Arthroscopic Treatment of Anterosuperior Rotator Cuff Tears

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abstract

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This study evaluated pre- and postoperative clinical and structural outcome data on anterosuperior rotator cuff tears involving the supraspinatus and subscapularis treated by arthroscopic methods. Between June 2006 and October 2007, a total of 155 consecutive patients underwent an arthroscopic repair for a supraspinatus or supraspinatus and infraspinatus (superior) rotator cuff tear. Of these, 44 (28%) were identified on preoperative imaging to have involvement of the subscapularis. Confirmation of subscapularis tears occurred during arthroscopic repair of the superior rotator cuff. If the subscapularis was found to be torn, it was documented, and an arthroscopic repair was performed. Postoperative clinical and radiographic outcomes were assessed with the belly press and lift-off tests, range of motion, strength, pain score, Constant score, and either a magnetic resonance imaging arthrogram or a computed tomography arthrogram at an average of 15 months postoperatively. Failure was determined based on rotator cuff integrity on radiologic studies. Sixteen of the 44 anterosuperior rotator cuff tears identified on preoperative imaging were found to have a full-thickness subscapularis tear requiring repair on arthroscopic examination. On preoperative imaging, subscapularis tears were all either grade 1 or grade 2 (no complete grade 3 tears). Mean follow-up was 16.9 months (range, 13-24 months). Compared with preoperative values, significant postoperative improvements occurred in Constant scores, forward flexion, strength, and pain scores ($P<.01$). Patients also showed significant improvements in both the lift-off and belly press tests ($P<.001$). Mean postoperative patient satisfaction was 7.9 (range, 5-10) with 10 (59%) of 17 patients being extremely satisfied. Two of the 17 patients with an anterosuperior rotator cuff tear had confirmed retears of the supraspinatus (1 partial and 1 full-thickness) with no radiographic evidence of retear of any of the subscapularis repairs at most recent follow-up.

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Rotator cuff tears are a common cause of shoulder disability. The large majority of rotator cuff tears involve the supraspinatus tendon and extend posteriorly into the infraspinatus as they enlarge.[1,2] Isolated subscapularis tears occur, but a tear of the subscapularis is more likely to occur in association with a supraspinatus tear, which has been termed an anterosuperior rotator cuff tear.[3,4]

The incidence of anterosuperior rotator cuff tears has been reported to occur anywhere from 2% to 24% and is likely to be underreported and undertreated.[2,4-8] Diagnostic imaging studies have been proven to have a low sensitivity for detecting subscapularis tears.[9] Much attention has been paid to the treatment of isolated subscapularis ruptures,[3,6-8,10-12] but much less has been written regarding the treatment of anterosuperior rotator cuff tears, particularly by arthroscopic methods.[2,13-16] In one of the few studies on anterosuperior rotator cuff lesions treated arthroscopically, Bennett[14] showed clinical improvement at 2 and 4 years postoperatively; however, others have not shown the same improvement in the arthroscopic repair of these difficult injuries.[15]

With the continued improvement in arthroscopic techniques and the increased awareness and diagnosis of anterosuperior rotator cuff tears, further study on the treatment and functional outcomes of this injury is warranted. With preoperative imaging having a low sensitivity for detecting subscapularis tears, it is likely that many of these tears are left untreated. The purpose of this study was to evaluate a cohort of patients who underwent arthroscopic anterosuperior rotator cuff repairs with a minimum follow-up of 12 months. The authors hypothesized that significant improvements in range of motion, strength, and clinical outcomes can be expected when a subscapularis tendon tear is repaired in combination with a supraspinatus tear.

Table 1

Lafosse Classification of Subscapularis Tears

Type	Description
I	Partial-thickness tear of the superior third of the subscapularis without tendon retraction
II	Complete tear of the superior third of the subscapularis tendon
III	Complete tear of the superior two-thirds of the subscapularis tendon
IV	Complete tear of the subscapularis with tendon retraction and a concentric glenohumeral joint
V	Complete tear of the subscapularis with tendon retraction and an eccentric glenohumeral joint

MATERIALS AND METHODS

This study received institutional review board approval, and all patients were enrolled in compliance with this protocol. Between June 2006 and October of 2007, a total of 225 arthroscopic rotator cuff repairs were performed by 2 senior surgeons at 2 surgical centers in Europe. A retrospective review was conducted of the 225 patients who underwent surgery for rotator cuff repair; 155 patients were available for clinical and radiographic follow-up at a minimum of 1 year. The indication for surgery was the failure of conservative treatment, defined as a trial of physical therapy with the goal of strengthening the rotator cuff, deltoid, and scapular stabilizers. Preoperatively, all 225 patients underwent advanced imaging documenting a full-thickness rotator cuff tear. Of these 225, twenty percent were found to have radiologic evidence of an associated subscapularis tear. Intraoperatively, all subscapularis tendons were evaluated and classified according to Lafosse et al (Table 1).[7] Type I tears were not repaired because they were not full-thickness tears of the superior third of the tendon. All patients with type II and III full-thickness tears of the superior third or two-thirds of the tendon were repaired arthroscopically. No patients with type IV tears were included in this study. Seventeen (11%) shoulders were found to have a repairable subscapularis tendon in association with a supraspinatus tear because the type I tears were too small to technically repair.

The study cohort of arthroscopic-documented anterosuperior rotator cuff tears comprised 13 (76%) men and 4 (24%) women. Nine (53%) right shoulders and 8 (47%) left shoulders were studied. Nine of the patients underwent surgery on the dominant shoulder. Postoperative imaging and clinical follow-up were performed at a minimum of 13 months (average, 16.9 months; range, 13-24 months). Clinical outcome measures were completed at final follow-up and included visual analog pain scores, forward flexion, strength, and Constant scores.[17]

Classification of Rotator Cuff Tears

The superior component of the anterosuperior rotator cuff tears was evaluated in both the coronal and sagittal planes at the time of arthroscopy. In the coronal plane, the lesion was evaluated according to the classification system of Patte.[18] Type 1 (small tears) indicates retraction to the margin of the articular surface on the humerus, type 2 (large tears) indicates retraction between the articular margin of the humerus to the glenoid, and type 3 (massive tears) indicates retraction of the tendon to the level of the glenoid or medial. In the current study cohort, 2 (12%) patients had type 1 lesions, 8 (47%) had type

2 lesions, and 7 (41%) had type 3 lesions. Subscapularis lesions were identified on preoperative imaging and confirmed and classified at the time of arthroscopy using the methods previously described by Pfirrmann et al[19] and Lafosse et al,[7] respectively.

Postoperative Evaluation

Clinical outcome measures evaluated pre- and postoperatively included the visual analog score for pain (0-15 points, with 0 representing maximal pain), the Constant score,[17] active range of motion, and strength for each shoulder. Lift-off and belly press tests were performed preoperatively and at final follow-up and were graded on a scale of 0 to 3, with 0 representing no weakness, 1 representing moderate weakness, 2 representing significant weakness, and 3 representing the inability to perform the test at all secondary to pain or weakness. Ideally, patients were seen at 2 weeks, 6 weeks, 3 months, 1 year, and beyond postoperatively; however, many of these patients traveled far distances for their medical care, and regular surveillance was difficult in these cases.

All patients underwent either computed tomography arthrography or magnetic resonance imaging (MRI) arthrography at follow-up that was evaluated by 2 board-certified radiologists at 2 different institutions who specialize in musculoskeletal radiology. The integrity of each rotator cuff repair on these shoulder images was classified into 1 of 4 groups: normal, intratendinous leakage, transtendinous leakage, and complete rupture of repair. Rotator cuff repairs with either no leakage or intratendinous leakage were considered intact. Rotator cuff repairs with transtendinous or complete ruptures of the footprint were categorized as failed repairs.

Strength Testing

Manual strength testing was performed for each shoulder pre- and postoperatively with a portable isometric dynamometer (Isobex 2.0; Cursor, Bern, Switzerland). Strength testing was performed with the arm in 90° of abduction in the scapular plane and neutral rotation while the patient was standing with the dynamometer at shoulder level. The patient was instructed to hold this position with a maximum force for 3 seconds during the measurements.

Arthroscopic Rotator Cuff Repair

All patients received a preoperative interscalene block. The patients were placed in the beach-chair position. Three to 5 arthroscopic portals were used to perform the surgery. The subacromial space was inspected and cleared of bursa, reactive synovitis, and subdeltoid adhesions. One hundred fifty-four (99.4%) patients underwent an acromioplasty, and 28 (18.1%) underwent acromioclavicular joint resection. In patients with biceps tendon pathology, operative management of the long head of the biceps tendon included tenotomy or arthroscopic tenodesis. If the biceps tendon appeared pristine, it was left alone. The 17 patients who were identified as having a full-thickness subscapularis tear requiring repair underwent repair using a single suture anchor in the lesser tuberosity. The tendon was prepared intra-articularly, and a standard single-row repair was performed using a double-loaded suture anchor. The superior rotator cuff was repaired as previously described from the subacromial side of the rotator cuff.[20] The current authors performed a double-row rotator cuff repair with 1 to 2 medial anchors and 1 to 2 lateral anchors. Final double-row constructs consisted of 3 to 4 anchors. The patients were placed in a sling with an abduction pillow before leaving the operating room.

Rehabilitation

The postoperative rehabilitation protocol included restriction of passive external rotation to neutral and no active internal rotation for the first 6 weeks while under the supervision of a qualified physical therapist. Patients were started on pendulums and passive forward flexion to 90° on postoperative day 1. The patients remained in a sling in 30° of internal rotation when not participating in therapy exercises. Any passive or active overhead exercises were not permitted. At 6 weeks postoperatively, active range of motion was started, and the patients were instructed that sling immobilization was no longer necessary. Strengthening of the rotator cuff, deltoid, and scapular stabilizers were started at 3 months postoperatively. This standard protocol was used regardless of the presence or absence of a subscapularis tear.

Subjective Outcome Score

At final follow-up, patients were asked via questionnaire to rate how happy they were with their rotator cuff repair on a 10-point scale (1-10/10), with 1 being unhappy and 10 being happy with their results.

Statistical Analysis

Statistical analysis was performed with SPSS 17.0 (SPSS Inc, Chicago, Illinois). Measurements are expressed as mean±SD. To evaluate patient outcomes, the means were compared with a paired *t* test (comparing samples pre- and postoperatively) for continuous variables. The independent-sample *t* test was used to evaluate differences in demographic data. Analysis of variance was used to compare rotator cuff lesion types (Patte types 1, 2, and 3) and rotator cuff imaging outcomes (intact vs failure) to clinical outcome parameters. The level of significance was set at a *P* value less than or equal to .05.

RESULTS

Of the 44 patients with identified subscapularis tears on preoperative imaging, 16 were confirmed as having more than a partial-thickness tear during arthroscopy (grade 2 or 3). This grading system is not to be confused with the intraoperative grading system of Lafosse et al (Table 1).[7] One additional subscapularis tear requiring fixation was found during arthros-

copy not previously documented on preoperative imaging, for a total of 17 (8%) repaired anterosuperior rotator cuff tears. Subscapularis tears were classified preoperatively by advanced imaging according to Pfirrmann et al[19] as follows: grade 1 tears involve less than one-quarter of the cephalocaudal dimension of the subscapularis tendon, grade 2 tears involve more than one-quarter of the tendon, and grade 3 tears are complete detachment of the subscapularis tendon from the lesser tuberosity. Ten grade 1 tears and 7 grade 2 tears existed in this cohort. Twenty-seven subscapularis tears identified on preoperative imaging were determined intraoperatively to be partial-thickness (grade 1) tears and did not require fixation.[21] At 12-month minimum follow-up, 13 (76%) of 17 patients underwent repeat computed tomography arthrography, and 3 underwent MRI arthrography; 1 patient declined to have the shoulder reimaged. (This patient's clinical results are included in the postoperative clinical results.)

Overall, the structural results of rotator cuff repair showed 14 (88%) intact repairs and 2 failed rotator cuff repairs with respect to the supraspinatus and infraspinatus tendons. No radiographic failures of the subscapularis tendon were identified postoperatively.

A statistically significant improvement was observed in all the clinical parameters measured. Constant scores improved by a mean of 35.4 ($P \leqslant .001$) (Table 2; Figure 1). Pain scores improved by a mean of 5.1 ($P = .001$) (Figure 2), strength improved by a mean of 7.2 ($P \leqslant .001$), and forward flexion improved by a mean of 50° ($P \leqslant .001$) (Figure 3). The patients also performed better on the lift-off and belly press tests ($P \leqslant .001$) (Table 2).

Overall, patients were satisfied with their repair, with a mean subjective patient satisfaction score at follow-up of 7.9±1.4 (range, 5-10) (Figure 4). Three postoperative complications occurred in 17 patients; 3 (18%) patients reported a stiff shoulder postoperatively. The patients showed significantly lower Constant scores ($P \leqslant .008$), worsening pain scores ($P \leqslant .005$), and lower improvements in forward flexion ($P \leqslant .02$). These 3 patients were also less satisfied with their surgery, with subjective level of repair scores of 5, 5, and 8, respectively, which accounted for the lowest 2 scores in the series. These patients all underwent biceps tenodesis and acromioplasty, and 1 underwent an acromioclavicular joint resection.

Table 2

Clinical Outcome Measures

Outcome	Mean (Range)			*P*
	Preoperative	Postoperative	Improvement	
Constant score	42.59±8.12 (31-60)	77.9±7.47 (61-88)	35.35	<.001
Pain score	6.24±3.15 (0-10)	11.35±3.22 (5-15)	5.12	.001
Strength, kg	2.35±0.99 (0-4)	9.59±3.62 (3-16)	7.24	<.001
Forward flexion, deg	117.0±29.53 (80-160)	166.76±5.29 (155-170)	49.71	<.001
Lift-off test	1.18±0.73 (0-3)	0.06±0.24 (0-1)	1.12	<.001
Belly press test	1.24±0.44 (1-2)	0.06±0.24 (0-1)	1.17	<.001

Abbreviation: deg, degrees.

No significant differences were noted in etiology, age, sex, operated dominant side, job status, athletic activities, or duration of symptoms. When comparing the 17 patients who underwent subscapularis fixation with the 28 patients who had a partial-thickness tear without fixation, no significant difference was found in age ($P = .79$), postoperative Constant score ($P = .51$), postoperative pain score ($P = .14$), postoperative strength ($P = .62$), complications ($P = .68$), radiographic failure ($P = .11$), postoperative lift-off test ($P = .28$), or postoperative belly press test ($P = .28$).

DISCUSSION

Tears of the subscapularis can occur in isolation or in conjunction with superior rotator cuff tears.[2,3,6,14,15,22] An 8% incidence of full-thickness subscapularis tears associated with a supraspinatus tear (anterosuperior) was found in the original cohort of patients with a supraspinatus rotator cuff tear, which is consistent with other reports in the literature.[2,5,10,15] After arthroscopic repair of the anterosuperior rotator cuff tear, this cohort of patients exhibited significant improvement in range of motion, strength, and functional outcomes at most recent follow-up. Overall, a 12% failure rate occurred in this subset of 17 patients with anterosuperior rotator cuff tears who underwent subscapularis fixation; however, none of the failures had clinical or radiographic evidence of a subscapularis failure.

Recently, increased attention has centered on the role of the subscapularis in shoulder function. Ticker and Burkhart[10] discussed the importance of recognizing and treating subscapularis tears. They believed that in the setting of a planned rotator cuff repair, when a subscapularis tendon tear is found in continuity with a supraspinatus tendon tear (anterosuperior tear), it is essential to recognize it and repair it because the function of the subscapularis muscle will be lost otherwise. In addition, a posterosuperior rotator cuff tear can be more difficult and less securely

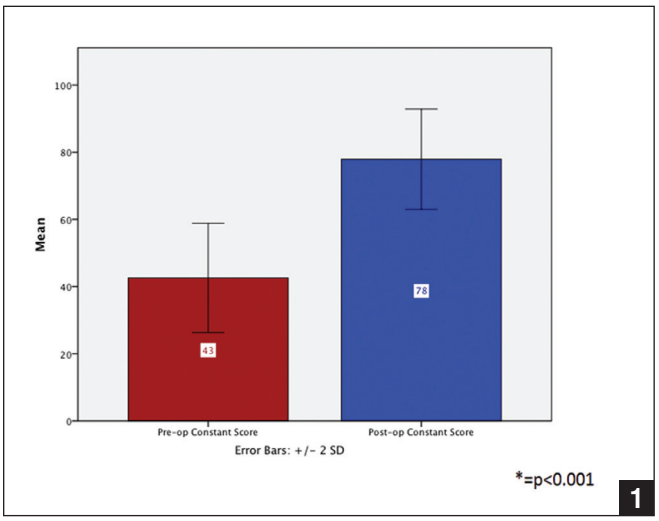

Figure 1: Constant score preoperatively and 1 year postoperatively.

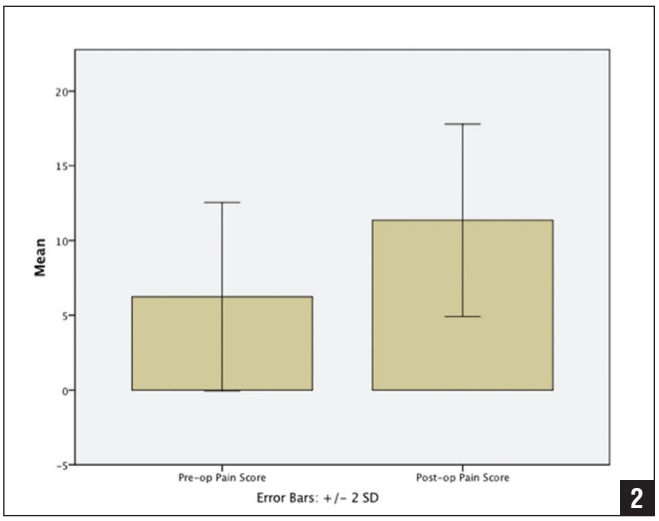

Figure 2: Pain scores preoperatively and 1 year postoperatively.

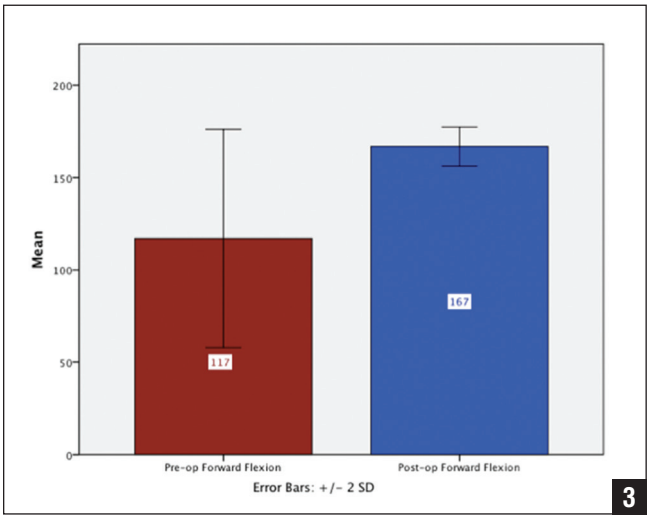

Figure 3: Range of motion (forward flexion) preoperatively and 1 year postoperatively.

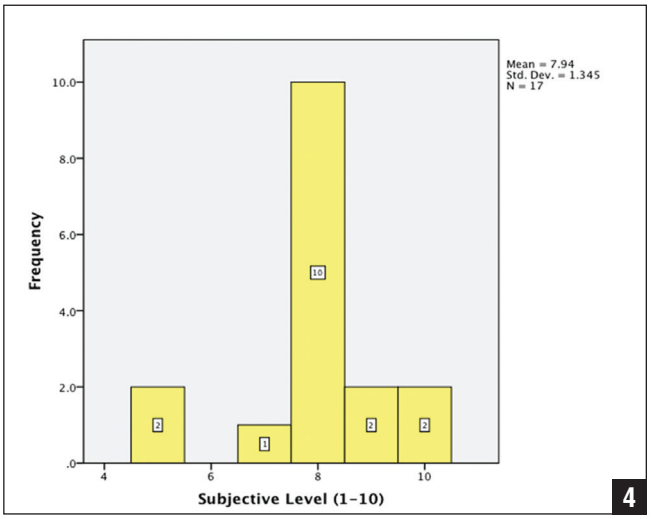

Figure 4: Patient satisfaction score at 1 year postoperatively.

repaired if the subscapularis tendon is not repaired. Similarly, the current study had a low rate of radiographic failure of the superior portion of anterosuperior rotator cuff tears; thus, repairing a torn subscapularis may improve the healing rate of a concomitant superior tear. Longer follow-up is needed.

Multiple studies have reviewed the results of subscapularis repair in isolation and in association with superior rotator cuff tears. Lafosse et al[7] reported the repair of an isolated subscapularis tear by arthroscopic methods alone. They showed a clear improvement in pain, strength, and function with a low failure rate of 9%. Bartl et al[13] reported similar results with only 1 radiographic failure after an all-arthroscopic repair of isolated subscapularis ruptures with a substantial improvement of shoulder function in all patients. Edwards et al[23] retrospectively examined their results of open isolated subscapularis repairs. They reported both traumatic and degenerative tears in their population and found good to excellent clinical outcomes, with a documented radiographic failure of the repair in 5 (6%) patients. The results of combined tears (anterosuperior) in the literature have not shown the same improvement and low rate of failure when treated by arthroscopic methods. Bennett[14] reported the outcomes of arthroscopic repair of anterosuperior rotator cuff tears, showing that improvement in function, decreases in pain, improvement in shoulder scores, and clinical findings of subscapularis insufficiency could be expected. However, Ide et al[15] reported a failure rate of 35% detected on postoperative MRI arthrography in a study of arthroscopically repaired anterosuperior

rotator cuff tears at a mean of 3 years.[15] Unlike in the current study, only 1 of the failed repairs had an intact subscapularis tendon. The reasons for the differences in outcomes in the current study compared with the aforementioned study would be speculative at best. Arthroscopic subscapularis tears have been proven to be an effective way to treat subscapularis tears.[22] A double-row repair was performed on the superior rotator cuff in the current study, and this could be a contributing factor. Better results have been reported in the literature when the anterosuperior tears are treated with open methods. Namdari et al[2] examined 30 patients who had an anterosuperior rotator cuff tear fixed by open methods and found a near return to strength, pain, and clinical outcomes. Radiographic failure was not documented, but they found that the size of the supraspinatus tear, extension into the infraspinatus, and workers' compensation were associated with poorer outcomes. Bartl et al[13] also reported their results on the open treatment of anterosuperior rotator cuff tears and found similar radiographic failure rates to the current study for the subscapularis (4%) and superior rotator cuff (19%). The current study is consistent with the reports on open repair of anterosuperior tears showing that similar outcomes and rates of healing can be obtained via arthroscopic or open methods for these difficult injuries.

Adams et al[21] examined sensitivity and specificity of MRI for the detection of subscapularis tears and found it to be highly specific but nonsensitive because it appears that small tears can be missed by conventional MRI. Interestingly, in the current study, many subscapularis tears (27/155) diagnosed on preoperative advanced imaging were found at arthroscopy to not be a full-thickness tear. One subscapularis tear that was false positive was identified intraoperatively. Sixteen of the 44 tears identified were found to be large enough to require fixation, thus making the sensitivity 94% (16/16+1×100%) and the specificity 80% (110/110+27×100%). These results are in line with Pfirrmann et al's finding when they had 2 musculoskeletal radiologists reading MR arthrograms with both high sensitivity (91%/91% for reader 1/reader 2) and high specificity (86%/79%).[19]

The patients with the poorest clinical outcomes were not those with failed repairs but rather those diagnosed with shoulder stiffness postoperatively. These patients also were less satisfied with their results, with 2 of the 3 having the lowest satisfaction scores in the group. The occurrence of postoperative stiffness is a well-known complication of rotator cuff surgery that reduces patient satisfaction and clinical outcomes.[24,25] Much work has been performed examining the cause of postoperative stiffness, including time of immobilization postoperatively[26] and various preoperative factors that may contribute to a loss of motion postoperatively.[24,27] Further investigation is needed with regard to postoperative stiffness after subscapularis tear repair because the low numbers seen in the current study make it difficult to draw concrete conclusions. Modified rehabilitation protocols have been developed for patients with certain risk factors for the development of a frozen shoulder, but this must be balanced by the need to avoid retears of the rotator cuff from early mobilization.[25,27]

This study has several limitations, including the inherent limitations of a retrospective study, short clinical follow-up, lack of a control group for either nonoperative management or open repair of anterosuperior tears, and small sample size. However, this study provides short-term information regarding the structural integrity and functional outcomes of patients who have an anterosuperior rotator cuff tear. Failure rates of 35% have previously been reported at an average 3-year follow-up.[15] Flury et al[6] reported that intact repairs were found with ultrasound in 88% of their patients who had undergone an open repair of anterosuperior rotator cuff tears through a deltopectoral approach. In the current study's patient population, 89% of the patients' rotator cuff tears and all of the subscapularis repairs were intact at 1 year with a significant increase in all clinical parameters measured. It is possible that if type 3 subscapularis tears had been identified in this cohort, the healing rate would have been lower than what was observed. Further studies examining the results of open vs arthroscopic repair of anterosuperior rotator cuff tears may be warranted. Another weakness of the study is that postoperative imaging studies could be missing retears, and the failure rate may be higher because low sensitivity of subscapularis tears exists in general.[9]

The detection and treatment of anterosuperior rotator cuff tears continue to evolve and improve. Future work will focus on improved diagnosis and treatment of these difficult injuries.

CONCLUSION

In this study, arthroscopic repair of grade II and III subscapularis anterosuperior rotator cuff tears have acceptable structural integrity at 1 year with high clinical function as long as postoperative complications, such as postoperative stiffness, are avoided.

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