Arthroscopic Repair of Anterosuperior Rotator Cuff Tears Combined With Open Biceps Tenodesis

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Purpose: The purpose of this study was to look at the functional outcomes of arthroscopic repair of anterosuperior rotator cuff tears with open biceps tenodesis when indicated. **Methods:** We retrospectively reviewed the cases of 17 patients (17 shoulders) who underwent arthroscopic repair of anterosuperior tears with concurrent open biceps tenodesis. At final follow-up, an independent examiner collected shoulder functional outcome scores including the American Shoulder and Elbow Surgeons score, Simple Shoulder Test, and visual analog pain scale. Objective information including range of motion and strength was also collected. **Results:** Of the 17 patients, 13 (77%) were available for evaluation with a mean age of 52.7 ± 7.0 years at the time of surgery (range, 32 to 65 years) and a mean follow-up of 34.6 ± 10.5 months (range, 14 to 52 months). The mean American Shoulder and Elbow Surgeons score improved from 50.6 ± 18.9 (range, 13 to 75) preoperatively to 89.6 ± 7.5 (range, 50 to 100) postoperatively ($P < .001$). There was a significant increase in the mean Simple Shoulder Test score from 6.1 ± 3.2 preoperatively (range, 0 to 10) to 10.7 ± 1.2 (range, 9 to 12) postoperatively ($P < .001$). Of the 13 patients, 11 (85%) patients were "delighted" with the surgical outcome and the other 2 patients (15%) were "pleased." **Conclusions:** Arthroscopic repair of anterosuperior rotator cuff tears with open biceps tenodesis provides a significant improvement in pain relief and shoulder function. **Level of Evidence:** Level IV, therapeutic case series.

Anterosuperior rotator cuff tears have been recognized as a distinct pattern of rotator cuff tears involving the subscapularis tendon in combination with supraspinatus with or without infraspinatus tendons.[1] Gerber et al.[2,3] previously reported that subscapularis tears in conjunction with supraspinatus tears were more common than isolated subscapularis tears. Warner et al.[1] reported that patients with anterosuperior tears comprised 4% of all patients who underwent rotator cuff repairs. Other authors have reported that combined subscapularis and supraspinatus tears occur at a rate of 9.3% to 23.9%.[4,5] The clinical presentation, operative technique, and prognosis were thought to be associated with less favorable outcomes compared with isolated subscapularis tears and posterosuperior (supraspinatus and infraspinatus) rotator cuff tears.[1] Since the initial clinical series of open anterosuperior rotator cuff repair, this clinical entity has become more widely recognized and earlier diagnosis has led to earlier operative intervention.

Arthroscopic repair of rotator cuff tears continues to improve with mastery of surgical techniques and stronger biomechanical repair constructs. Published reports of arthroscopic repair of supraspinatus and combined supraspinatus and infraspinatus tears have shown significant improvements in clinical outcomes and improvement in shoulder function, with comparable, if not better, results compared with open techniques.[6,7] Previous studies on arthroscopic repairs of the subscapularis have also reported good to excellent results in 79% to 92% of cases.[8-12] Furthermore, ar-

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throscopic surgical approaches require smaller incisions, provide improved operative exposure, are less traumatic to the supporting tissues of the shoulder, and allow for a faster recovery time, overall decreasing the complication and surgical morbidity rate when compared with open surgical approaches. Thus, because arthroscopic approaches for anterosuperior rotator cuff repair provide comparable, if not better, surgical outcomes while decreasing surgical morbidity to the joint, it is clear that the arthroscopic approach may be advantageous to the patient.

Two recent studies on arthroscopic repair of anterosuperior rotator cuff tears reported significant improvement in clinical outcome scores.[11,13] Both studies reported a high association with injuries to the long head of the biceps tendon (LHB) that were recognized either before surgery or during arthroscopic examination.[11,13] Other studies have reported that the association of anterosuperior rotator cuff tears and LHB pathology occurs in 30% to 69% of cases.[3,5] The treatment of the biceps pathology in the setting of anterosuperior rotator cuff tears has been debated in the literature.[6,7,13]

The treatment of anterosuperior rotator cuff tears has improved with early diagnosis and enhanced surgical techniques. The purpose of this study was to report the clinical results after arthroscopic repair of anterosuperior rotator cuff tears and open biceps tenodesis. Our hypothesis was that patients undergoing arthroscopic repair of anterosuperior rotator cuff tears with open biceps tenodesis would show significant improvement in shoulder function and pain relief, as well as a high rate of satisfaction.

METHODS

From January 2004 to December 2006, all patients who underwent primary arthroscopic repair of the subscapularis tendon were reviewed. Patients aged under 65 years who had arthroscopic repairs of subscapularis and supraspinatus tendon tears were included. The exclusion criteria were patients with isolated supraspinatus tears, isolated subscapularis tears, revision surgery, prior total shoulder arthroplasty, and open subscapularis repair. Patients with concomitant infraspinatus tears were not excluded. Patient demographic information and intraoperative characteristics were recorded (Table 1). All patients underwent an informed-consent process, and the study was approved by the institutional review board.

Patients who met the study criteria completed a preoperative evaluation that included American Shoulder and Elbow Surgeons (ASES) score, visual analog score (VAS) for pain, Simple Shoulder Test (SST) score, and active range-of-motion measurements. Intraoperative data included both diagnostic information and concomitant procedures. Supraspinatus rotator cuff tears were classified based on size (length) and thickness (full or partial). Tears were assessed after bursectomy of the subacromial space but before rotator cuff debridement. Tear size was measured in the sagittal plane at the involved tendon's insertion into its respective anatomic footprint. Additional diagnoses were also recorded including osteophyte of the undersurface of the acromion (yes or no), biceps pathology (yes or no), acromioclavicular joint osteoarthritis (yes or no), and glenohumeral osteoarthritis (yes or no). The number of anchors and row configuration (single or double) were also recorded at the time of surgery.

TABLE 1. *Patient Demographic Data*

	Data
Time to follow-up (range) (mo)	34.6 (14-52)
Age at time of surgery (range) (yr)	54.7 (32-65)
Gender	
Male	85% (11/13)
Female	15% (2/13)
Operative arm	
Dominant	69% (9/13)
Nondominant	31% (4/13)
Work-related injury	77% (10/13)
History of trauma	92% (12/13)
History of prior surgery	0% (0/13)
Physical therapy before repair	69% (9/13)
Steroid injections before repair	77% (10/13)
Tobacco use	38% (5/13)

Surgical Technique

The patient was placed in the beach-chair position with the arm draped free. The procedure began with a diagnostic arthroscopy initiated from a standard posterior arthroscopic portal. The subscapularis tear was identified along with any additional intra-articular pathology (Fig 1). If other rotator cuff or bicep tendon pathology was noted, the subscapularis repair was performed before the surgeon performed repair of the other rotator cuff tendons or biceps tenodesis because of the difficulty in visualizing the subscapularis repair site with fluid extravasation into the shoulder and upper arm. If a biceps tenodesis was required, the tendon was released from its intra-articular insertion to allow it to retract out of the way of the subscapularis repair site. A biceps tenodesis was performed

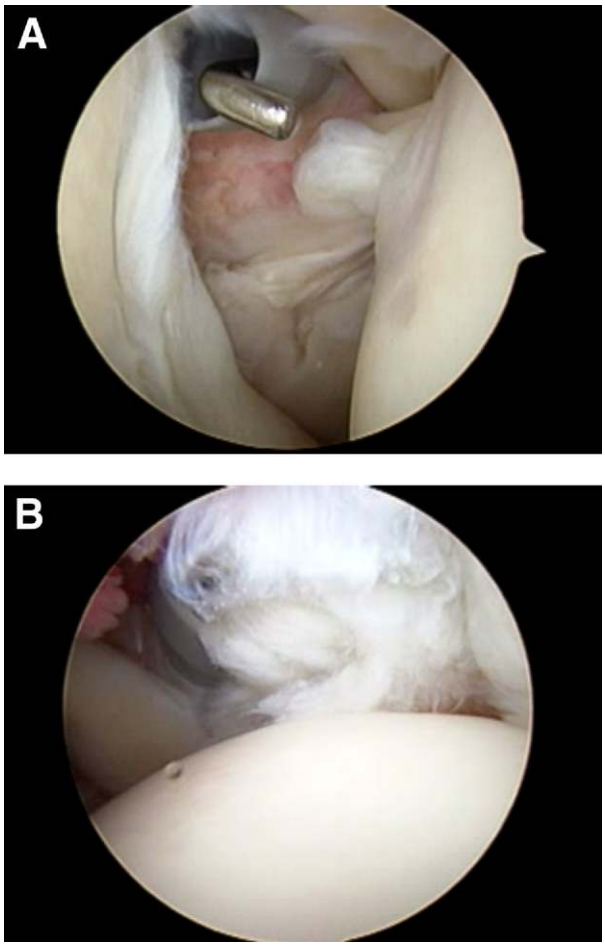

FIGURE 1. Arthroscopic evaluation of anterosuperior rotator cuff tears. (A) Subscapularis tear visualized in external rotation showing complete tear of upper 25% (type II). (B) Supraspinatus tear involving anterolateral border adjacent to LHB.

after the rotator cuff repair was completed by use of the previously described open subpectoral approach with fixation by use of 8 × 15 mm interference screw (Arthrex, Naples, FL).[14]

Subscapularis tears were classified according to the following scheme: type I, partial-thickness tears with the insertion site of the tendon into the lesser tuberosity still intact; type II, complete tears of up to 25% of the tendon; type III, complete tears of 25% to 50% of the tendon; and type IV, any tears of the tendon greater than 50% of the tendon width.[10] All subscapularis tears (grades I to IV) were repaired.

Two anterior cannulas were used, one just lateral to the coracoid process and the other more anterolateral, with adequate space between the cannulas to allow room to work between the cannulas. The anterior cannula was used for the coracoplasty and placement of anchors. The anterolateral cannula was used to mobilize the subscapularis tendon, to aid in suture management, and for visualization if necessary. The rotator interval capsule was released to allow mobilization and better visualization of the subscapularis tendon. A coracoplasty was performed on all patients because of the reported relation between a prominent coracoid and the development of a subscapularis tendon tear (Fig 2).[15-17] Type I tears were repaired with a side-to-side suturing technique by use of absorbable suture (PDS; Ethicon, Somerville, NJ). For all other tears, 4.5 mm fully threaded corkscrew anchors were placed at the level of the lesser tuberosity after creation of a bony trough to promote tendon-to-bone healing, and nonabsorbable suture was shuttled through the subscapularis tendon. The number of anchors used for the repair ranged from 1 to 3 (Fig 3). A horizontal stitch was tied by use of a series of 5 half-hitches with alternating posts.[10]

After the subscapularis repair, the supraspinatus tendon was repaired anatomically. With the arthroscope in the lateral portal, the rotator cuff can be viewed in its entirety. By use of an arthroscopic grasper, the torn tendon edges were grasped and pulled laterally to approximate the appearance with fixation. The points of fixation were planned while the torn tendon was held in its reduced position, and double-row suture-bridge fixation was used in all cases. The medial row was created with two 4.5-mm fully threaded corkscrew anchors with 2 fiberwire

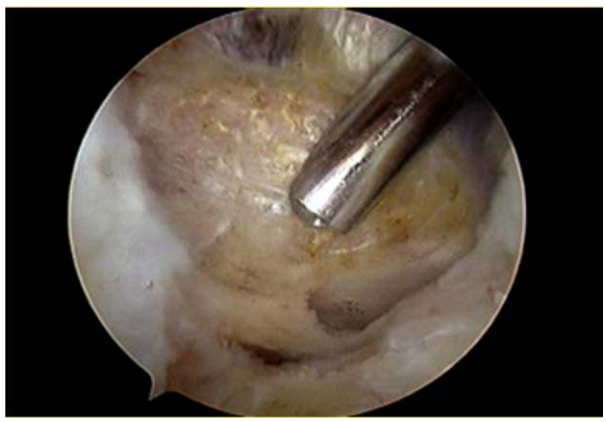

FIGURE 2. Arthroscopic coracoplasty. After the rotator interval capsule has been released, the posterior surface of the coracoid is visible and the superior border of the torn subscapularis tendon can be seen on the lower right. The posterior surface of the coracoid can be removed with an arthroscopic burr so that there is at least 7 mm of space between the coracoid and the subscapularis tendon.

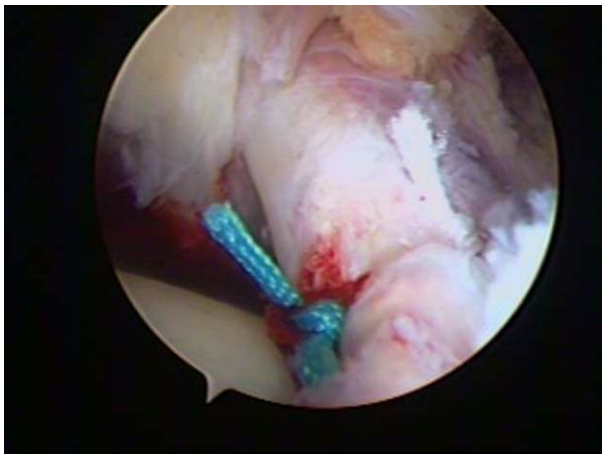

FIGURE 3. With the arthroscope in the lateral portal of the subacromial space, the repaired subscapularis tendon is visualized, and the humeral head can be seen at the lower left corner. The final appearance of the repaired subscapularis tendon is shown with the arm in internal rotation.

sutures and was placed at the juxta-articular margin. The sutures were individually passed through the area of the tendon just lateral to the musculotendinous junction and delivered out the anterior portal for the anterior anchor and the posterior portal for the posterior anchor. One limb from each knot was then brought together, passed through the close eyelet of the 4.5 mm Pushlock anchor (Arthrex, Naples, FL). The 4.5 mm Pushlock anchor was inserted after using a tap to establish a bone socket, with the anchor placed lateral to the ridge of the greater tuberosity. The surgeon can tension the suture and plan for the lateral-row anchor placement to produce an anatomic restoration of the rotator cuff footprint. Two additional bioabsorbable anchors were placed in an appropriate fashion on the lateral aspect of the humerus so that a criss-cross pattern of the sutures over the top of the rotator cuff tendon was achieved.

Rehabilitation

Early range-of-motion exercises were instituted on the first postoperative day, but strengthening of the subscapularis was delayed for 6 weeks to allow optimal healing of the tendon-bone interface. For the first 2 weeks, external rotation was limited to 40° to prevent gap formation at the repair site. The patient was allowed to perform forward elevation to 90° and internal rotation to the abdomen. From 2 to 6 weeks, the patient was allowed to gradually increase external rotation and forward elevation as tolerated without manipulation by the therapist. This program was a general rule only and may need to be modified by the surgeon based on the size of the tear. The overall rehabilitation protocol was guided by several factors including the size of the tendon tear, the presence of retraction and atrophy, the quality of the repair, the surgeon's perception of the tension on the repair, and variables related to the patient such as chronic medical comorbidities.

Functional Outcome Assessment

All patients were evaluated by an independent examiner who performed physical examinations and strength testing. All patients completed validated, shoulder-specific outcome scores including the ASES form,[18] SST,[19] and pain VAS.[20-22] Forward elevation in the scapular plane and external rotation with the arm at the side were measured with a goniometer. Rotator cuff strength was assessed with a manual muscle dynamometer (Isobex; Medical Device Solutions, Oberburg, Switzerland) in forward elevation and external rotation, and the strength index was calculated as a percentage of the operative extremity compared with the contralateral extremity in forward elevation and external rotation.

Statistical Analysis

Descriptive analysis consisted of frequencies and percentages for discrete data and means and standard deviations for continuous data. Paired *t* tests were performed to compare preoperative and postoperative measures including range of motion and VAS, SST, and ASES scores. $P < .05$ was considered to be statistically significant.

RESULTS

Over a 3-year period, 13 of 17 patients (77%) met the study criteria, with a mean age of 52.7 ± 7.0 years (range, 32 to 65 years) at the time of surgery and a mean follow-up of 34.6 ± 10.5 months (range, 14 to 52 months). There were 11 male patients (85%) and 2 female patients (15%), and the dominant arm was the affected extremity in 9 cases (69%). Of the patients, 12 (92%) reported a traumatic event that led him or her to seek medical attention. Ongoing tobacco use was reported by 5 patients (38%). There were 10 patients (77%) who sustained a work-related injury and were involved in Workers' Compensation claims. A preoperative examination with either tenderness over the proximal biceps, positive Speed test, or positive Yerga-

Table 2. *Intraoperative Characteristics*

	Data
Subscapularis tear classification	
Type I (partial thickness)	0% (0 patients)
Type II (complete tear of upper 25%)	31% (4 patients)
Type III (complete tear of upper 50%)	46% (6 patients)
Type IV (complete rupture)	23% (3 patients)
Supraspinatus involvement	
Associated tear	100% (13 patients)
Size of tear	33% (range, 25%-100%)
Suture anchors used	2 (range, 1-3)
Stitch configuration	
Horizontal mattress	100%
Simple	0%
Associated biceps tendon subluxation	100% (13 patients)
Associated open biceps tenodesis	100%
Associated subacromial decompression	100% (13 patients)
Associated distal clavicle excision	31% (4 patients)

son test was found in 8 patients (62%). Before surgery, 8 patients (62%) also had a positive liftoff test.

The intraoperative characteristics of the patient cohort are described in detail in Table 2. All 13 patients (100%) had evidence of LHB instability and underwent open biceps tenodesis with interference screw fixation. An associated supraspinatus tear was present in all 13 patients (100%). The mean supraspinatus tear size was 1.6 ± 0.9 cm (range, 1 to 3 cm), and such tears were concomitantly repaired with the subscapularis.

The postoperative outcomes of the patient cohort at a mean of 34.6 ± 10.5 months (range, 14 to 52 months) are presented in detail in Table 3. At the most recent follow-up, the VAS, ASES, and SST outcomes scores were significantly improved compared with preoperative values. Forward flexion and external rotation measurements were also improved from baseline. All patients had a negative belly-press test and liftoff test after surgery. In addition, all patients had a painless bicipital groove to palpation, negative Speed test, and negative Yergason test (Table 3).

At final follow-up, no neurovascular complications or infections were encountered. One patient had a rerupture of the repair that occurred as the result of a traumatic event 1 year after initial repair, and the patient underwent revision with an open subscapularis repair.

DISCUSSION

The findings of this study showed that arthroscopic repair of anterosuperior tears involving the subscapularis and supraspinatus tendons with concomitant open biceps tenodesis results in significant improvement in clinical outcome scores and shoulder function, high patient satisfaction, and pain reduction. Postoperative physical examination showed restoration of shoulder range of motion without evidence of subscapularis dysfunction or persistent biceps pain. The strength of the operative extremity in forward elevation and external rotation was greater than the nonoperative extremity. It must be noted that the dominant extremity was the operative arm in 72% of the cases, which

Table 3. *Outcomes After Arthroscopic Subscapularis Repair*

	Preoperatively	Postoperatively	*P* Value
VAS	5.1 ± 2.5	0.8 ± 1.2	<.001
ASES	50.6 ± 18.9	89.6 ± 7.5	<.001
SST	5.9 ± 3.1	10.6 ± 1.3	<.001
Forward flexion (°)	135.3 ± 46.5	162.9 ± 1.7	0.120
External rotation (°)	59.0 ± 16.7	78.1 ± 8.9	<0.05
Forward elevation strength (N)			
Operative		59.6 ± 28.9	121.8% (strength index)
Nonoperative		48.9 ± 30.7	
External rotation strength (N)			
Operative		47.3 ± 14.7	104.0% (strength index)
Nonoperative		45.4 ± 12	
Satisfaction			
Pleased		15% (2/13)	
Delighted		85% (11/13)	
Current narcotic use		0%	

NOTE. Data are presented as mean ± SD unless otherwise indicated.

suggests that the dominant extremity regained its role as the stronger extremity postoperatively.

Rotator cuff tears, and in particular anterosuperior rotator cuff tears, are commonly associated with biceps tendon pathology.[1,13,23-27] Arthroscopic findings can include tenosynovitis, tendonitis, fraying, flattening, subluxation, and/or avulsion. Clinically, the presentation of biceps tendon pathology associated with massive rotator cuff tears such as an anterosuperior cuff tear may be nonspecific, although patients will often complain of pain and/or subluxation. Therefore it is critical for the orthopaedic surgeon to address any potential biceps tendon injury both preoperatively and at the time of surgery to adequately address the patient's subjective and objective findings. The question at hand is whether to treat the biceps tendon (ie, with a tenodesis) in addition to the rotator cuff repair. To date, there are no prospective randomized controlled studies addressing this issue available in the literature, and many of the available studies discuss outcomes after open rotator cuff repair as opposed to the arthroscopic approach described in this study. An analysis of several of the available studies that discuss arthroscopic cuff repair with biceps tenodesis, with a comparison to the data presented in our study, is provided here as well as in Table 4.

The patient population in this study was younger than those in prior case series, with a mean age of 52.3 years and a maximum age of 65 years. In addition, the mean size of the supraspinatus tears was 1.6 cm, with no tears that extended into the infraspinatus tendon, and 88% of the subscapularis tears involved less than 50% of the tendon. Numerous studies have reported an improvement in clinical outcome and tendon healing in patients aged under 65 years,[28-33] and rotator cuff tear size has been well established as a prognostic indicator of both clinical outcome and postoperative structural integrity.[28-33] The findings from our study showed improvement in clinical outcome scores and shoulder function that were comparable to the recent studies on arthroscopic repair of isolated subscapularis tears or anterosuperior tears.

TABLE 4. *Comparison With Historical Controls*

Authors	Journal, Year	No. of Patients	Average Follow-Up	Surgical Technique	Outcomes
Namdari et al.[13]	JBJS, 2008	30	56 mo	Isolated superior deltoid-splitting approach (20/30), isolated deltopectoral approach (5/30), or combined approach (5/30)	21/30 satisfied VAS improved ($P < .001$) SST improved ($P < .001$) Constant, 93.4
Ide et al.[11]	JBJS, 2007	20	36.1 mo	Arthroscopic suture anchor repair of RCT involving subscapularis, supraspinatus, and infraspinatus; no BT performed	35% with recurrent RCT, although 90% of these had good to excellent outcomes
Maier et al.[27]	JBJS, 2007	21	28.4 mo	Open BT stabilization with transosseous suture subscapularis reconstruction	Constant score improved ($P < .01$) 2 patients with LHB tendon instability by dynamic ultrasound
Edwards et al.[26]	JBJS, 2006	84	45 mo (range, 24-132 mo)	Open repair of subscapularis, 48/84 with BT, 13/84 with biceps tenotomy, and 4/84 with re-centering of biceps	Tenodesis or tenotomy associated with improved subjective and objective results (irrespective of preoperative condition of LHB tendon)
Checchia et al.[24]	JSES, 2005	15	32.4 mo	Single approach: arthroscopic RCT repair with associated SAD and arthroscopic BT incorporated into RCT suture	Satisfactory UCLA score in 93.4% 11 with excellent results, 3 with good results, and 1 with unsatisfactory results
Warner et al.[1]	JSES, 2001	19	40 mo (range, 24-75 mo)	Open deltopectoral approach (4/19) or formal anterosuperior approach (15/19) with open BT in 100%	Excellent in 5, good in 3, fair in 4, and poor in 7 Repair before 6 mo of symptoms associated with better outcomes

Abbreviations: JBJS, *The Journal of Bone and Joint Surgery,* American edition; JSES, *Journal of Shoulder and Elbow Surgery*; RCT, rotator cuff tear; BT, biceps tenodesis; SAD, subacromial decompression; UCLA, University of California, Los Angeles.

Initial open studies of anterosuperior rotator cuff repairs reported a dismal prognosis, and these tear patterns were thought to be worse than posterosuperior tears. Warner et al.[1] studied 19 patients with a mean duration of symptoms for 18 months before an open repair of the rotator cuff and biceps tenodesis. At a mean of 40 months follow-up, the modified Constant score improved from 38% to 69%, but 14 of 19 patients had evidence of persistent subscapularis dysfunction as determined by use of physical examination findings with persistence of a positive liftoff and/or belly-press test, as well as increased passive external rotation. The authors warned that a delay in diagnosis was associated with tendon degeneration and muscular atrophy and recommended early operative management.[1]

Ide et al.[11] reported a lower rate of repair integrity of 65% about 36 months postoperatively, although 90% of the patients with recurrent tears had good to excellent results at this time point. They reported that 17 of 20 shoulders had LHB instability, complete tear, or partial tear. One patient had persistent tenderness over the bicipital groove but was found to have a normal LHB tendon at the time of the index repair for a 3-tendon tear.

In a recent study, Lafosse et al.[34] evaluated the frequency and type of biceps tendon pathology during arthroscopic rotator cuff repair. They found biceps tendon subluxation or dislocation in 90 of 200 patients (45%). Interestingly, they were able to classify the tendon instability by direction and found that anterior LHB instability was more likely to be associated with subscapularis tears whereas posterior LHB instability was more likely with supraspinatus tears.[34]

In anterosuperior rotator cuff tears, there is macroscopic evidence of subscapularis tears as well as supraspinatus tears, but the arthroscopic appearance of the LHB may be normal, unstable, inflamed, frayed, or ruptured. The injury to the LHB has a high association with this particular rotator cuff tear pattern, and the appropriate treatment has not been clearly defined. In cases of obvious biceps abnormality at the time of arthroscopy with a consistent physical examination, performing a biceps tenodesis or tenotomy would be the preferred treatment for most orthopaedic surgeons. The LHB may have a benign intra-articular appearance, and studies have reported that only 49% of cases may have LHB pathology that can be visualized by arthroscopy.[35] In our experience a coracoplasty was performed in all patients to allow for improved visualization of the tendon during repair. Furthermore, coracoplasty minimized the risk of persistent anterior shoulder pain after surgery due to subcoracoid impingement of the tendon between the coracoid and lesser tuberosity.[36] Another study determined that concomitant biceps tendon pathology as visualized at the time of arthroscopy after adjustment for age and tear size had an 11-fold increased risk of a postoperative tendon defect after arthroscopic rotator cuff repair.[37] Our approach to anterosuperior rotator cuff tears has been to perform an arthroscopic repair of the torn rotator cuff tendons and an open biceps tenodesis when indicated by physical examination or biceps tendon instability, which has been met with successful results. In this clinical series all patients had an unstable LHB in the setting of the subscapularis tendon tear, but we would also perform a biceps tenodesis for a clinical diagnosis of biceps tendinosis. Although we prefer to perform an open biceps tenodesis through a subpectoral approach, we acknowledge that there are a number of different methods of performing biceps surgery, and it can be done with a tenotomy using open or arthroscopic techniques.

This study has a number of strengths. It reported on a younger patient population with a high percentage of follow-up. The study criteria included only patients with subscapularis and supraspinatus rotator cuff tears, but the patient group was homogeneous and was diagnosed relatively early in the disease process. The study group was younger with smaller rotator cuff tears compared with the early open studies and therefore represents a more favorable study group with demonstrable improvement in outcomes. It should be noted that early surgical intervention, strict patient selection criteria, and appropriate patient expectations are crucial for success. A single surgeon performed all the repairs, so the repair constructs were consistent. The study used validated, shoulder-specific functional outcome measures as evaluated by an independent examiner.

This study also had a number of limitations. It was conducted as a retrospective case review. The study did not have a comparison group, but historical controls were used to draw comparisons, as described in detail previously. Lastly, for reasons of study cost, we did not perform postoperative imaging to assess the integrity of the repair, which would have provided objective data.

CONCLUSIONS

Arthroscopic repair of anterosuperior rotator cuff tears with open biceps tenodesis provides a significant improvement in pain relief and shoulder function.

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