mean \pm SD, 43 ± 2 vs 33 ± 3 N; $P = .01$). This trend was further continued with regard to adduction strength at 6 weeks postsurgery (61 ± 3 vs 47 ± 5 N; $P = .01$). By 6 months, internal rotation was greater in the shorter symptoms group compared with the longer symptoms group (65 ± 3 vs 49 ± 5 N; $P = .01$). Patient-ranked stiffness and shoulder satisfaction were similar between the cohorts preoperatively and throughout the postoperative period. The shorter symptoms group experienced greater shoulder satisfaction at 6 weeks postoperatively ($P = .02$). There was no significant difference at 6 months in patient-reported stiffness between the shorter symptoms and the longer symptoms groups (1.4 vs 1.75 ; $P = .14$). No differences were seen for other strength tests at 6 weeks or 6 months. The shorter symptoms group improved more quickly in external rotation and adduction.

Table 1 provides a comparison of strength between the cohorts.

Regression Analysis

Change in External Rotation. Multiple linear regression analyses were used to determine the variables with the greatest independent effect on the change in external

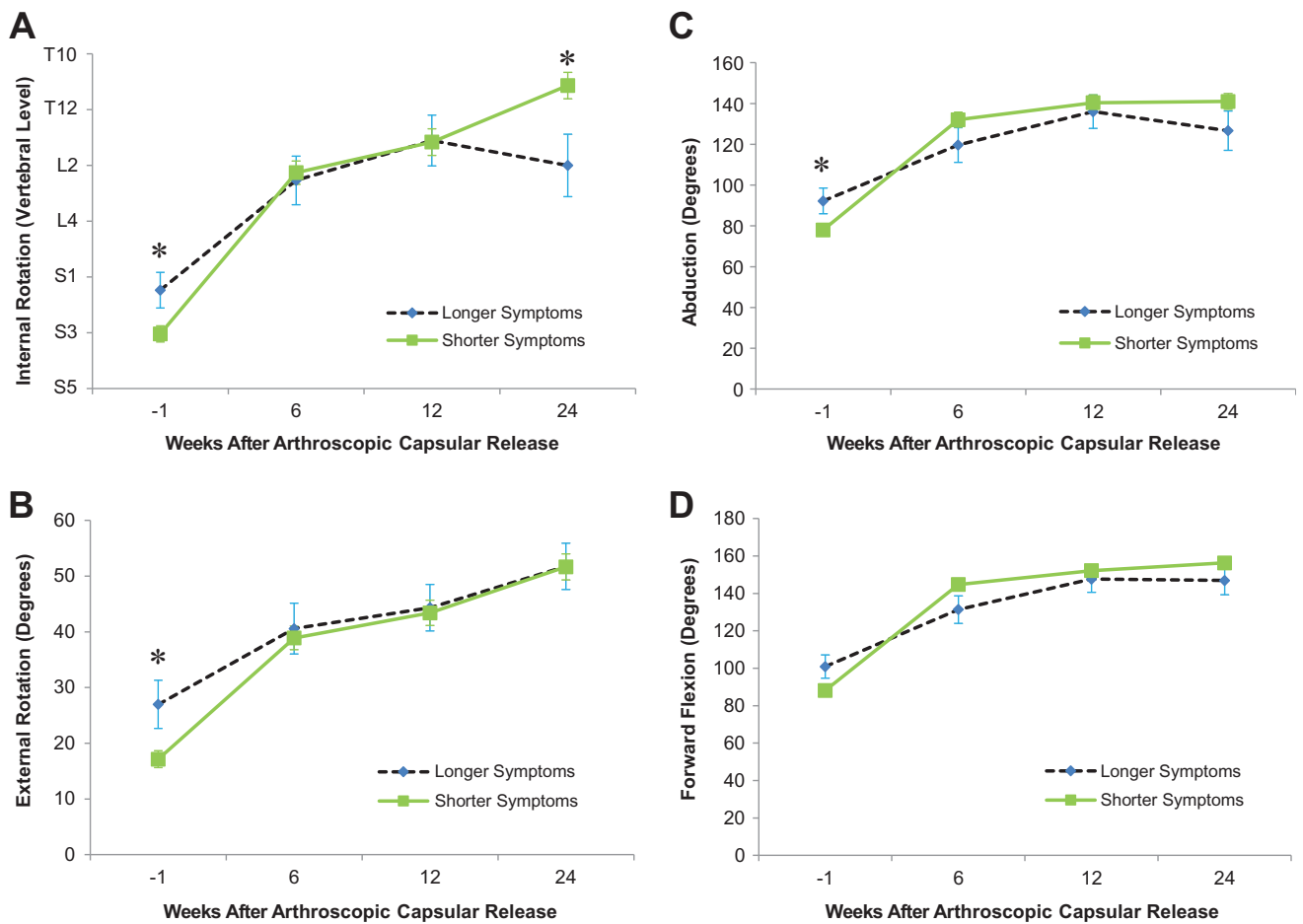


Figure 1. Range of motion in (A) internal rotation, (B) external rotation, (C) abduction, and (D) forward flexion measured preoperatively until 6 months after surgery in the shorter and longer symptoms cohorts. Values are presented as mean ± SEM. **P* < .05 between cohorts.

TABLE 1
Comparison of Strength in the Shorter vs Longer Symptoms Cohorts^a

Strength at 6 mo, N	Shorter Symptoms (n = 131)	Longer Symptoms (n = 38)	<i>P</i> Value
External rotation	56 ± 3	46 ± 5	.11
Supraspinatus	48 ± 3	38 ± 4	.07
Adduction	71 ± 4	54 ± 6	.03
Internal rotation	65 ± 3	49 ± 5	.01
Liftoff	36 ± 3	28 ± 5	.18

^aValues are expressed as mean ± SEM.

rotation; significant variables included younger age (*P* = .004), decreasing preoperative external rotation (*P* < .001), and increasing preoperative internal rotation (*P* = .001). Duration of symptoms (*P* = .52), operative time (*P* = .3), preoperative abduction (*P* = .22), preoperative forward flexion (*P* = .87), sex (*P* = .45), capsular release

versus manipulation under anesthesia (*P* = .5), and left versus right shoulder (*P* = .51) demonstrated no significance to the change in external rotation when assessed by regression. The independent predictive variables could be combined for predicting the change in external rotation.

$$\begin{aligned}
 \text{Change in external rotation} &= 84.203 \\
 &- (0.699 \times \text{age at surgery in years}) \\
 &- (0.969 \times \text{preoperative external rotation in degrees}) \\
 &+ (1.888 \times \text{preoperative internal rotation in number of vertebral levels}).
 \end{aligned}$$

This model had a fit for the raw data in our study, with a correlation coefficient of 0.77.

Change in Patient-Ranked Stiffness. Three variables demonstrated an effect on the change in patient-ranked stiffness 6 months after surgery when entered into a linear regression analysis: increasing preoperative external rotation (*P* = .003), sex (male; *P* = .004), and left versus right shoulder (left; *P* = .038). No other variables were significant. The independent predictive variables could be

combined for predicting the change in patient-ranked stiffness.

$$\begin{aligned} \text{Change in patient-ranked stiffness} &= -2.381 \\ &+ (0.723 \times \text{sex}^{**}) \\ &+ (0.505 \times \text{left or right}^{***}) \\ &+ 0.0179 \times \text{preoperative external rotation in degrees).} \end{aligned}$$

**Female = 0, male = 1

***Right = 0, left = 1

This model had a good fit with our raw data and a correlation coefficient of 0.52.

Change in Overall Shoulder Satisfaction. Linear regression also revealed that 2 independent variables had a significant effect on the change in the patients' overall shoulder satisfaction 6 months after surgery: decreasing preoperative external rotation ($P < .001$) and increasing preoperative forward flexion ($P = .045$). No other factors demonstrated any significance when assessed by regression. The independent predictive variables could be combined for predicting the change in overall shoulder satisfaction.

$$\begin{aligned} \text{Change in overall shoulder satisfaction (C)} &= 1.704 \\ &+ (0.00851 \times \text{preoperative forward flexion in degrees}) \\ &- (0.0227 \times \text{preoperative external rotation in degrees}). \end{aligned}$$

This model had a modest fit with our raw data and a correlation coefficient of 0.35. In this model, C may range from 0 to 4 (0 = very bad, 1 = bad, 2 = moderate, 3 = good, 4 = very good).

DISCUSSION

We hypothesized that capsular release undertaken during the early symptomatic stage of idiopathic adhesive capsulitis would provide less improvement in range of motion compared with surgery at a later stage; the hypothesis was refuted. This study found that patients with a shorter duration of symptoms (<10 months) showed greater improvement in internal rotation and similar improvements in other motions. Additionally, those with shorter symptoms had greater improvements in patient-ranked stiffness after arthroscopic capsular release for idiopathic adhesive capsulitis than those with a longer duration of symptoms.

In our study, both patients with a shorter duration of symptoms and those with a longer duration of symptoms experienced an improvement in range of motion, patient-ranked stiffness, and strength postoperatively. This finding is consistent with previous studies that demonstrated a significant impact on functional outcomes after arthroscopic capsular release.^{10,12,14,16}

To our knowledge, our study is the first to explore surgical outcomes based on which phase of adhesive capsulitis patients received surgery. Notably, patients with a duration of symptoms <10 months were more restricted in all planes of glenohumeral motion prior to surgery compared with those with symptoms lasting ≥ 10 months. In particular, external rotation was significantly reduced in the shorter symptoms cohort versus the longer symptoms cohort. Perhaps because they were more restricted prior to surgery, patients in the

shorter symptoms group demonstrated greater improvements in range of motion, most markedly in internal rotation. Furthermore, patients who underwent capsular release after a shorter duration of symptoms were also stronger in external rotation and adduction by 6 weeks postoperatively and in external rotation by 6 months postoperatively than those who had symptoms for ≥ 10 months, perhaps because those with long-term stiffness may have undergone more muscle disuse with subsequent atrophy. These marked improvements in functional outcomes in patients with frozen shoulders with a duration of symptoms <10 months suggest that it is beneficial, perhaps ideal, to perform surgery in the early stages of idiopathic adhesive capsulitis.

One of the primary aims was to determine which subsets of patients were most suitable for arthroscopic capsular release. Regression analysis revealed that the patients who demonstrated the greatest improvement in external rotation range of motion were those with decreased preoperative external rotation range of motion, increased internal rotation range of motion, and younger age. Patients who had the greatest improvement in patient-ranked stiffness were those with decreased preoperative external rotation range of motion, females, and those with a left-sided affected shoulder.

A major strength of this study was the cohort of 169 patients for 189 capsular releases. This represents, to our knowledge, the largest single study examining functional outcomes for idiopathic adhesive capsulitis. Another strength is that demographics and preoperative data were all collected prospectively with standardized, validated techniques. All surgical procedures were carried out by a single experienced surgeon.

A limitation was that the study was an evaluation of prospectively collected data from a single surgeon and a single center. Therefore, the results may not apply to other surgeons or centers. Furthermore, previous nonoperative treatment, complications, and medical comorbidities were not recorded. Another limitation is that the duration of symptoms were dependent on patient recall. Also, the arbitrary definition of 10 months may include patients in the freezing, frozen, and thawing categories. Finally, there was follow-up until only 6 months, a time point at which the range of motion gains had not yet plateaued.

CONCLUSION

This study identified that patients who underwent arthroscopic capsular release during the early clinical phase (<10 months) of idiopathic adhesive capsulitis demonstrated greater improvements in range of motion and strength 6 months after surgery compared with those who underwent surgery in a later phase of the disease course—so there is no reason to delay surgery. We also found that patients who benefit the most from this procedure include younger patients, females, and those with greater restriction in preoperative range of motion.

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