Arthroscopic Subscapularis Tendon Repair
Technique and Preliminary Results

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Arthroscopic Subscapularis Tendon Repair: Technique and Preliminary Results

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Purpose: Our objective was to evaluate the preliminary results of 25 consecutive arthroscopic subscapularis tendon repairs.

Type of Study: Case series.

Methods: All 25 shoulders had longer than 3 months follow-up, with an average of 10.7 months (range, 3 to 48 months). The average age was 60.7 years (range, 41 to 78 years). The average time from onset of symptoms to surgery was 18.9 months (range, 1 to 72 months). The shoulders were evaluated using a modified UCLA score, Napoleon test, lift-off test, radiographs, and magnetic resonance imaging (MRI). Indications for surgery included clinical and/or MRI evidence of a rotator cuff tear. An arthroscopic suture anchor technique devised by the senior author (S.S.B.) was used for repair.

Results: UCLA scores increased from a preoperative average of 10.7 to a postoperative average of 30.5 (P < .0001). By UCLA criteria, excellent and good results were obtained in 92% of patients, with 1 fair and 1 poor result. Forward flexion increased from an average 96.3° preoperatively to an average 146.1° postoperatively (P = .0016). Eight of 9 patients with a positive Napoleon test had complete tears of the subscapularis. All 7 patients with a negative Napoleon test had a tear of the upper half only. The lift-off test could not be performed reliably due to pain or restricted motion in 19 of the 25 patients. Eight patients had isolated tears of the subscapularis. The remaining 17 patients had associated rotator cuff tears with an average total tear size of 5 # 8 cm. Ten patients had proximal migration of the humerus preoperatively. Eight of these 10 patients had durable reversal of proximal humeral migration following surgery. These 8 patients improved their overhead function from a preoperative “shoulder shrug” with attempted elevation of the arm to functional overhead use of the arm postoperatively.

Conclusions: (1) The senior author has been able to consistently perform arthroscopic repair of torn subscapularis tendons, with good and excellent results, in 92% of patients. (2) The Napoleon test is useful in predicting not only the presence of a subscapularis tear, but also its general size. (3) Combined tears of the subscapularis, supraspinatus, and infraspinatus tendons are frequently associated with proximal humeral migration and loss of overhead function. Arthroscopic repair of these massive tears can produce durable reversal of proximal humeral migration and restoration of overhead function.

Key Words: Subscapularis tendon—Rotator cuff tear—Arthroscopic repair—Proximal humeral migration.
Arthroscopic rotator cuff repair is being performed by orthopaedic surgeons with increasing frequency. The arthroscopic technique, originally thought to be applicable only to small tears of the supraspinatus, has been expanded and refined to the point that large and massive tears can be repaired arthroscopically. The notable exception to the expanded application of arthroscopic rotator cuff repair has been the case of the torn subscapularis. Arthroscopic subscapularis repair has not been previously reported.

In this report we present the preliminary results of arthroscopic repair of 25 consecutive subscapularis tears performed by the senior author (S.S.B.). In so doing, we intend to focus on 3 unique aspects of subscapularis tears: (1) Correlation of subscapularis function with a graded Napoleon test. (2) Techniques to overcome the formidable technical challenges of arthroscopic subscapularis repair. (3) Reversal of chronic proximal humeral migration by arthroscopic repair of 3-tendon tears involving the subscapularis, supraspinatus, and infraspinatus.

METHODS

The senior author performed 32 consecutive arthroscopic subscapularis repairs in 31 patients between August 1996 and May 2000. Twenty-five shoulders in 24 patients (1 bilateral) with longer than 3-month follow-up were evaluated by the junior author (A.M.T.). For the 25 shoulders with longer than 3-month follow-up, the average duration of follow-up was 10.7 months. These 25 shoulders constitute our study group. Six of the 25 patients had follow-up of more than 1 year. The average patient age was 60.7 years (range, 41 to 78 years). Fourteen repairs involved the right shoulder and 11 involved the left. Seventeen repairs were in men and 8 were in women. The most common mechanism of injury was resistance to an external rotation force with the shoulder in a position of abduction and external rotation. The average time from onset of symptoms to surgery was 18.9 months (range, 1 to 72 months). The shoulders were evaluated functionally by means of a modified University of California at Los Angeles (UCLA) score (Table 1). Other important factors in evaluation were the lift-off test, the Napoleon test, radiographs, and unenhanced magnetic resonance imaging (MRI). The Napoleon test (Fig 1) as described by Imhoff is a variation of the Gerber belly-press test. It is named after the position in which Napoleon held his hand (against the stomach) for portraits. We graded the Napoleon test as negative (normal) if the patient could push the hand against the stomach with the wrist straight; positive if the wrist flexed 90° while pushing against the stomach; and intermediate if the wrist flexed 30° to 60° when the patient pushed against the stomach (Fig 1). In the patient with a subscapularis tear, the reason that the wrist flexes as the patient attempts to push the hand against the stomach is that this maneuver allows the patient to harness the power of the posterior deltoid. 60° when the patient pushed against the stomach (Fig 1). In the patient with a subscapularis tear, the reason that the wrist flexes as the patient attempts to push the hand against the stomach is that this maneuver allows the patient to harness the power of the posterior deltoid. Ordinarily, one performs a belly-press by using the subscapularis to obtain nearmaximal internal rotation of the arm. With a subscapularis-deficient shoulder, the only way to perform a belly-press is to flex the wrist in order to orient the arm so that the posterior deltoid can perform this function. In our study, the Napoleon test could be performed in every patient, whereas the lift-off test was often too painful to perform.

For statistical analysis in this study, we used Pearson’s !-square test and the Fisher exact probability test.

Diagnostic arthroscopy was performed through a standard posterior viewing portal in every case. When a subscapularis tear was identified, it was repaired as the first stage in the repair sequence before repair of any other tendons. This prioritization of subscapularis repairs was done to maximize visualization in this very confined space.
Four portals were used for the procedure (Fig 2). The anterior portal was used for anchor placement and suture passage, the anterolateral portal was used for subscapularis mobilization and preparation of the bone bed, the accessory anterolateral portal was used for the traction sutures, and the posterior portal was used for the arthroscope. The anterolateral portal was placed just anterior to the biceps tendon, and the accessory anterolateral portal was placed just posterior to the biceps.

TABLE 1. Modified UCLA Scoring System

<table>
<thead>
<tr>
<th>Pain</th>
<th>Function</th>
<th>Active Forward Flexion</th>
<th>Strength of resisted external rotation (manual testing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present all of the time and unbearable; strong medication frequently 1</td>
<td>Unable to use limb 1</td>
<td>150° or more 5</td>
<td>Grade 5 (normal) 5</td>
</tr>
<tr>
<td>Present all of the time but bearable; strong medication occasionally 2</td>
<td>Only light activities possible 2</td>
<td>120° to 150° 4</td>
<td>Grade 4 (good) 4</td>
</tr>
<tr>
<td>None or little at rest, present during light activities; salicylates frequently 4</td>
<td>Able to do light housework or most activities of daily living 4</td>
<td>90° to 150° 3</td>
<td>Grade 3 (fair) 3</td>
</tr>
<tr>
<td></td>
<td>Most housework, shopping, and driving possible; able to do hair and dress and undress including fastening brassiere 6</td>
<td>45° to 90° 2</td>
<td>Grade 2 (poor) 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30° to 45° 1</td>
<td>Grade 1 (muscle contraction) 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>130° 0</td>
<td>Grade 0 (nothing) 0</td>
</tr>
</tbody>
</table>

In the case of a chronic retracted subscapularis tear, the tendon edge is often located far medially, at the level of the glenoid rim, and it can be difficult to recognize. We have found it useful to employ a tendon grasper to pull on the medially retracted tissues until we can positively identify the upper border of the subscapularis (Fig 3).
3). Another trick to finding the retracted subscapularis is to identify what we call the “comma sign.” In retracted subscapularis tears, the medial sling of the biceps, composed of the superior glenohumeral ligament and a portion of the coracohumeral ligament, is torn from the humerus at the upper border of the subscapularis footprint and remains attached to the superolateral portion of the subscapularis, forming a comma-shaped arc just above the superolateral corner of the subscapularis (Fig 4).

For partial tears of the biceps, debridement or tenotomy were performed. For dislocations or subluxations of the biceps, arthroscopic tenotomy or arthroscopic tenodesis were performed. In the senior author’s experience with open repair of subscapularis tears in association with dislocation of the biceps, attempts to preserve the biceps by relocating it and stabilizing it within the bicipital groove have not been successful due to redislocation of the biceps causing disruption of the subscapularis repair. Therefore, we have not attempted to relocate and stabilize the biceps arthroscopically.

FIGURE 4. (A) Retracted subscapularis tendon is difficult to identify (left shoulder, as viewed through posterior portal). (B) Comma sign, seen in chronic retracted subscapularis tears. The arc of the comma (*) is formed by the detached medial sling of the biceps, which extends proximal to the superolateral border of the subscapularis tendon. The upper border of the subscapularis tendon (- - -) leads to the lower end of the comma. The lateral border of the subscapularis tendon (——) is located at the inferior projection of the lateral border of the comma.

FIGURE 5. Mobilization of subscapularis using arthroscopic elevator. (A) Superior view, (B) anterior view.
With traction being exerted on the subscapularis by means of traction sutures, an arthroscopic elevator was brought in through the anterolateral portal to mobilize the anterior and posterior aspects of the subscapularis (Fig 5). In the case of isolated tears of the subscapularis, the muscle-tendon unit was generally not retracted and did not require mobilization. However, the massive combined tears that comprised all of the subscapularis tendon plus the supraspinatus and infraspinatus tendons generally required mobilization. If the tendon could not be pulled easily over the bone bed on the lesser tuberosity, it would be mobilized on its anterior, posterior, and superior aspects with an arthroscopic elevator while pulling on the tendon with traction sutures. The inferior border of the tendon was avoided to minimize the chance of neurovascular injury. By freeing all except the inferior border, traction on the tendon would effectively disrupt any adhesions inferiorly.

Next, the bone bed on the lesser tuberosity was prepared by means of a high-speed burr through an anterolateral portal (Fig 6).

To maximize tendon-to-bone contact, the bone bed was frequently medialized 5 mm by removing articular cartilage to a bleeding base of bone. After bone bed preparation, 1 of 2 fixation methods was used. For complete tears with enough elasticity to pull easily past the bone bed and with adequate visualization to see both the anterior and posterior surfaces of the tendon, a Parachute Anchor (Arthrex, Naples, FL) was placed by transtendon insertion. This implant had a biodegradable disk that compressed the tendon against the bone bed. It was particularly useful in this confined space because it obtained fixation without the need for knot tying. For tendons that reached to the bone bed but could not be overpulled beyond the bone bed, transtendon fixation was not used because it was felt that the implant would make a hole too close to the distal end of the tendon to ensure secure fixation. In these cases, standard screw-type anchors (Corkscrew, Arthrex) were placed (Fig 7), followed by suture passage through the tendon by standard suture passers or shuttle techniques (Fig 8). For large complete subscapularis tears that required mobilization, we used a “traction shuttle” repair technique, in which we passed the braided sutures from the anchor through the tendon by threading them through a loop on the traction suture, then pulled the traction suture through the tendon so that it “shut-tled” the braided sutures through the tendon with it.
The sutures were then retrieved and brought out through an anterolateral portal, through which arthroscopic knot tying was accomplished (Fig 9). For complete tears, 2 anchors were used, and for tears of the upper half of the tendon, 1 anchor was used (Fig 10). After passage of the suture through the tendon, before knot tying, retrieval of the transtendon suture limb could be difficult because of poor visualization caused by deltoid swelling. In those cases, the suture limb was threaded through the lumen of a single-hole knot pusher which then delivered the suture into the joint where it could be easily retrieved.

After subscapularis repair was completed, patients with combined multitendon rotator cuff tears extending more posteriorly underwent subacromial smoothing, with preservation of the coracoacromial ligament, followed by arthroscopic suture anchor repair of the rest of the tear.

Postoperatively, the patients were immobilized in a padded sling for 6 weeks with the shoulder in 30° of internal rotation. External rotation beyond neutral was avoided for 6 weeks, as was any attempt at active or passive overhead motion. At 6 weeks postoperatively, overhead motion was initiated. Resisted isotonic strengthening began at 10 weeks postoperatively.

RESULTS

At an average follow-up of 10.7 months, the total UCLA score improved from a preoperative average of 10.7 to a postoperative average of 30.5, out of a maximum 35 points in this scoring system. This average improvement was statistically significant (P < .0001). Good to excellent results were obtained in 92% of patients, with 1 fair result and 1 poor result. For the 6 patients who had complete subscapularis tears in addition to supraspinatus and infraspinatus tears, the average total UCLA score increased from 9.5 preoperatively to 28.3 postoperatively, a statistically significant improvement (P < .001). The tear size in the 17 patients who had either partial or complete subscapularis tears in association with supraspinatus and infraspinatus tears, averaged 5 ± 8 cm. For the 8 patients with isolated subscapularis tears, UCLA scores significantly improved from a preoperative average of 10.0 to a postoperative average of 32.8 (P < .002). The biceps tendon was torn in 8 patients and dislocated in 6. Of the 8 patients with partial tears of the biceps, 6 underwent debridement and 2 had biceps tenotomy. Of the 6 shoulders with dislocated biceps tendons, 2 underwent mini-open tenodesis, 2 underwent arthroscopic tenodesis, and 2 had arthroscopic biceps tenotomy performed. Forward flexion increased significantly, from an average of 96.3° to 146.1° (P < .01). Eleven of the patients had preoperative flexion of less than 90°. Eight of 9 patients with positive Napoleon test had tears of the entire subscapularis tendon. All 7 patients with a negative Napoleon test had tears of the upper half of the subscapularis. The Napoleon test correlated with the degree of subscapularis tear in that the tears involving the entire subscapularis tended to have positive Napoleon tests, whereas tears involving less than the upper half of the subscapularis tended to have
negative Napoleon tests. Tears involving more than the upper half of the tendon but not the entire tendon (e.g., the upper two thirds) tended to have intermediate Napoleon tests. This tendency was confirmed by the Fisher exact probability test ($P = .00007$). The lift-off test could not be performed in most patients due to pain or restricted motion. In fact, it could only be reliably tested in 6 of the 25 shoulders. Postoperatively, the Napoleon test either remained the same (in cases where it was negative preoperatively and postoperatively, and in the 1 poor result, which was positive preoperatively and postoperatively), or else it was successfully converted to a more negative sign. All 6 patients who were heavy laborers returned to full duty. There were no complications. Satisfaction was obtained in 96% of the patients.

Ten patients (40% of the total) had proximal migration of the humerus on preoperative radiographs. Several authors have concluded that narrowing of the acromiohumeral interval to less than 7 mm on the anteroposterior radiograph signifies a complete rotator cuff tear.\(^1\)\(^,\)\(^7\)\(^,\)\(^12\) However, the senior author has reported that narrowing of the acromiohumeral interval to less than 7 mm can occur without proximal migration of the humerus in patients with congenital subacromial stenosis.\(^13\) In such patients, proximal migration of the humerus is best measured at the inferior articular surface of the glenohumeral joint, where the inferior articular margins of the humerus and the glenoid should both be at the same level. For the purpose of this study, our criteria for proximal humeral migration included both an acromiohumeral interval of less than 5 mm, and proximal migration of the inferior humeral articular margin relative to the inferior glenoid articular margin of greater than 5 mm.

Eight of these 10 patients with proximal humeral migration had reversal of the proximal migration as confirmed on postoperative radiographs. UCLA scores in patients with proximal migration significantly improved from 8.4 preoperatively to 27.7 postoperatively ($P < .0001$) and forward flexion significantly improved from 50.8° preoperatively to 135.2° postoperatively ($P < .0001$). In 1 of the 2 patients whose proximal migration recurred, active forward elevation was unchanged at only 45° postoperatively, and in the other patient active forward elevation improved from 90° preoperatively to 110° postoperatively. By UCLA criteria, these two patients with recurrence of proximal migration had poor and fair results respectively, with little or no change in range of motion, in contrast to the significant improvement in UCLA scores and range of motion demonstrated by patients with durable reversal of proximal migration. In this series, recurrence of proximal humeral migration led to a poor outcome.

Preoperative external rotation averaged 70°, and the postoperative external rotation was 52.2°. A postoperative decrease in external rotation in this group of patients is to be expected with successful repairs, since complete subscapularis tears allow excessive external rotation. The 6 weeks of immobilization did not have an adverse effect on functional range of motion because the postoperative average flexion of 146.1° was a 50° improvement over the preoperative average flexion of 96.3°. Eleven patients could not perform overhead activities preoperatively, whereas only 2 patients could not perform overhead activities postoperatively.

**DISCUSSION**

There is very little published information on rupture of the subscapularis tendon, and what information there is relates to open repair of that tendon.\(^14\)\(^-\)\(^20\) Our report is the first to deal with arthroscopic repair of the subscapularis. Furthermore, massive rotator cuff tears that involve the subscapularis in addition to the supraspinatus and infraspinatus have been separately investigated in only one other study.\(^21\) Our series is the first to report on the arthroscopic repair of this particularly disabling pattern of tear, with its propensity to cause proximal migration of the humerus and loss of active overhead motion.

Arthroscopic subscapularis tendon repair is technically challenging. Because of the retroversion of the humeral neck, the anterior deltoid tends to drape itself tightly across the footprint of the subscapularis tendon on the lesser tuberosity. For that reason, there is an extremely tight space in which to work when one performs arthroscopic subscapularis repair, and that space becomes even tighter as the shoulder begins to swell during arthroscopy. Therefore, when we identify a subscapularis tear, we immediately initiate its repair, before doing any other part of the procedure so as to maximize our visualization.

The lift-off test, although very reliable in patients who can perform the test, was of limited value to us because most of our patients could not get their arms into the position required to perform it because of pain or restriction of motion. The Napoleon test, on the other hand, could be tested in everyone and was very effective in determining not only whether the subscapularis was torn, but how much was torn. The degree of subscapularis that was torn was directly related to the degree of positivity of the Napoleon test, with the larger subscapularis tears tending to have positive Napoleon tests and the smaller subscapularis tears tending to have negative Napoleon tests ($P = .00007$). The examiner must beware...
of the patient with an external rotation contracture who has loss of passive internal rotation. Such patients may have a false-positive Napoleon test due to their loss of internal rotation rather than any intrinsic loss of active subscapularis power; they are unable to straighten their wrists when the hand is placed on the stomach due to their inability to internally rotate the shoulder.

The patients in our series had an average improvement in their UCLA score of from 10.7 preoperatively to 30.5 postoperatively (maximum score, 35), a highly significant improvement (P < .0001). A total of 92% of the shoulders had good or excellent results by UCLA criteria. There was 1 fair result and 1 poor result.

We found that multitendon rotator cuff tears that involve at least half the subscapularis in association with tears of the supraspinatus and infraspinatus cause profound functional deficits, particularly when they display proximal humeral migration on radiographs. We had 17 patients with this tear pattern. Ten of the 17 had proximal humeral migration, and all 10 of these had complete loss of overhead function. In fact, attempted forward elevation of the shoulder in these patients resulted in only a shoulder shrug of motion. The results in this group were gratifying, particularly those patients in whom we were able to reverse the proximal migration. In 8 of the 10 patients with proximal migration, we were able to achieve durable reversal of proximal migration as confirmed by postoperative radiography. These 8 patients all improved their overhead function from a preoperative “shoulder shrug” with attempted elevation of the arm to good postoperative overhead function with average forward flexion of 135.2°.

Gerber et al. have suggested that a delay in repair of a torn subscapularis tendon may produce less satisfactory results due to fatty degeneration of the muscle. Although we would agree that the repairs should be done as soon as possible, we do not feel that long-standing tears with their associated fatty degeneration are a contraindication to surgical repair. The delay from injury to surgical repair in our series averaged 1.5 years and was as long as 6 years in 1 patient. Even if the muscle is not fully functional, we believe there may be a beneficial tenodesis effect by repair. Speer has suggested that much of the function of the subscapularis is likely due to its tenodesis effect because, in throwers, it is electrically silent during portions of the throwing motion in which one would expect it to exert a contraction in order to produce a force couple. We agree with this tenodesis concept for the subscapularis, and we believe that it may help to explain the outstanding functional improvement that we saw in some of the long-standing tears.

One potential criticism of this study is that follow-up was short and that results may deteriorate over time. However, previous authors have noted that results of rotator cuff repair have remained stable at long-term review and have not deteriorated with time, unlike the results of rotator cuff debridement. Furthermore, there is evidence that results after rotator cuff repair continue to improve for approximately 9 to 12 months postoperatively. Therefore, it is possible that the preliminary results in this report may actually improve over time. We intend to follow these patients carefully so that we may later report on these long-term results.

Finally, we feel compelled to comment on the prevalence of subscapularis tears. The large number of tears in this study reflects the referral practice of the senior author, but also points out that subscapularis tears may be underdiagnosed. DePalma in a cadaver study of 96 shoulders, found a 20.8% incidence of partial tears of the subscapularis. Most incomplete tears of the subscapularis cannot be diagnosed simply by inspecting the bursal side of the cuff, as one would do in a purely open surgical approach. These tears can be seen only from an intra-articular view, so that proper diagnosis demands arthroscopic evaluation.

CONCLUSIONS

The senior author has developed a technique of arthroscopic subscapularis repair that can be consistently and reproducibly performed, and he has used this technique to obtain good and excellent results in 92% of patients. The Napoleon test is useful in predicting not only the presence of a subscapularis tear, but also its size. Combined tears of the subscapularis, supraspinatus, and infraspinatus tendons are frequently associated with proximal humeral migration and loss of overhead function. Arthroscopic repair of these tears can produce durable reversal of proximal humeral migration and restoration of overhead function.

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