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The Influence of Arthroscopic Subscapularis Tendon and Capsule Release on Internal Rotation Strength in Treatment of Frozen Shoulder

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Background: Arthroscopic release of the capsule is a popular treatment option for chronic refractory frozen shoulder. Additional release of the intra-articular part of the subscapularis is controversial regarding possible impairment of subscapularis function.

Hypothesis: Arthroscopic release of the intra-articular part of the subscapularis produces good clinical results and does not lead to reduced internal rotation strength.

Study Design: Case series; Level of evidence, 4.

Methods: Twenty-two patients were retrospectively evaluated 53 months (range, 12-106) after undergoing arthroscopic anterior capsular release, including release of the intra-articular portion of the subscapularis. Clinical outcome was evaluated using the American Shoulder and Elbow Surgeons score and the Constant score. Isometric and isokinetic strength for internal and external rotation were determined at the time of follow-up in both shoulders using a Cybex dynamometer.

Results: The Constant score was improved significantly from 17.7 points to 82.8 points ($P < .0001$) and the American Shoulder and Elbow Surgeons score increased significantly from 23.5 points to 76.8 points ($P < .0001$). The mean range of motion was significantly improved for external rotation from 16° to 58°, from 66° to 142° for abduction, and from 76° to 155° for forward flexion. Isometric and isokinetic strength in the standard abduction position of the Cybex dynamometer showed no significant side-to-side difference.

Conclusion: Arthroscopic capsular release combined with a release of the intra-articular portion of the subscapularis tendon revealed good clinical results in the arthroscopic treatment of adhesive capsulitis without significant loss of internal rotation strength.

Keywords: frozen shoulder; subscapularis release; capsular release; isokinetic strength

The term "frozen shoulder" was first described by Codman in 1934 and describes a condition characterized by pain and reduced range of motion of the affected shoulder.[3] While its cause is still unknown, medical conditions such as diabetes, disorders of the thyroid, and hyperlipidaemia have been associated with a higher incidence of frozen shoulder. In the general population, the incidence of frozen shoulder has been estimated to be just above 2%.[7] Women between the ages of 40 and 60 years are affected more often.[15] Also, frozen shoulder has been known to occur after shoulder trauma and is a known complication of shoulder surgery.

Frozen shoulder is a self-limiting disease whose natural course involves resolution of pain and stiffness during the course of 6 to 24 months. The natural course of frozen shoulder can be subdivided into 3 stages. The "freezing" phase is characterized by the onset of pain and loss of motion.[19] In the "frozen" phase, pain usually subsides while stiffness of the shoulder reaches its maximum. This phase usually lasts between 4 and 9 months. In the final "thawing" phase, range of motion returns to normal during a period of up to 2 years.

This natural course must be considered when treatment options are evaluated. Management of frozen shoulder

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involves many different conservative and operative treatment options and remains controversial. Initial treatment is mostly conservative and can involve physiotherapy, cortisone injections, oral steroids, nerve blockade, or simple so-called "supervised neglect." Manipulation under anesthesia is a way of mobilizing the shoulder noninvasively and has been described by a number of authors.[1,5,6] However, a recent study confirms that the procedure can cause significant intra-articular damage.[10]

If conservative treatment fails, the contracted capsule can be released surgically in an open or arthroscopic fashion. Open procedures often require detachment of the subscapularis, possibly combined with a lengthening procedure of the subscapularis and incision and release of the anterior capsule.[8] Arthroscopic capsular release for frozen shoulder has become more popular, for it allows a visually controlled capsular release reducing danger of intra-articular damage. Good results of arthroscopic capsular release have been reported; however, the amount of capsular release of the intra-articular part of the subscapularis has been the subject of further investigations. Pearsall et al,[17,18] who performed a biomechanical and clinical study and showed good clinical results without adjacent instability symptoms, have advocated release of the intra-articular part of the subscapularis. Our own biomechanical evaluation of this technique showed that this part of the subscapularis functions as a restraint to anteroinferior translation primarily in the midrange of glenohumeral motion. Release of the subscapularis did not lead to a significant increase in translation above 90° where anterior instability would occur.[12] While we do not use subscapularis release in every case of frozen shoulder treated arthroscopically, we performed a release of the intra-articular part of the subscapularis in cases with severe frozen shoulder when no sufficient gain of external rotation could be achieved intraoperatively.

Isokinetic dynamometers have been used reliably to quantify rotational strength of the rotator cuff in the postoperative shoulder. In a recent study, isometric strength testing was also found to provide reliable information on the functional integrity of the rotator cuff.[11] Concerns about anterior instability and weakness in internal rotation after subscapularis release during the procedure have been raised. We therefore performed isokinetic and isometric strength testing with a Cybex 6000 dynamometer (Lumex Inc, Ronkonkoma NY) to quantify rotational strength after the subscapularis takedown.

The purpose of this study is to assess the clinical outcome of arthroscopic capsular release, including takedown of the intra-articular part of the subscapularis, and evaluate isokinetic and isometric internal and external rotation strength after this procedure.

MATERIALS AND METHODS

Participants

In a retrospective review, 22 patients were identified who had arthroscopic capsular release, including release of the intra-articular part of the subscapularis, for treatment of frozen shoulder between 1996 and 2004. Average age of the patients was 51.9 years at the time of surgery (range, 23-75 years). There were 10 women and 12 men. After an average follow-up of 52.5 months (range, 12-106 months) patients were examined by an independent observer. Clinical evaluation was performed with use of the Constant and Murley score as well as the American Shoulder and Elbow Surgeons (ASES) score. Patients were excluded if arthroscopy revealed any kind of intra-articular lesion or injuries visible from the subacromial space. All patients had an asymptomatic contralateral shoulder.

Surgical Technique

All patients received an interscalene nerve block preoperatively. They were operated in a beach-chair position. Before the procedure, examination under anesthesia was performed. The arthroscope was introduced through a standard posterior portal, and a diagnostic arthroscopy was performed. For the anterior capsular release, a second anterior portal was established about 1 cm proximal to the intra-articular part of the subscapularis and 1 cm lateral to the glenoid rim. After careful synovectomy on the anterior capsule and debridement of the labrum, a radiofrequency ablation electrode (VAPR; FA Mitek, Norderstedt, Germany) was introduced through the anterior portal to perform the capsular release. Starting at about the 1 o'clock position (for a right shoulder), the release was performed and involved takedown of the superior and middle glenohumeral ligament. The capsular release was continued to the 5 o'clock position, and examination of external rotation was performed. If an external rotation of 50° could not be achieved by capsular release alone, the intra-articular part of the subscapularis was subsequently released with the VAPR electrode (Figure 1). If the patient showed an internal rotation deficit, the release was continued on the posterior side after switching the arthroscope to the anterior portal with the VAPR electrode in the posterior portal. The posterior release was performed in the same fashion as anteriorly. After sufficient gain in range of motion was achieved, the procedure was completed by a subacromial arthroscopy with bursectomy and release of subacromial adhesions without acromioplasty or takedown of the coracoacromial ligament. Finally, patients received a careful mobilization of the shoulder.

Postoperatively mobilization of the patient's shoulder started at the day of surgery with passive range of motion exercises with the physiotherapist and a continuous passive motion device. No immobilizing sling or pillow was used at any time. The patients stayed in hospital for 1 week with the use of a continuous passive motion device several times a day.

Isokinetic and Isometric Strength Testing

Strength testing of the operated shoulder on the Cybex 6000 was performed against the healthy contralateral shoulder of the same individual as there was no healthy or otherwise operated control group in this study. Therefore the 2 groups of data acquired for statistical analysis were operated versus nonoperated shoulder in the same patient.

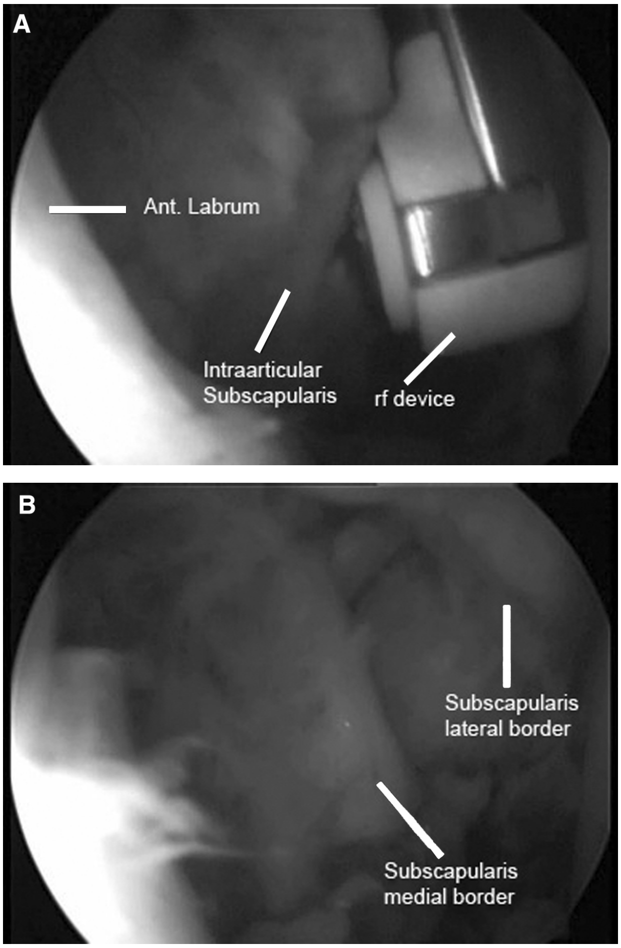

Figure 1. Arthroscopic view of subscapularis release.

Isokinetic and isometric strength testing were performed in a standardized fashion with a Cybex 6000. Patients were asked to warm up both shoulders sufficiently. Then they were introduced to the Cybex 6000, and the upcoming procedure was explained in detail. The tests were performed with the patient lying on his or her back with the arm in 90° of abduction (Figure 2). Isometric testing of internal rotation strength was tested first. From a fully externally rotated position, the patient was asked to internally rotate the arm with full force. This was repeated 5 times, with a break of 20 seconds between measurements. After these measurements, isokinetic strength was evaluated at an angular speed of 60° per second. The patient was asked to move the shoulder from maximum external to maximum internal rotation and back again 5 times. This was repeated at an angular speed of 90° per second. The nonoperated shoulder was tested first every time.

Statistical Analysis

Statistical analysis was performed using statistical software SPSS Version 13.0. (SPSS Inc, Chicago, Ill). Level of significance was set at .05. Preoperative and postoperative nonparametric data from both groups were analyzed using the Wilcoxon signed rank test. Comparisons between the operated and nonoperated shoulder were performed using the Wilcoxon signed rank as well.

Figure 2. Cybex 6000 strength testing in 90° of abduction in the prone position.

RESULTS

Patient Demographics

The cause of the frozen shoulder was idiopathic in 11 patients (50%). None of the above-mentioned associated medical conditions or any sort of trauma could be found for this group. Eight patients (7 men, 1 woman) reported some form of trauma preceding the frozen shoulder. Two of these 8 patients had direct trauma to their shoulder, while the remaining 6 patients had an indirect trauma with hyperextension of the shoulder. No fractures were reported. Three patients had an anterior dislocation or subluxation of the shoulder as result of the hyperextension trauma. None of these patients suffered from symptomatic instability of the shoulder. Intraoperatively, no Bankart lesion or other intra-articular lesion was found in these patients. Three other patients suffered from insulin-dependent diabetes mellitus and had no history of trauma preceding the onset of symptoms. Between the idiopathic, the diabetic, and the posttraumatic group, no significant difference in clinical outcome or postoperative range of motion could be identified. The dominant shoulder was involved 13 times (59.1%), the nondominant shoulder 9 times (41.9%). This had no influence on the clinical outcome. Patients' ability to perform sports was evaluated on a 0 (no problem) to 10 (not possible) point scale and was significantly improved from 7.05 points (±2.10) to 3.00 points (±2.41). However, only 3 patients were involved in sports directly affecting the shoulder.

Range of Motion

Range of motion was improved significantly in all measured planes. In forward flexion, range of motion improved from 76° ± 40° preoperatively to 155° ± 26° postoperatively ($P <$ .001). Abduction significantly improved from 66° ± 31° to 142° ± 43° ($P <$ .0001), external rotation from 16° ± 13° to 58° ± 24° ($P <$ .0001), and internal rotation from 33° ± 23° to 64° ± 10° ($P <$ .0001). This equals an improvement of 79° for forward flexion, 76° for abduction, 42° for external rotation, and 31° for internal rotation.

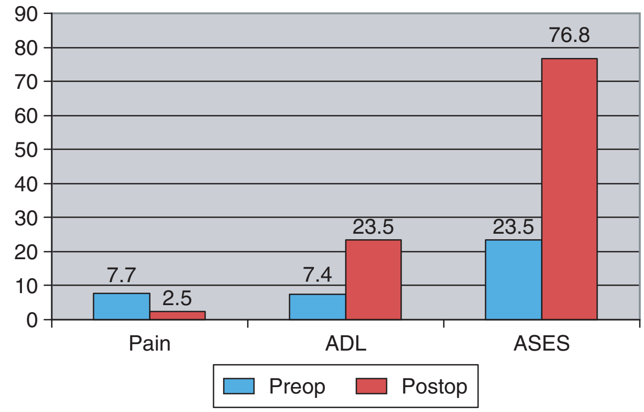

Figure 3. Preoperative and postoperative ASES score.

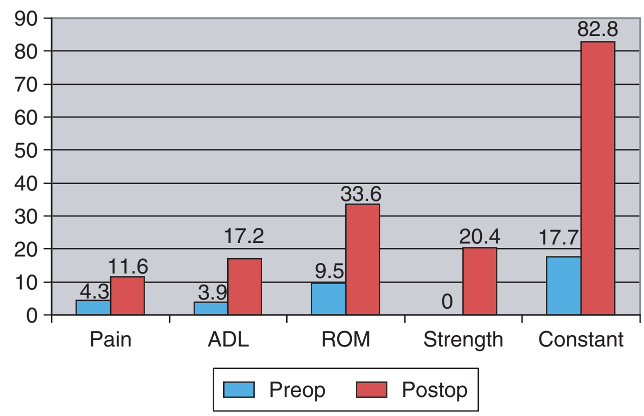

Figure 4. Preoperative and postoperative Constant score.

Outcome Scores

Pain scores for the ASES score were significantly reduced from 7.7 points (±2.0) to 2.5 points (±2.2) ($P < .0001$) (Figure 3). Combined activities of daily living scores were significantly improved from 7.4 points (±4.8) to 23.5 points (±5.8) ($P < .0001$). Overall, the ASES score was significantly improved from 23.5 points (±14.3) to 76.8 points (±19.2) ($P < .0001$). All parameters of the Constant score were significantly improved postoperatively (Figure 4). Pain was improved from 4.3 to 11.6 points ($P < .0001$), Points for "activities of daily living" were improved from 3.9 to 17.2 ($P < .0001$). Range of motion was significantly improved from 9.5 to 33.6 points ($P < .0001$). None of the patients was able to abduct the arm to 90°, so preoperatively strength was evaluated with 0 points in all cases. At follow-up, points for abduction strengths were 20.4, which was a significant improvement ($P < .0001$). Overall, the Constant score improved significantly from 17.7 points to 82.8 points ($P < .0001$).

Isokinetic Testing

Isokinetic strength testing for internal rotation revealed no significant differences for internal rotation strength when the operated and nonoperated shoulders were compared. The measured torque values for internal rotation at 60 deg/s were 19.2 N·m (±10.7) for the operated and

TABLE 1
Isokinetic Strength Measured With Cybex Dynamometer (N·m)[a]

	60 deg/s				
	Min	Max	Average	±	*P* Value[b]
ERO healthy	1	34	18.38	10.35	
ERO OP	2	33	15.29	9.06	.0665
IRO healthy	2	40	18.76	10.43	
IRO OP	4	43	19.24	10.69	.6761
	90 deg/s				
	Min	Max	Average	±	*P* Value[b]
ERO healthy	1	28	15.05	8.56	
ERO OP	1	27	12.48	8.05	.1026
IRO healthy	2	34	16.67	9.72	
IRO OP	1	39	15.90	10.59	.7222

[a]Min, minimum; Max, maximum; ERO, external rotation; OP, operated shoulder compared with healthy shoulder; IRO, internal rotation.
[b]Significant if $P < .0500$.

TABLE 2
Isometric Strength (maximum and average) Measured With Cybex Dynamometer (N·m)[a]

	Min	Max	Average	±	*P* Value[b]
IRO healthy max	8	55	28.52	13.40	
IRO OP max	6	64	27.38	15.00	.8664
IRO healthy average	4	43	20.76	10.27	
IRO OP average	3	50	20.48	12.90	.7277

[a]Min, minimum; Max, maximum; IRO, internal rotation; OP, operated shoulder compared with healthy shoulder.
[b]Significant if $P < .0500$.

18.8 N·m (±10.4) for the nonoperated shoulder ($P = .676$). At 90 deg/s, the operated shoulder generated a torque of 15.9 N·m (±10.6) compared with 16.7 N·m (±9.7) ($P = .722$). For external rotation, differences between the operated and nonoperated shoulder were still below significance level. At 60 deg/s, external rotation torque was 15.3 N·m (±9.0) on the operated and 18.4 N·m (±10.3) on the nonoperated side ($P = .067$). At 90 deg/s, the operated side generated a torque of 12.5 N·m (±8.0) compared with 15.0 N·m (±8.6) ($P = .103$) (Table 1). No significant difference was noted when weight-adjusted values for rotation torque were calculated. Time for acceleration to the preset dynamometer speed was also not different at either 60 deg/s or 90 deg/s for internal or external rotation.

Isometric strength testing, which was only performed for internal rotation, showed no significant differences between the operated and nonoperated shoulder. The operated shoulder showed values of 27.4 N·m (±15.0) compared with 28.5 N·m (±13.4) on the nonoperated shoulder ($P = .866$) (Table 2).

Strength values were also analyzed according to hand dominance. There were no significant differences to be noted between patients with the dominant shoulder

TABLE 3
Isokinetic Strength Measured With Cybex Dynamometer (N·m) Comparison of Cases With the Dominant or Nondominant Shoulder Involved[a]

	60 deg/s		
	Dominant	Nondominant	*P* Value[b]
ERO healthy	16.67	19.33	.722
ERO OP	16.00	14.33	.722
IRO healthy	17.25	20.78	.593
IRO OP	20.75	17.22	.669
	90 deg/s		
	Dominant	Nondominant	*P* Value[b]
ERO healthy	14.00	16.44	.477
ERO OP	13.00	11.78	.859
IRO healthy	14.16	20.00	.226
IRO OP	17.33	14.00	.830

[a]ERO, external rotation; OP, operated shoulder compared with healthy shoulder; IRO, internal rotation.
[b]Significant if $P < .0500$.

TABLE 4
Isometric Strength (maximum and average) Measured With Cybex Dynamometer (N·m) Comparison of Cases With the Dominant or Nondominant Shoulder Involved[a]

	Dominant	Nondominant	*P* Value[b]
IRO healthy max	28.58	28.44	.866
IRO OP max	31.00	22.56	.188
IRO healthy average	21.58	19.67	.887
IRO OP average	23.83	10.98	.125

[a]IRO, internal rotation; OP, operated shoulder compared with healthy shoulder.
[b]Significant if $P < .0500$.

involved compared with those whose nondominant shoulder was involved (Tables 3 and 4).

DISCUSSION

Historically, arthroscopic capsular release does not involve takedown of the intra-articular part of the subscapularis. In 1986, Olgivie-Harris and Wiley[16] reported on their general use of shoulder arthroscopy in 439 patients for different shoulder injuries. For frozen shoulder, their technique included only release of the anterior part of the capsule to protect against axillary nerve injuries. Harryman et al[9] reported on results of 30 patients with refractory shoulder stiffness after an average of 20 months of conservative treatment. Their patients showed improvement as soon as the first day after surgery when motion of the affected shoulder had improved from 41% to 78% of the unaffected side. The final motion at an average follow-up of 33 months was 93% of the motion of the unaffected side. Three patients (10%) developed refractory stiffness; no difference was noted between diabetic and nondiabetic patients.[9] Warner et al[20] showed the effectiveness of releasing the posterior capsule arthroscopically either combined with anterior release in 6 of their 18 cases or as a selective procedure in 5 patients with reduced flexion and internal rotation. Both groups were able to improve their function significantly. In 1999, Pearsall et al[18] first looked at clinical results of anterior capsular release, including the intra-articular part of the subscapularis. In their study, 43 patients were followed and evaluated by a modified shoulder score. This indicated an average score of 19 points, with 13 indicating normal shoulder function and 65 indicating a completely disabled shoulder. The authors concluded that this method was effective and safe in treating frozen shoulder arthroscopically.[18] In 2000, a second study was released by this group in which the dimensions of the intra-articular part of the subscapularis were studied in a cadaveric model.[17] They found that the anterior-posterior diameter and cephalad-caudad height of the intra-articular subscapularis tendon represented 83% of the sagittal diameter and 25% of the total height of the subscapularis at the point of release. Overall, release of the intra-articular part of the subscapularis was not assessed to be harmful or produce anterior instability.[17] Marquardt et al[12] in a biomechanical evaluation showed that the intra-articular part of the subscapularis functions as a restraint to anteroinferior translation primarily in the midrange of glenohumeral motion. Release of the subscapularis did not lead to a significant increase in translation above 90°, where anterior instability would occur. Diwan and Murrell[4] directly compared anterior capsular release with and without release of the intra-articular part of the subscapularis. Intraoperatively, range of motion was inferior if the intra-articular part of the subscapularis was left intact. There was also a higher prevalence of recurrent stiffness in the group without subscapularis release. There were no complaints of weakness in internal rotation or lift-off power at 2 years. Power of lift-off was rated 5/5 in all patients in both groups at 2 years.[4] In accordance with the cited studies, our patient population showed significant increase in the outcome measures selected, which were the ASES and Constant scores. Range of motion was significantly increased as well. No complications were reported; no reoperation was necessary; none of the patients reported subjective instability. We therefore conclude that arthroscopic release of the anterior capsule in combination with subscapularis release can effectively treat cases of frozen shoulder refractory to conservative treatment. Whether it is more effective than capsular release without subscapularis release cannot be answered from our results.

The main goal of this study was to assess whether the release of the intra-articular part of the subscapularis as part of the capsular release procedure had a negative influence on internal rotation strength. Isokinetic dynamometers like the Cybex 6000 testing system have been used reliably to assess shoulder strength after surgery of the rotator cuff.[11] We chose cycle speeds of 60 deg/s and 90 deg/s in accordance with studies that looked at patients with shoulder injury rather than healthy subjects. The testing was performed in the supine position to isolate the shoulder and minimize the influence of trunk muscles on the strength testing. Overall, we found no data indicating inferior internal rotation strength in comparison with the healthy contralateral shoulder. Maximum strength was not significantly inferior after release of the subscapularis either for isokinetic or isometric strength testing. The influence of arm dominance has been the subject of several studies on isokinetic strength of the shoulder. Some authors have found no significant differences between the dominant and nondominant arm,[13,14] while others have found a difference of 10% in favor of the dominant side to be normal.[2] In our study, the dominant and nondominant arm were considered equal to allow comparison of the operated and nonoperated shoulder. The differences for maximum strength for internal rotation were below 10% for internal rotation in 60 deg/s and 90 deg/s. Therefore, we conclude that there was no significance regardless of hand dominance.

Limitations of this study include the fact that follow-up was longer than the natural history of the disease, which has to be taken into account when evaluating clinical outcome and range of motion results. This is, however, the case in most of the clinical studies cited above. Outcome was measured in 2 established shoulder-scoring systems. The fact that abduction strength was improved in the Constant score is of somewhat lesser significance, since abduction below 90° was scored with 0 points and this was the case in almost all patients. However, all other parameters were significantly improved as well. A known problem with isokinetic strength testing is that it cannot resemble natural movements of the tested joint. The influence of other muscle groups like the trunk muscles cannot be fully eliminated. However, we used a supine position in which the patient was fixed to the Cybex 6000 to eliminate this effect as much as possible.

In conclusion, an anterior capsular release with takedown of the intra-articular part of the subscapularis muscle leads to significantly improved clinical outcome and good patient satisfaction. Through reliable isokinetic and isometric strength testing, we were not able to show a negative influence on internal rotation strength. While superiority of subscapularis release cannot be proved, our results show that it can be performed safely, if needed, without producing subjective or objective loss of internal rotation strength.

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