Midterm Outcomes After Arthroscopic Coracoid Decompression Combined With Manipulation for the Treatment of Frozen Shoulder Associated With Subcoracoid Impingement

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Research Article

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Abstract

Background

Patients with frozen shoulder (FS) suffer considerably, and some also present with subcoracoid impingement. However, effective treatments for frozen shoulder associated with subcoracoid impingement (FSASI) are limited. Primary purpose of this study was to introduce an arthroscopic coracoid decompression method combined with manipulation to treat FSASI and investigate its mid-term efficacy.

Methods

From April 2015 to May 2018, 177 patients with frozen shoulder who had no positive response to conservative therapy after a minimum of 6 months underwent arthroscopic coracoid decompression combined with manipulation. Shoulder condition was evaluated using the abbreviated Constant-Murley score (ACMS) and the modified University of California at Los Angeles Shoulder Rating Scale (MUCLA) preoperatively; at the 1st, 3rd, and 6th months postoperatively; and at the final follow-up (May 15, 2020).

Results

Eight patients were lost to follow-up, and 169 were included in the final analysis. The mean follow-up duration was 38.22 (range, 24–60) months. The ACMS improved from 16.39 ± 2.99 points (preoperative) to 72.08 ± 1.04 points at the last follow-up ($p < 0.001$). The MUCLA improved from 10.84 ± 0.71 points (preoperative) to 32.94 ± 0.74 points at the last follow-up ($p < 0.001$). Improvements in ACMS and MUCLA scores were significant in the first 3 months, then leveled off, and remained stable between the 6th month and the final follow-up. Recovery of forward flexion and abduction progressed synchronously, and almost full scores were achieved (9.96 ± 0.08 and 9.92 ± 0.11 points, respectively). Some patients lost ranges of motion: eight patients partially lost forward flexion and abduction, four partially lost external rotation, and fourteen partially lost internal rotation. The ACMS pain rating score improved from 1.12 ± 0.68 (preoperative) to 13.06 ± 0.71 points, and the MUCLA pain rating score improved from 1.67 ± 0.27 (preoperative) to 8.94 ± 0.43 points (last follow-up). Most improvements occurred in the first month after surgery. Timely pain improvement can effectively help patients improve sleep; complaints of sleep disturbance decreased significantly postoperatively. No complications or recurrence occurred.

Conclusion

Arthroscopic coracoid decompression combined with manipulation was an alternative method for treating FSASI, and satisfactory results were maintained through midterm follow-up.

Introduction

Frozen shoulder (FS) is a disease that often occurs in middle-aged and elderly persons. It is a common clinical condition characterized by progressively increasing pain and decreasing shoulder range of motion (ROM). The cause of FS may be idiopathic, or it may be secondary to a variety of clinical conditions, such as diabetes, thyroid and autoimmune diseases, rotator cuff tear, shoulder fracture, history of surgery, or rheumatologic diseases [1].

Subcoracoid impingement is the symptomatic impingement of the subscapularis tendon between the coracoid process and the humeral head. When the shoulder is in internal rotation, the coracoid process compresses the subscapularis tendon; thus, if the subcoracoid space is narrow, impingement of the subscapularis can lead to edema of the subscapularis bursa or even to subscapularis tendon tears [2–6]. Previous studies have identified subcoracoid impingement as a potential source of persistent shoulder pain and limited internal rotation of this joint [3–5]. The anatomy of the coracoid process changes with age, and the subcoracoid space is narrower in older individuals than in young people. As such, subcoracoid impingement becomes more prevalent with age [2]. Subcoracoid impingement is a clinical diagnosis supported by magnetic resonance imaging (MRI) findings: edema of the subscapularis bursa is a sign of subcoracoid impingement [6, 7]. In our clinical practice, we found that a proportion of patients with FS have concomitant subcoracoid impingement. We define this type of FS as a frozen shoulder associated with subcoracoid impingement (FSASI) for the present study.

FS is a commonly self-limiting disorder with a course of 1–3 years. However, during the disease course, patients are incapacitated and experience excruciating pain, insomnia, and may even feel anxious or depressed. A part of patients with FS continued to have shoulder ROM deficiencies and mild pain for a long time after the onset of initial symptoms compared with the action and sensation of the contralateral shoulder [8, 9]. Given these factors, many patients desire an immediate resolution of their symptoms, even if FS may spontaneously resolve in most of the patients [10].

There are many effective conservative treatments for FS, including physical therapy, non-steroidal anti-inflammatory drugs, intra-articular corticosteroid injection, and hydrodilation. Surgical options are generally reserved for patients with symptoms refractory to conservative management. These options include manipulation under anesthesia (MUA) and arthroscopic or open capsular release [11]. If the FS is associated with subcoracoid impingement, coracoid decompression is an effective and safe option, which can increase the subcoracoid space, helping to relieve the persistent shoulder pain and promote the recovery of internal rotation function [2, 12–16].

FSASI is rarely reported, and literature on its treatment is limited. Therefore, an investigation into the characteristics and treatment of this type of FS is warranted. In our study, we aimed to introduce coracoid decompression combined with manipulation to treat patients with FSASI and to investigate the midterm efficacy of this surgical approach.

Methods

Inclusion criteria

All patients underwent detailed physical examinations, shoulder X-rays, and MRIs for diagnosis. Inclusion criteria were as follows: (1) patients with FS, (2) patients with no positive response to conservative therapy after a minimum of 6 months [17], and (3) patients whose MRI suggested subcoracoid impingement. The exclusion criteria were as follows: (1) patients who were eventually diagnosed arthroscopically as not having subcoracoid impingement, (2) patients with FS secondary to diabetes, rheumatologic diseases, thyroid, and autoimmune diseases, (3) the presence of rotator cuff tear(s) or superior labral anterior and posterior lesions, (4) previous trauma or surgery, and (5) patients with moderate-to-severe glenohumeral osteoarthritis. From April 2015 to May 2018, 177 patients met the inclusion criteria (Fig. 1).

Surgical techniques

All patients underwent a standardized procedure under general anesthesia in the lateral decubitus position. Anatomic structures and arthroscopic portals were marked before the operation. A gentle MUA was first performed to improve a part of the ROM of the shoulder. The posterior viewing portal was created approximately 2 cm medial and inferior from the posterolateral corner of the acromion. An anterolateral portal was then made approximately 1.5 cm lateral to and in line with the acromion border (Fig. 2.A) [18]. We inserted a 30° arthroscope through the portals to examine the joint and rotator cuff tendons and recorded the pathological findings. An anterior portal was created approximately 1 cm lateral to the coracoid process under arthroscopic supervision (Fig. 2.A). Before creating the anterior portal, a 20-mL syringe needle was used as a guide to provide access to the rotator interval (Fig. 2.B).

Hyperemic, hyperplastic, and scar tissues around the subscapularis were removed using a 90° radiofrequency pulse (Fig. 3.A-B). The coracoid process was then exposed. Impingement of the coracoid against the subscapularis tendon and lesser tuberosity was confirmed by manipulating the arm in a combination of forward flexion, adduction, and internal rotation [19]. After coracoid impingement has been confirmed, coracoid decompression was performed until external and internal rotation ranges of motion of the arm demonstrated adequate decompression (Fig. 3.C-D). After the operation, the patient's shoulder was gently manipulated again in all directions to ensure that its ROM was the same as that of the healthy shoulder (Fig. 3.E).

Rehabilitation program

The rehabilitation protocol [9] was initiated on the first day after the procedure. Patients were encouraged to perform active and passive ROM exercises in all directions. The range and frequency of exercise increased gradually, according to each patient's recovery progress. Progressive resistance exercises were encouraged to enhance muscle strength. An arm sling and ice compress treatment were used at rest (Fig. 3.F). A month after the operation, patients were permitted to remove the arm sling and resume daily activities.

Evaluation

The abbreviated Constant-Murley score (ACMS; full score, 75) and the modified University of California at Los Angeles Shoulder Rating Scale (MUCLA; full score, 35) were used to evaluate the shoulder condition of each patient [15, 20]. The ACMS and MUCLA assessments were performed preoperatively, at 1, 3, and 6 months postoperatively, and at the final follow-up (May 15, 2020). The assessments were documented by two doctors who were blinded to the study details. (Please refer to the supplementary materials for the assessment forms used.)

Institutional review board approval

This study was conducted following the principles of the Declaration of Helsinki. The data reported from this study comply with the Consolidated Standards of Reporting Trials (CONSORT) statement.

Statistical analysis

All quantitative data were presented as means with 95% confidence intervals (95% CI). Student’s t-test was used to analyze differences between findings. Changes in preoperative and postoperative scores were tested using the paired t-test. $p < 0.05$ was considered statistically significant. All statistical analyses were performed using IBM SPSS Statistics version 21.0 (IBM Corp., Armonk, NY, USA), and the graphs were generated with GraphPad Prism version 7.04 (GraphPad Software Inc., CA, USA).

Results

Demographic and clinical characteristics

A total of 177 patients underwent arthroscopic coracoid decompression combined with manipulation for the treatment of FSASI. Eight patients were lost to follow-up, and 169 patients were included in the final analysis. The demographics of the remaining patients are shown in Table 1.

Table 1
Baseline demographic and clinical characteristics (n = 169)

Variable	Data
Age (years)	52.65 [41–64]
Sex	
Female	99 (58.58%)
Male	70 (41.42%)
Duration of symptoms (months)	10.12 [7–24]
Last follow-up (months)	38.22 (24–60)
Data are presented as mean (minimum-maximum) or n (%).	

Preoperative MRIs showed edema of the subscapularis bursa near the coracoid process in the patients. In some patients, the subscapularis muscle was compressed and showed morphological changes. Bone edema at the impingement site was also observed (Fig. 4.A). During the operation, we found synovial membrane hyperemia and hyperplasia around the subscapularis tendon, accompanied by scar hyperplasia (Fig. 3.A-B). At the 6th month after surgery, 20 patients underwent MRI reexaminations. The MRIs showed that the edema around the subscapularis tendon had significantly reduced or resolved (Fig. 4.B-C).

ACMS and MUCLA ratings

All subjects demonstrated improved ACMS and MUCLA scores after surgery (Table 2). Figure 5.A-B show that the trend of shoulder score improvement is consistent between the ACMS and MUCLA scores. Improvement was significant during the first 3 months. The magnitude of improvement then decreased, and the rating scores remained stable between the 6th month after surgery and final follow-up.

Table 2
Changes in ACMS and MUCLA score during follow-up

	Preoperative	1st month	3rd month	6th month	Last follow-up
ACMS	16.37 (13.38–19.36)	43.96 (40.13–47.79) ***	61.08 (58.02–64.14) ***	69.16 (67.36–70.96) ***	72.12 (71.10–73.15) ***
MUCLA	10.84 (10.13–11.54)	23.76 (22.49–25.02) ***	30.00 (28.80–31.20) ***	31.96 (30.97–32.95) ***	32.94 (32.20, 33.68) ***
The values presented are the ACMS and MUCLA score (95% confidence intervals).					
*** $p < 0.001$, compared with the postoperative score.					
ACMS, abbreviated Constant-Murley score; MUCLA, modified University of California at Los Angeles Shoulder Rating Scale.					

Movement

We used the movement component from the ACMS to evaluate the function of forward flexion, abduction, external rotation, and internal rotation motion (10 points each).[20] The forward flexion score improved from 3.92 ± 0.74 (preoperative) to 7.22 ± 0.62 (1st month), 9.06 ± 0.44 (3rd month), 9.71 ± 0.26 (6th month), and 9.96 ± 0.08 (last follow-up), with a $p < 0.001$. The abduction score improved from 3.67 ± 0.71 (preoperative) to 7.10 ± 0.63 (1st month; $p < 0.001$), 9.14 ± 0.42 (3rd month; $p < 0.001$), 9.67 ± 0.27 (6th month; $p < 0.001$), and 9.92 ± 0.11 (last follow-up; $p < 0.001$). The external rotation score improved from

0.82 ± 0.58 (preoperative) to 4.57 ± 1.06 (1st month; $p < 0.001$), 8.20 ± 0.82 (3rd month; $p < 0.001$), 9.47 ± 0.35 (6th month; $p < 0.001$), and 9.84 ± 0.16 (last follow-up; $p < 0.001$). The internal rotation score improved from 2.61 ± 0.61 (preoperative) to 5.27 ± 0.50 (1st month; $p < 0.001$), 7.47 ± 0.59 (3rd month; $p < 0.001$), 8.78 ± 0.42 (6th month; $p < 0.001$), and 9.35 ± 0.32 (last follow-up; $p < 0.001$).

As shown in Fig. 5.C-G, the recovery of forward flexion and abduction progressed synchronously, and almost full scores were achieved at the final follow-up (9.96 ± 0.08 and 9.92 ± 0.11 points, respectively). A full score ranges from 151° to 180° [20]; thus, a full score does not always mean that the patient recovered completely. Some patients ($n = 8$) still had complaints of forward flexion and abduction ranges that were not the same as those of their healthy shoulders: their forward flexion and abduction ROM at the final follow-up were $163.13^\circ \pm 7.04^\circ$ and $160.00^\circ \pm 8.65^\circ$, respectively. At the final follow-up, some patients still had limited external and internal rotation ROMs: 4 patients had a score of 8 in external rotation, 12 patients had a score of 8 in internal rotation (thumb pointing to the 12th dorsal vertebra), and 2 patients had a score of 6 in internal rotation (thumb pointing to the waist). However, the degree of loss was slight and did not affect their activities of daily living; all patients were satisfied with the ROM of their affected shoulders at the final follow-up.

Pain and sleep quality

We used the pain score subitems of the ACMS and MUCLA scales to assess pain. The ratings ranged from 0 to 15 points and from 0 to 10 points, respectively. In the ACMS pain rating, the score improved from 1.12 ± 0.68 (preoperative) to 9.69 ± 0.74 (1st month; $p < 0.001$), 11.73 ± 0.70 (3rd month; $p < 0.001$), 12.76 ± 0.73 (6th month; $p < 0.001$), and 13.06 ± 0.71 (last follow-up; $p < 0.001$), respectively. In the MUCLA pain rating scale, the score improved from 1.67 ± 0.27 (preoperative) to 5.96 ± 0.66 (1st month; $p < 0.001$), 8.04 ± 0.49 (3rd month; $p < 0.001$), 8.78 ± 0.44 (6th month; $p < 0.001$), and 8.94 ± 0.43 (last follow-up; $p < 0.001$), respectively.

Figure 5.H-I show that the trend of pain improvement was consistent in both pain scales, which suggested that pain relief was gradual and that most of the improvement occurred within the first month after surgery. Nocturnal pain is the leading cause of sleep disturbance in patients. With the resolution of pain, the patient's sleep state also gradually improved. Forty-five patients complained of sleep disturbances preoperatively, and the number decreased to 9 at the 1st month and to 1 at the 3rd month postoperatively. From the 6th month postoperatively, none of the patients had insomnia due to shoulder pain.

Patient satisfaction, complications, and recurrence

Forty-seven patients were satisfied with the operation, whereas the remaining two patients were dissatisfied. The latter two complained that the shoulder ROM recovery was slow. They did not follow our recovery plan because they experienced pain while performing it. They had limited improvement in shoulder ROM at 1 month after surgery. They were asked to comply with their prescribed rehabilitation exercises, and finally, they recovered their ROM at 2 and 2.5 years, respectively). However, they both went

through a long and painful recovery process. At the final follow-up, no complications or recurrence occurred in any of the patients.

Discussion

In our present study, we introduced a particular type of FS (FSASI) and a feasible method to treat the disease. FSASI was diagnosed in this study according to the symptoms of the patient, MRI, and arthroscopy examinations. We describe our experience with 169 patients with FSASI who required surgical management after conservative therapy alone failed. Over an average of 38 months after surgery, the patients improved significantly in key areas such as pain and functionality. Our results showed that arthroscopic coracoid decompression combined with manipulation is an alternative method for FSASI. The procedure had few complications, the rates of recurrence were low, and patient satisfaction was high. This study contributes to the limited literature on therapeutic interventions for FSASI.

Arthroscopic capsular release is a conventional, minimally invasive method for the treatment of FS. However, the optimal method for capsular release remains controversial [11]. Although the “360° total capsular release” allows for a complete release of the contracted capsule and provides immediate improvements in ROM, this technique may lead to axillary nerve injury [21–25]. Studies have shown that the rotator interval is the primary site of pathology in FS. The release of the rotator cuff space, combined with the inferior capsule release, provides a significant improvement in ROM [26]. Some other studies have indicated that the lower capsule release should be avoided to prevent axillary nerve injury. Many surgeons release only the rotator cuff interval and the contracted coracohumeral ligament; they report positive outcomes [27–29]. In our study, we performed a finite release of the rotator interval: we cleaned the pathological tissues covering the subscapularis and rotator interval as well as a part of the anterior articular capsule and the medial glenohumeral ligament, which was performed before the coracoid decompression. After the finite release, we found that it was insufficient for restoring full ROM; hence, we followed this procedure with MUA.

MUA is often used to treat FS when conservative treatments have failed. MUA can provide improvement of shoulder function [30, 31]. However, sometimes MUA is subject to great resistance because of joint adhesion, and aggressive manipulation may result in iatrogenic lesions, including hemarthrosis, superior labral anterior and posterior lesions, rotator cuff tears, and humeral or glenoid fractures. Arthroscopic release before MUA may decrease the incidence of these complications [32, 33]. We found a gentle manipulation could easily restore the patient’s ROM after arthroscopic coracoid decompression.

In summary, our treatment method is a combination and refinement of previously reported techniques [27–29, 31–33]. The axillary nerve injury resulting from a wide range of capsule release and iatrogenic injuries resulting from aggressive manipulation are avoided with our method. Meanwhile, coracoid decompression can increase the subcoracoid space, helping to relieve shoulder pain and promote the recovery of internal rotation function [19, 34].

In our study, we used ACMS and MUCLA scales to evaluate the patients. The ACMS scale excluded the strength subitem of the Constant-Murley score because the strength score was based on the weight of pull that a patient could resist in 90° of abduction, and this subitem does not apply to patients with FS [20, 35, 36]. As a supplement, we used the MUCLA scale to evaluate strength by testing forward flexion with manual muscle testing. In addition, the MUCLA scale evaluates pain and function according to different evaluation criteria and considers patient satisfaction. The MUCLA and ACMS scales complement each other and together reflect the symptoms and progress during recovery.

Limitations

The evaluation method we used has limitations. First, the full scores of forward flexion and abduction represent 151–180°; thus, a full score does not necessarily mean that patients recover completely. Moreover, the external rotation outcome in the ACMS reflects a functional movement that combines external rotation, forward flexion, and abduction. Pure external rotation was not assessed [37]. Although our results indicate that our surgical approach was effective and that most patients were satisfied with the rehabilitation process and the eventual outcome, the recovery of ROM was time-dependent, and a slight degree of loss in ROM may occur. As mentioned in the results, two patients were not satisfied with the operation. The lesson we learned from these two patients was that because we performed a finite release, postoperative rehabilitation exercise is essential, especially in the 1st month after surgery. Otherwise, ROM can be difficult to recover.

In addition, although the clinical manifestations of coracoid impingement and its association with FS are well established [1], the causal relationship between FS and subcoracoid impingement remains controversial [5, 38, 39]. Some authors propose that progressive osteoproliferation of the coracoid process caused by constant friction during the internal rotation leads to collagen fibers' thickening. They described coracoid impingement as a potential etiology of shoulder pain, limited ROM, and subscapularis tears [3–5]. Conversely, some authors argue that subcoracoid impingement is a consequence rather than a cause of FS, and they proposed that rotator interval lesions and the contracture of the capsule reduced the subcoracoid space, resulting in further impingement in patients with FS [40, 41]. This remains an important topic for future study.

Lastly, although we introduced a novel method to treat FSASI and found the procedure was effective, we did not use a randomized controlled trial to prove superiority over other methods. In future studies, randomized controlled trials are needed to compare our surgical approach with other treatment methods.

Conclusion

Arthroscopic coracoid decompression combined with MUA was an alternative method to treat FSASI when coupled with a rehabilitation program, and the satisfactory results were maintained through midterm follow-up. Randomized controlled trials are required to determine the treatment regimen that is superior for patients with FSASI.

Abbreviations

FS

Frozen shoulder

FSASI

Frozen shoulder associated with subcoracoid impingement

ACMS

The abbreviated Constant-Murley score

MUCLA

The modified University of California at Los Angeles Shoulder Rating Scale

ROM

Range of motion

MRI

Magnetic resonance imaging

MUA

Manipulation under anesthesia

CI

Confidence intervals

Declarations

Ethics approval and consent to participate

The study is approved by the Institutional Review Board (IRB) of Tongji Medical College (No.S498). Each author certifies that all the investigations were conducted in conformity with ethical principles. All the patients provided written informed consent for the study.

Consent for publication

Written informed consent for publication of images was obtained from the participants.

Availability of data and materials

The datasets supporting the conclusion of this article are included within the article. Upon request, raw data can be provided by the corresponding author.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Shengyang Jin and Hong Wang contributed to the idea of the study. Shengyang Jin and Xiaohong Wang designed the study. Hong Wang performed all the operations. Chunqing Meng and Yu He participated in the operations as surgical assistants. Wei Huang and Ze Wang assessed the scores preoperative and postoperative. Yu He and Chunqing Meng analyzed the data. Shengyang Jin drafted the paper. Xiaohong Wang substantially revised the paper. Hong Wang gave the final approval of the version to be submitted. All authors have read and approved the final manuscript. Shengyang Jin and Xiaohong Wang contributed equally to this work.

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References

1. Mohammed H, Skalski MR, Patel DB, Tomasian A, Schein AJ, White EA, et al. Coracoid Process: The Lighthouse of the Shoulder. *Radiographics*. 2016;36(7):2084-101.
2. Dugarte AJ, Davis RJ, Lynch TS, Schickendantz MS, Farrow LD. Anatomic Study of Subcoracoid Morphology in 418 Shoulders: Potential Implications for Subcoracoid Impingement. *Orthop J Sports Med*. 2017;5(10):2325967117731996.
3. Dumontier C, Sautet A, Gagey O, Apoil A. Rotator interval lesions and their relation to coracoid impingement syndrome. *Journal of shoulder and elbow surgery*. 1999;8(2):130-5.
4. Paulson MM, Watnik NF, Dines DM. Coracoid impingement syndrome, rotator interval reconstruction, and biceps tenodesis in the overhead athlete. *Orthop Clin North Am*. 2001;32(3).
5. Gerber C, Terrier F, Zehnder R, Ganz R. The subcoracoid space. An anatomic study. *Clinical orthopaedics and related research*. 1987(215):132-8.
6. Colas F, Nevoux J, Gagey O. The subscapular and subcoracoid bursae: descriptive and functional anatomy. *J Shoulder Elbow Surg*. 2004;13(4):454-8.
7. Giaroli EL, Major NM, Lemley DE, Lee J. Coracohumeral interval imaging in subcoracoid impingement syndrome on MRI. *AJR Am J Roentgenol*. 2006;186(1):242-6.
8. Manske RC, Prohaska D. Diagnosis and management of adhesive capsulitis. *Curr Rev Musculoskelet Med*. 2008;1(3-4):180-9.
9. Ranalletta M, Rossi LA, Zaidenberg EE, Campos C, Ignacio T, Maignon GD, et al. Midterm Outcomes After Arthroscopic Anteroinferior Capsular Release for the Treatment of Idiopathic Adhesive Capsulitis. *Arthroscopy*. 2017;33(3):503-8.
10. Watson L, Dalziel R, Story I. Frozen shoulder: a 12-month clinical outcome trial. *Journal of shoulder and elbow surgery*. 2000;9(1):16-22.

11. Le HV, Lee SJ, Nazarian A, Rodriguez EK. Adhesive capsulitis of the shoulder: review of pathophysiology and current clinical treatments. *Shoulder Elbow*. 2017;9(2):75-84.
12. Chuaychoosakoon C, Suwanno P, Klabklay P, Sinchai C, Duangnumsawang Y, Suwannapisit S, et al. Proximity of the Coracoid Process to the Neurovascular Structures in Various Patient and Shoulder Positions: A Cadaveric Study. *Arthroscopy*. 2019;35(2):372-9.
13. Kleist KD, Freehill MQ, Hamilton L, Buss DD, Fritts H. Computed tomography analysis of the coracoid process and anatomic structures of the shoulder after arthroscopic coracoid decompression: a cadaveric study. *J Shoulder Elbow Surg*. 2007;16(2):245-50.
14. Lo IKY, Parten PM, Burkhart SS. Combined subcoracoid and subacromial impingement in association with anterosuperior rotator cuff tears: An arthroscopic approach. *Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association*. 2003;19(10):1068-78.
15. Ellman H, Kay SP. Arthroscopic subacromial decompression for chronic impingement. Two- to five-year results. *The Journal of bone and joint surgery British volume*. 1991;73(3):395-8.
16. Valadie AL, Jobe CM, Pink MM, Ekman EF, Jobe FW. Anatomy of provocative tests for impingement syndrome of the shoulder. *Journal of shoulder and elbow surgery*. 2000;9(1):36-46.
17. Neviaser AS, Neviaser RJ. Adhesive capsulitis of the shoulder. *J Am Acad Orthop Surg*. 2011;19(9):536-42.
18. Karnaugh RD, Sperling JW, Warren RF. Arthroscopic treatment of coracoid impingement. *Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association*. 2001;17(7):784-7.
19. Lo IKY, Burkhart SS. Arthroscopic coracoplasty through the rotator interval. *Arthroscopy : the journal of arthroscopic & related surgery : official publication of the Arthroscopy Association of North America and the International Arthroscopy Association*. 2003;19(6):667-71.
20. Vrotsou K, Avila M, Machon M, Mateo-Abad M, Pardo Y, Garin O, et al. Constant-Murley Score: systematic review and standardized evaluation in different shoulder pathologies. *Qual Life Res*. 2018;27(9):2217-26.
21. Le Lievre HM, Murrell GA. Long-term outcomes after arthroscopic capsular release for idiopathic adhesive capsulitis. *J Bone Joint Surg Am*. 2012;94(13):1208-16.
22. Georgiannos D, Markopoulos G, Devetzi E, Bisbinas I. Adhesive Capsulitis of the Shoulder. Is there Consensus Regarding the Treatment? A Comprehensive Review. *Open Orthop J*. 2017;11:65-76.
23. Jerosch J. 360 degrees arthroscopic capsular release in patients with adhesive capsulitis of the glenohumeral joint—indication, surgical technique, results. *Knee Surg Sports Traumatol Arthrosc*. 2001;9(3):178-86.
24. Jerosch J, Nasef NM, Peters O, Mansour AMR. Mid-term results following arthroscopic capsular release in patients with primary and secondary adhesive shoulder capsulitis. *Knee Surgery, Sports Traumatology, Arthroscopy*. 2012;21(5):1195-202.

25. Lafosse L, Boyle S, Kordasiewicz B, Aranberri-Gutierrez M, Fritsch B, Meller R. Arthroscopic arthrolysis for recalcitrant frozen shoulder: a lateral approach. *Arthroscopy*. 2012;28(7):916-23.
26. Snow M, Boutros I, Funk L. Posterior arthroscopic capsular release in frozen shoulder. *Arthroscopy*. 2009;25(1):19-23.
27. Berghs BM, Sole-Molins X, Bunker TD. Arthroscopic release of adhesive capsulitis. *J Shoulder Elbow Surg*. 2004;13(2):180-5.
28. Holloway GB, Schenk T, Williams GR, Ramsey ML, Iannotti JP. Arthroscopic capsular release for the treatment of refractory postoperative or post-fracture shoulder stiffness. *The Journal of bone and joint surgery American volume*. 2001;83(11):1682-7.
29. Baums MH, Spahn G, Nozaki M, Steckel H, Schultz W, Klinger HM. Functional outcome and general health status in patients after arthroscopic release in adhesive capsulitis. *Knee Surg Sports Traumatol Arthrosc*. 2007;15(5):638-44.
30. Rangan A, Brealey SD, Keding A, Corbacho B, Northgraves M, Kottam L, et al. Management of adults with primary frozen shoulder in secondary care (UK FROST): a multicentre, pragmatic, three-arm, superiority randomised clinical trial. *The Lancet*. 2020;396(10256):977-89.
31. Dodenhoff RM, Levy O, Wilson A, Copeland SA. Manipulation under anesthesia for primary frozen shoulder: effect on early recovery and return to activity. *Journal of shoulder and elbow surgery*. 2000;9(1):23-6.
32. Magnussen RA, Taylor DC. Glenoid fracture during manipulation under anesthesia for adhesive capsulitis: a case report. *J Shoulder Elbow Surg*. 2011;20(3):e23-6.
33. Loew M, Heichel TO, Lehner B. Intraarticular lesions in primary frozen shoulder after manipulation under general anesthesia. *Journal of shoulder and elbow surgery*. 2005;14(1):16-21.
34. Okoro T, Reddy VR, Pimpelnarkar A. Coracoid impingement syndrome: a literature review. *Curr Rev Musculoskelet Med*. 2009;2(1):51-5.
35. Constant CR, Murley AH. A clinical method of functional assessment of the shoulder. *Clinical orthopaedics and related research*. 1987(214):160-4.
36. Othman A, Taylor G. Is the constant score reliable in assessing patients with frozen shoulder? 60 shoulders scored 3 years after manipulation under anaesthesia. *Acta Orthop Scand*. 2004;75(1):114-6.
37. Constant CR, Gerber C, Emery RJ, Sojbjerg JO, Gohlke F, Boileau P. A review of the Constant score: modifications and guidelines for its use. *J Shoulder Elbow Surg*. 2008;17(2):355-61.
38. Watson AC, Jamieson RP, Mattin AC, Page RS. Magnetic resonance imaging based coracoid morphology and its associations with subscapularis tears: a new index. *Shoulder Elbow*. 2019;11(1 Suppl):52-8.
39. Park JY, Lhee SH, Oh KS, Kim NR, Hwang JT. Is arthroscopic coracoplasty necessary in subcoracoid impingement syndrome? *Arthroscopy*. 2012;28(12):1766-75.

40. Nové-Josserand L, Boulahia A, Levigne C, Noel E, Walch G. [Coraco-humeral space and rotator cuff tears]. Rev Chir Orthop Reparatrice Appar Mot. 1999;85(7):677-83.
41. Hunt SA, Kwon YW, Zuckerman JD. The rotator interval: anatomy, pathology, and strategies for treatment. J Am Acad Orthop Surg. 2007;15(4):218-27.

Figures

Figure 1

Flowchart of patients throughout the study

Figure 2

(A) Establishment of surgical portals: (1) the posterior portal was used as the arthroscopic viewing portal, and the anterolateral portal was used (2) for examining the rotator cuff tendons and (3) for pathological tissue cleaning and coracoid decompression. (B) A 20-mL syringe needle was used as a guide to provide access to the rotator interval. The white star indicates hyperemia and hyperplastic tissue.

Figure 3

Surgical procedure and postoperative management. (A) Hyperemic, hyperplastic, and fibrous scar tissues surrounding the subscapularis tendon. (B) Clearing of the pathological tissue surrounding the subscapularis tendon (blue star). (C) Exposure of the coracoid process (black triangle). (D) Coracoid decompression. (E) Manipulation. (F) An arm sling (white arrow) and ice compress (red arrow) provided postoperatively.

Figure 4

Magnetic resonance imaging (MRI). (A, B) Typical preoperative MRI manifestations of the frozen shoulder associated with subcoracoid impingement. Red star, subscapularis bursa edema near the coracoid process; red arrow, subscapularis muscle being compressed and changed in shape; yellow arrow, bone edema at the impingement site. (C) MRI performed 6 months after surgery of a patient whose preoperative MRI manifestation is presented in B.

Figure 5

Quantitative analysis of preoperative and postoperative. (A) ACMS; (B) MUCLA score; (C) forward flexion, abduction, external rotation, and internal rotation scores; (D) forward flexion scores; (E) abduction scores; (F) external rotation scores; (G) internal rotation scores; (H) ACMS and (I) MUCLA pain rating scores. Data are presented as the mean with 95% confidence interval. * $p < 0.05$, ** $p < 0.001$, and *** $p < 0.001$. ACMS, abbreviated Constant-Murley score; MUCLA, modified University of California at Los Angeles Shoulder Rating Scale.

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