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Results of the repair of acute rotator cuff tears is not influenced by tear retraction

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ABSTRACT

Purpose: This study evaluated retraction in the setting of acute rotator cuff tears and determined its effects on patient outcomes and tendon repair integrity.

Materials and Methods: A total of 22 patients had surgery within 6 weeks or less from the time of injury. Fifteen of these patients were prospectively followed at a minimum of 2 years; average 40.5 months (range 24-69). Pre-operative objective and subjective outcomes were compared. Tendon repair integrity was assessed with ultrasound at a minimum of 1 year from surgery. The population was stratified into Group 1 (8 patients) with minimal intra-operative medial tendon retraction to the mid-line level of the humeral head and Group 2 (7 patients) with a large medial tendon retraction to the glenohumeral joint or greater.

Results: The average time to surgery from the onset of symptoms was 27 days (range, 6-42). Post-operative motion increased significantly for external rotation and forward elevation, 77% of patients were pain free, 80% were completely satisfied, and 100% would have the surgery again. Group 1 (small retraction) versus Group 2 (large retraction) showed that post-operative pain levels, satisfaction, range of motion, strength, subjective shoulder value (95.4% vs. 92.3%), Constant Score (80.8 vs. 78.1), and American Society of Shoulder and Elbow Surgeons (96.2 vs. 93.5) scores were not statistically different. Ultrasound showed a tendon repair integrity rate of 87%. 2 patients who did have a re-tear were in Group 2, yet had comparative outcomes.

Conclusion: In acute rotator cuff tears, equal patient satisfaction, pain scores, range of motion, strength, and outcome measures should be expected with surgical repair despite the level of retraction.

Level of Evidence: Therapeutic level IV.

Key words: Outcomes, retraction, rotator cuff tear, shoulder

INTRODUCTION

Multiple classification schemes exist for rotator cuff tears; morphologically, the type (partial or full thickness), size (small, medium, large or massive), geometry (crescent, L-shaped, U-shaped), and level of retraction,[1-3] have been used to describe various tear patterns. In addition to the morphology, rotator cuff tears can be classified based on the chronicity of the tear, that being acute versus chronic.

While non-operative management can be successful for chronic rotator cuff tears,[4,5] acute rotator cuff tears may have better outcomes when treated with early surgical intervention.[6-12] Few studies have sought to evaluate the outcomes in patients with acute rotator cuff tears. Bassett and Cofield,[2] found improvement in function and strength in patients with rotator cuff tears repaired within 3 weeks. Recently, Lähteenmäki *et al.*[13] Commented on their experience with early operative treatment of full thickness cuff tears with acute symptoms. They found a 96% satisfaction rate and an overall result of excellent or good in 92% of their patients.

While these studies have demonstrated good outcomes with acute repair, neither have addressed retraction as a factor

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affecting healing nor confirmed repair integrity with post-operative imaging. A study by Boileau *et al.*[14] evaluated tendon healing in 65 "chronic" supraspinatus tears, and found that retraction and extension of the tear correlated with tendon healing, concluding that smaller tears with less retraction resulted in better tendon healing. Ide *et al.*[15] looked at anterosuperior tears involving the subscapularis tendon in patients with a mean duration from time of injury to surgery of 2.7 months and found that more severely retracted tears were less likely to heal based on magnetic resonance imaging (MRI) findings and were associated with poorer outcomes.

The purpose of our study was to determine subjective and objective outcomes in patients with repairs of acute cuff tears controlling for the level of retraction. Although not clearly defined in the literature, 6 weeks was determined to be acute based on other clinical studies, which termed acute as 3 weeks to 3 months from the onset of symptoms[6,12,13,16,17] as well as animal studies, which observed fatty infiltration arising between 4 weeks and 6 weeks after a tear was created.[16,18,19] We further evaluated the effect of retraction on the outcomes and repair integrity of rotator cuff tears that were treated acutely. Our hypothesis was that in the setting of an acute rotator cuff tear, the degree of retraction would not adversely affect subjective and objective outcomes or tendon repair integrity. While comparisons of this nature have been conducted in a chronic setting,[14,15,20] no analysis has been performed when the injury is consistently repaired within 6 weeks of injury.

MATERIALS AND METHODS

Over a 3 year period from 2004 to 2007, 29 patients out of 382 consecutively treated patients who received a primary rotator cuff repair were identified as having a repair within 6 weeks from a self-reported time of injury. Because of potential bias and findings that worker's compensation claims and tobacco users can be negative prognostic factors, seven patients were excluded from the study.[21,22] Other exclusion criteria included previous shoulder surgery on the affected side, glenohumeral arthritis, shoulder instability, and/or moderate to severe shoulder pain prior to the date of injury. No patients met these additional exclusion criteria. Of the 22 remaining patients, 15 (68.1%) were available to be followed prospectively for follow-up at a minimum of 2 years clinically and 1 year for ultrasound evaluation, and had an average follow-up 40.5 months (range, 24-69 months) [Table 1].

The cohort of patients was followed prospectively and at their last follow-up the patients completed a subjective shoulder questionnaire and motion, strength, and ultrasound findings of the cuff were recorded. The study was approved by our hospital Institutional Review Board.

We attempted to contact the seven patients who did not participate in the study with serial phone calls and messages. However, one patient was not interested in the study, three patients had moved and could not be reached, and three were deceased.

Pre-operative evaluation

Pre-operatively, all patients included in the study underwent a history and physical exam, functional questionnaire, objective strength and range of motion measurements. The physical examination included bilateral measurement of the shoulder range of motion in active forward elevation in the scapula plain, external rotation in adduction, internal rotation behind the back. MRI studies were reviewed for tendon involvement, Goutallier score for fatty infiltration,[23] and staging for retraction of posterior-superior tears.[2] The interpretation of the grades of Goutallier fatty infiltration are: Grade 0 = no fat in the muscle; Grade 1 = fatty streaks in the muscle; Grade 2 = more muscle than fat; Grade 3 = equal muscle and fat; Grade 4 = more fat than muscle. The pre-operative questionnaire evaluation included a visual analog pain scale (VAS) – expansion confirmed and the Constant and Murley instrument.[24,25]

With regards to the intra-operative degree of tendon retraction, the 4 stages of retraction as described by Boileau *et al.*[14] were used to describe the position of the proximal or medial tendon stump edge [Figure 1]. Although this classification was described

Table 1: Demographic information of the patient population

Number of patients identified for the study	22
Number of participants	15
Number of male participants	8 (53%)
Number of female participants	7 (47%)
Dominant arm involved	10 (66%)
Mean age of patients	55.8 years (range: 43-73 years)
Mean duration from time of injury to time of surgery	27 days (range: 6-42 days)
Mechanism of injury	Direct falls onto the shoulder: 11(73%) Grabbing/bracing motions: 3 (20%) Fall from bicycle: 1(7%)

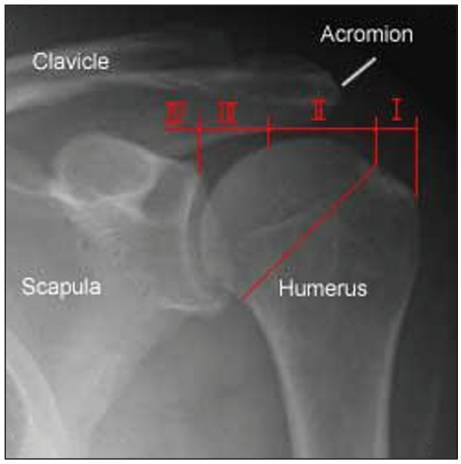

Figure 1: Grashey view of the retraction zones of supraspinatus tears of the rotator cuff, against a normal x-ray of the left shoulder.

for supraspinatus tears, the location of the zone of retraction was used for classifying the retraction of the other three tendons if they were involved. Ide *et al.*[15] described subascapularis zones of retraction as minimal, moderate, and severe, with the minimal retraction (edge of the tear was over the lateral articular cartilage margin) correlating to stage 1 of Boileau, moderate retraction (tendon edge lateral to the glenoid rim) for stage 2 and 3, and severe retraction (tendon edge lying medially to the glenoid rim) for stage 4. Based on Gerber's classification of size, in which a massive tear is defined as a complete rupture of two or more tendons, seven tears were classified as massive [Figures 2 and 3a].[1] The study population was then stratified into two groups to determine if the degree of retraction affected subjective and objective outcomes. Group 1 (eight patients) were those with maximal retraction to zone 2, and Group 2 (seven patients) were those with retraction to zone 3 or greater.

Surgical technique

A diagnostic arthroscopy was performed on all patients while positioned in the beach chair position. The size, pattern, tendon quality, and retraction of the rotator cuff tear were noted, and after preparation of the greater or lesser tuberosity, the rotator cuff was repaired arthroscopically [Figure 3b, 4a]. If there was pathology of the biceps tendon with hyperemia, subluxation, or fraying of the tendon determined intra-operatively that correlated with pre-operative tenderness over the bicipital groove, either a biceps tenotomy or a biceps tenodesis was performed, based on the patients age and activity level. Those who were over 55 years of age, were not active, with arms that had abundant adipose tissue, and did not have defined muscle contour received a biceps tenotomy. Overall, four tenotomies and four tenodesis were performed. All tenodesis were performed with a sub-pectoralis biceps tenodesis by a technique previously described in the literature,[26] a limited sub-acromial decompression with the recession of the coraco-acromial ligament was performed in all patients. Twelve repairs utilized a double-row trans-osseous equivalent technique while three had a single row technique. Of the three that had single-row repairs, one was performed because it was a very small, non-retracted tear; the other two were massive tears

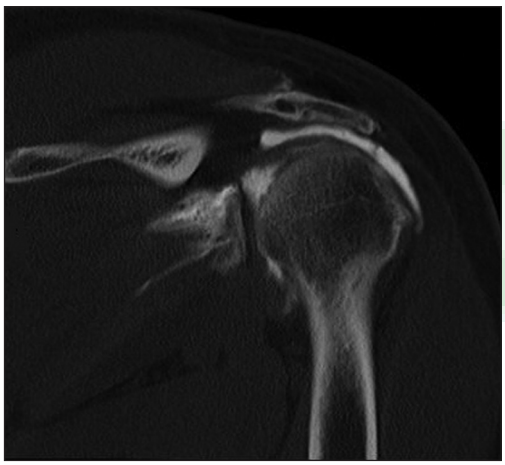

Figure 2: Coronal oblique view T1 view of a massive left rotator cuff tear of the supraspinatus demonstrating retraction of the tendon to the level of the glenoid.

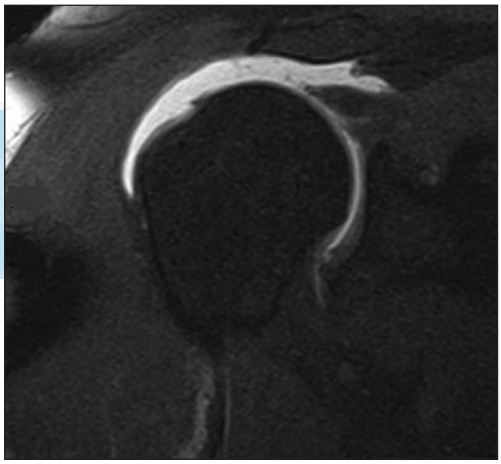

Figure 3a: Coronal T1 view of a full-thickness tear of the supraspinatus, retracted beyond the level of the glenoid (stage IV).

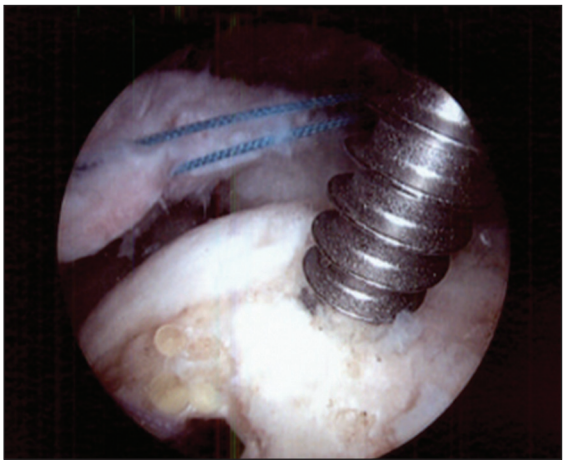

Figure 3b: Arthroscopic image of the same patient showing a traction suture pulling the massively retracted rotator cuff tear.

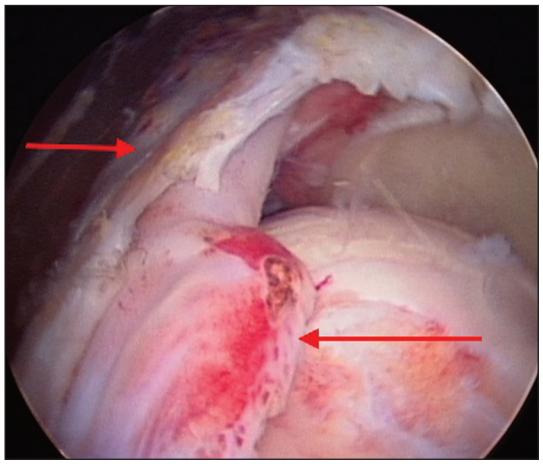

Figure 4a: Arthroscopic view of a right shoulder with a massive rotator cuff tear of the supraspinatus extending into the infraspinatus.

that involved at least three tendons, including subscapularis involvement, and the repair was made without a second row because of the complex nature of the configuration of the tear, and thus, the repair would not facilitate a second row. All tears were completely repaired back to the anatomic foot-print [Figures 4b and 5]. Bursal and articular releases were performed as necessary to return the tendon back to the anatomic position; however, no interval releases or marginal convergence stitches were needed to improve excursion as these were acute tears and the amount of adhesions were minimal.

Post-operative care

A standardized rotator cuff repair rehabilitation protocol was initiated post-operatively progressing through three phases. In Phase I, the patients were immobilized in a sling and bolster with assisted passive range-of-motion exercises of the shoulder beginning under the supervision of a physical therapist after the initial post-operative visit at 2 weeks from surgery. Phase II began at 6 weeks and consisted of active and active assisted range of motion. Phase III started at 10 to 12 weeks and included a progression from isotonic to isometric strengthening. After 3 month mark, active use was progressed as tolerated.

Post-operative assessment

The mean follow-up for all 15 patients was at 40.5 months (range, 24-69 months). Ultrasound evaluation for tendon integrity occurred at a minimum of 1 year and was performed by the same technician trained in ultrasound evaluation using a General Electric (GE) LOGIQ e ultrasound (General Electric Healthcare, Waukesha, WI, USA). Ultrasound assessment to evaluate the integrity of the rotator cuff repair was performed by a radiologist blinded to the study.

Range of motion assessment included forward elevation in the scapular plane, external rotation in adduction, and internal rotation behind the back. Shoulder strength assessment included resisted supraspinatus forward elevation, resisted external rotation in adduction, and resisted internal rotation in the bear hug position. This was evaluated with the use of the handheld digital dynamometer (Lafayette Manual Muscle Test System Model 01163, Lafayette, IN). Strength was measured in kilograms of force and was assessed as a continuous variable. Using an outcomes questionnaire combined with the objective physical exam, the Constant and Murley score,[24] and the American society of shoulder and elbow surgeons (ASES) score,[27] were determined. Subjective patient-based outcomes were assessed as well: (1). Subjective shoulder value (SSV),[1] (2). Patient satisfaction score (1 = very unsatisfied to 5 = very satisfied), (3). VAS pain score,[25] and.(4). The patient was asked whether they would have the surgery again in retrospect.

Statistical analysis

The student *t* test was used to compare the strength measurements, range of motion, visual analog pain scores, subject shoulder values, Constant Scores, and the American shoulder and elbow surgeons score. A Fisher's exact test was used to compare healing rates between Groups 1 and 2. Statistical significance was set at a P value < 0.05. A power analysis was performed for the total group of 15 patients with a type 1 error set at 0.05, and showed significant power greater than 80% for all the variables tested. However, when the groups were divided into Group 1 and Group 2, the power analysis demonstrated low statistical power of < 10%.

RESULTS

Rotator cuff pathology

Based on Gerber's classification for size, there were 7 massive tears that involved complete detachment of two or more tendons (3 with two tendons only, and 4 with three tendons).[1] The average retraction of these seven massive tears was to zone 3. For the less than two-full-tendon ruptures, the average retraction was to zone 2.

Eight of 15 (53%) patients had a biceps tenotomy or tenodesis. This was determined based on pre-operative tenderness over

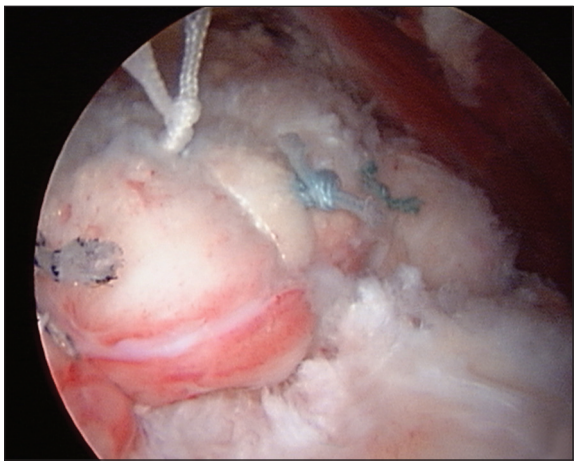

Figure 4b: Arthroscopic view of the same shoulder, after a suture anchor repair.

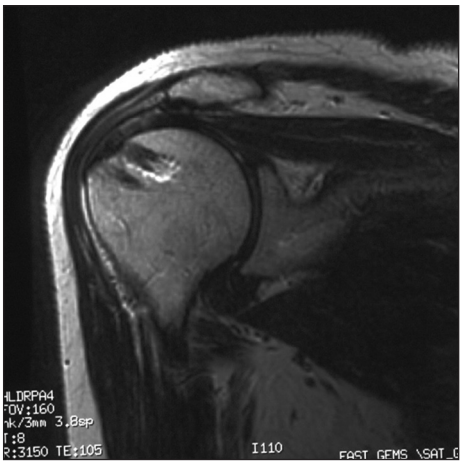

Figure 5: Coronal image of repaired right rotator cuff.

the biceps tendon and intra-operative pathology consisting of a hyperemia, a tear or subluxation of the biceps tendon. Of the eight that received a biceps tenotomy or tenodesis, six of the tears included a tear of the subscapularis tendon [Table 2].

Subjective outcome

Pain was assessed post-operatively using the visual analog scale and averaged 0.5 on a scale of 0-10.[25] Eleven (73%) of the individuals reported no pain, two (13%) individuals reported a pain score of 2 out of 10, and two (13%) individuals had a score of 3 out of 10. Patient satisfaction was assessed on a 1-5 scale, with 5 being "completely satisfied." Twelve of fifteen (80%) patients were "completely satisfied" and scored this outcome as 5 out of 5, with the average score being 4.8 out of 5 for the entire group. The three patients who were not completely satisfied had a satisfaction score of 4.5, 4, and 3, with SSV's of 80, 85, 98, ASES scores of 87, 88, 100, and Constant scores of 64, 86, and 90, respectively. Patients were also asked a subjective shoulder value from 1 to 100, and at final follow-up the patients rated their operative shoulder as 93.9% (S.D. ±6.4%) of normal. Group 1 had a mean SSV of 92.3% (S.D. ±6.2%), where group 2 had a mean SSV of 90.5% (S.D ± 6.6%); $P = 0.3675$,[28] [Table 3]. When asked, all patients asserted that they would have undergone the procedure again.

Clinical assessment

At final follow-up, external rotation improved 25.9° from 42.0° to 67.9° ($P = 0.0016$), internal rotation from the lumbosacral junction to L2 ($P = 0.2560$), and forward elevation increased 92.3° from 65.0° to 157.3° ($P = 0.0001$). There was no difference in the range of motions between Groups 1 and Group 2 [Table 3].

Objective strength measurements were performed post-operatively with the dynamometer as described above. Pre-operative strength was routinely attempted, but was not obtained in all cases due to patient discomfort. Post-operative strength measurements in all three planes were not statistically significant between the operative and the non-operative side [Table 4], and similarly the measurements were not statistically different between Group 1 and Group 2 as a whole [Table 3].

Outcome instruments

The ASES score on the operative side was 94.9 (S.D ± 6.3), compared to the non-operative, asymptomatic side of 93.3 (S.D ± 9.7); $P = 0.6166$ [Table 4]. The pre-operative Constant score for the study group was 25.5 (S.D ± 10.1) and improved to 79.5 (S.D ± 9.9) post-operatively, with a statistically significant

Table 2: Operative findings: zones of retraction and tendon involvement

Operative Findings	Average zone of retraction		Notes
4 isolated supraspinatus tears	1.25	• three retracted to zone 1 • one retracted to zone 2	
2 isolated subscapularis tears	2.75	• two to zone 1 • one to zone 2	Four complete tears involving the entire tendon
3 combined anterior-superior tears (supraspinatus±anterior aspect of infraspinatus and a subscapularis tear		• one to zone 3 • one to zone 4	One upper two thirds tear (to zone 2)
6 posterior-superior tears involving the supraspinatus and the infraspinatus, with three of these involving teres minor	2.75	• two to zone 4 • three to zone 3 • one to zone 2	

Table 3: Post-operative comparison of objective outcomes (ROM in degrees, strength measurements in kg) and functional outcomes (ASES scores, constant scores, and SSV) between Group 1 (maximal medial retraction to the mid-line level of the humeral head (Boileau stage<3) and Group 2 (maximal medial retraction to the glenohumeral joint or greater (Boileau stage ≥3). Significance set at *P*<0.05

Post-operative	Group 1 (retraction<3) (±σ)	Group 2 (retraction ≥3) (±σ)	*P* value
ROM (degrees)			
External rotation	64.2±15.9	71.3±15.1	0.3899
Forward elevation	155.0±15.3	159.4±15.4	0.5917
Internal rotation	Mid-back (T12)	Lower mid back (L2)	0.3417
Strength (kg)			
External rotation	8.1±3.1	9.8±3.5	0.3497
Forward elevation	5.8±2.3	6.3±3.5	0.7547
Internal rotation	9.3±3.7	9.5±3.6	0.9318
Outcomes			
Constant score	80.8±8.9	78.1±11.1	0.6039
ASES score	96.2±4.5	93.5±7.9	0.4226
SSV	92.3±6.2	90.45.4±6.6	0.3675

ROM=Range of motion; ASES=American society of shoulder and elbow surgeons; SSV=Subjective shoulder value

gain of 54.0 (P = 0.0001). Comparing Group 1 and Group 2 post-operatively, there was not a statistical difference regards to ASES or Constant score [Table 3]. Only pre-operatively, however, the Constant score between Group 1 and Group 2 was significantly different (20.5 ± 10.4 vs. 31.3 ± 6.4, P = 0.033), respectively. Demographically, there was a difference, which trended, but was not significant between the ages of the groups as well. Group 1 had an average age of 59 ± 10.3 versus 52 ± 10.4 (P = 0.2226) in Group 2.

The average Goutallier score of the entire cohort was 0.33 (range 0-2) with only 4 subjects having a score greater than 0. 2 patients that had recurrent supraspinatus tears by ultrasound assessment had a Goutallier score of 1 and grade 4 retraction in massive two-tendon tears that involved the supraspinatus and the infraspinatus in both cases [Table 5].

Ultrasound assessment

Blinded ultrasound assessment was used to evaluate failure of repair. It revealed 2 persistent tears in the study group (13.3%). A Fisher's exact test was used to compare the repair integrity rate between Group 1 (100%) and Group 2 (71%), and the two-tailed P values showed no statistical difference with a P value equal to 0.2000. 2 patients that had a tear at final follow-up both had a higher degree of retraction and more tendons involved than those that did not show a re-tear. However, their subjective and objective scores were not significantly different than the 13 that completely healed; furthermore, both would have surgery again. Both patients had a VAS of 0 out of 10 at final follow-up. An image of a fully healed tendon of a patient with previous zone 3 retraction [Figure 6] and an image of a fully re-torn supraspinatus tendon with previous zone 4 retraction [Figure 7] are represented here.

Table 4: Post-operative comparison of the strength (kg) and ASES scores between the operative side and the contralateral side. Significance set at P<0.05)

Post-operative	Operative side (±σ)	Contralateral side (±σ)	P value
Strength (kg)			
External rotation	8.9±3.3	9.5±3.3	0.6123
Forward elevation	6.0±2.8	6.8±2.6	0.4376
Internal rotation	9.4±3.5	10.4±4.2	0.4951
ASES	94.9±6.3	93.3±9.7	6.166

ASES=American society of shoulder and elbow surgeons

DISCUSSION

The current study demonstrates promising results when acute tears are repaired within 6 weeks of an injury and the reported start of symptoms, regardless of level of retraction. Furthermore, the study demonstrates an intact repair rate in 87% of cases at a minimum of 1 year ultrasound assessment.

Prior studies evaluating the effect of tendon retraction in healing and patient outcome have shown lower patient satisfaction rates as well as decreased healing potential. Boileau *et al.*[14] evaluated chronic supraspinatus tears and modified Patte's,[2] three stages of retraction into four stages, and found that tears with more retraction and involvement of either the subscapularis and/or the infraspinatus showed decreased tendon integrity and poorer outcomes. The authors demonstrated an intact tendon repair rate of 71% overall, with a 58% healing rate for stage 2 retraction compared to 78% for stage 1 retraction. For the failed repairs, the Constant score was 78.9 compared to 85.7 for those that had an intact tendon, the difference of which was statistically significant. Our tendon integrity repair rate was 100% for stage 1 and 2 retraction and 71% for stage 3 and 4 retraction.

Table 5: Retraction stage (Boileau) determined intra-operatively and Goutallier scores from pre-operative MRI correlated with healing based post-operatively with ultrasound. Gray indicates massive tears based on number of complete tendons involved ≥2

Retraction (Boileau)				Goutallier	Ultrasound
Subscapularis	Supraspinatus	Infraspinatus	Teres minor		
0	2	2	0	0	Normal
3	1	0	0	0	Normal
2	0	0	0	0	Normal
2	2	2	0	0	Normal
0	1	0	0	0	Normal
1	3	3	3	1 (supra)	Normal
0	1	0	0	0	Normal
0	1	0	0	0	Normal
4	1	0	0	2 (subscap)	Normal
0	2	0	0	0	Biceps edema
0	4	4	0	1 (supra)	Complete supraspinatus tear
0	4	4	0	1 (supra)	Supraspinatus 1 cm tear
2	0	0	0	0	Normal
0	3	3	2	0	Normal
0	2	3	3	0	Normal

*Grey=Massive tears by tear completeness and/or size; MRI=Magnetic resonance imaging

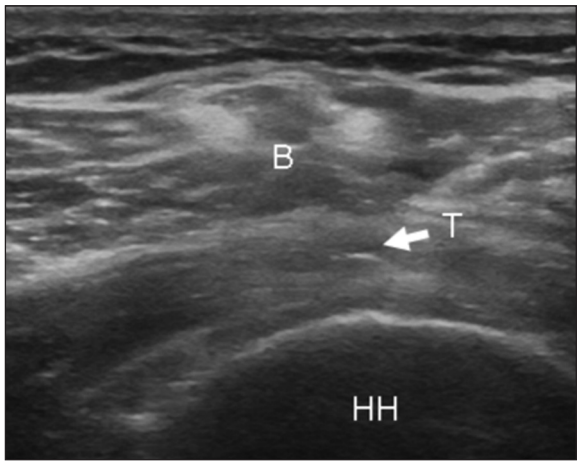

Figure 6: Ultrasound image of a fully healed supraspinatus tendon in a patient with previous zone 3 retraction (B = Bursa; T = Tendon; HH = Humeral Head; Arrow: pointing towards tendon).

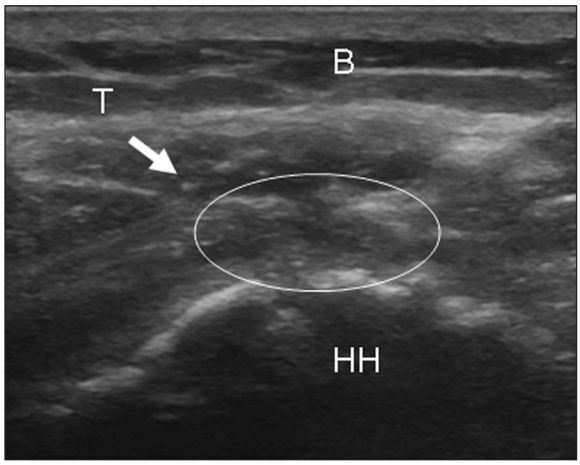

Figure 7: Ultrasound image of a fully torn supraspinatus tendon in a patient with previous zone 4 retraction. (B = Bursa; T = Tendon; HH = Humeral Head; Arrow: pointing towards tendon; Circle: delineating area between tendon stump and greater tuberosity).

Ide *et al.*[15] also evaluated retraction in the subscapularis and also found that larger tendon retraction predicted decreased healing and poorer outcomes. He reported failure of the repair in six out of seven "severe" chronic subscapularis tears (tendon edge at or medial to the glenoid rim when the arm was in neutral rotation). In our study, all subscapularis tendons remained intact. Furthermore, two of the subscapularis tendons that were repaired were retracted to zone ≥ 3, which corresponded to Ide *et al.*,[15] "severe" classification. We believe our low failure of repair rate may be attributed to early surgical treatment within 6 weeks of injury. Our average intact repair rate was 87%, and our Constant score compared favorably at 80%, and was not statistically different for both large retraction (zone 3 and 4) and small (zone 1 and 2) retraction.

Overall, the study population demonstrated improvements in pain, subjective outcomes, range of motion, and Constant scores. Range of motion in forward elevation and external rotation improved significantly. Strength testing in abduction, external rotation, and internal rotation was not statistically different from the contralateral side at final follow-up. Constant scores improved from 25.5 to 79.5, with 60% of patients scoring ≥ 80 points at the final post-operative evaluation. ASES scores at follow-up were also 94.9 compared to 93.3 on the contralateral side and the average SSV was 93.9%; the results (score > 90) of which are considered "excellent."[27] Furthermore, all patients (100%) said they would have the surgery again, with an average satisfaction of 4.8 out of 5 (12 out of 15 were completely satisfied). Lastly, only 4 patients reported any pain, with the highest score of 3 out of 10.

When the patients were stratified into two groups (Group 1: Maximal tendon retraction to zone 2, with the tendon edge still over the mid-line of the humeral articular surface; Group 2: Tendon retraction to zone 3 or 4, with the tendon edge medial to the articular surface of the humeral head) the results did not show a statistical difference between the groups. Range of motion, strength, subjective satisfaction, ASES scores, and post-operative Constant scores were not statistically different either. The only significant difference was found in the tendon integrity as previously described and the pre-operative Constant scores, with the more retracted tears having a statistically better pre-operative Constant score than the less retracted tears (30.3 vs. 20.5, respectively). A possible explanation could be that age played a factor as Group 1 had an average age of 59 (range 47-73), whereas Group 2 had an average age of 52 (range 43-72). Thus, the subjective and objective deficit from the tear in the slightly older patient more adversely affected the pre-operative assessment in the older patient group (Group 1) compared to the younger group (Group 2), yet normalized between the groups post-operatively. While age has been shown not to correlate with the size of a tendon tear in the anterior to posterior (AP) diameter when comparing symptomatic and asymptomatic individuals,[29] tears have been shown; however, to be more prevalent in an older patient and to progress in width (AP direction) over time.[30] Our study indicates that there might be either a negative correlation or no correlation between retraction and age, similar to the study by Yamaguchi *et al.* as the older patient population counter-intuitively had a less retracted tear than the younger patient population.[29] Again, this indicates that in the setting of an acute tear, neither an older age nor tendon retraction should adversely affect the decision to attempt repair.

A limitation to our study concerns the small size of the study population. However, we succeeded in showing a difference between pre- and post-operative outcomes, and demonstrated no difference between operative and non-operative sides at follow-up for the entire study population. Yet, with the numbers available, we could not expect to definitively show differences between the two groups if these differences actually existed. Another limitation is that we had 7 patients who could not be prospectively followed, which limited our analysis.

Furthermore, we had a mixture of anterior-superior tears and posterior-superior tears in the study. While we included subscapularis tears in this study along with supraspinatus and infraspinatus tears, we acknowledge that the mechanics and incidences of the anterior subscapularis tears differ from that of the superior-posterior tears. However, the purpose of this study was to evaluate for retraction of the rotator cuff tendon that was torn, and analyze this variable in regards to the outcome and repair integrity. For this reason, we felt it suitable to include subscapularis tears with the suprasinatus and infraspinatus tears. As there is no universal classification for tendon retraction, we adopted Boileau *et al.*,[14] non-validated staging of supraspinatus tears to be used for staging retraction of the subscapularis tendon as well. Nevertheless, even with the distinction of 4 zones of retraction, we found that large tendon retraction (zone 3 or 4), did not lead to poorer outcomes when compared to lower degrees of tendon retraction (zone 1 or 2) in the setting of acute rotator cuff repairs.

Ultrasound evaluation of tendon healing has been validated in previous studies.[31-33] Our study showed only 2 patients (13%) with unhealed tendons at final ultrasound evaluation. The subjective satisfactions of these two individuals were still rated as "excellent," and the two patients would have the surgery again when asked. In addition, while these two patients were in large retraction group, with the numbers available, we could not significantly correlate large retraction with the absence of tendon healing.

We also had seven tears that qualified as "massive", according to Gerber *et al.*[1] Definition of complete rupture of two or more tendons. Gerber's and other studies,[7,20,28,34-38] looked at "massive" chronic tears and discovered re-tear rates from 34% to 94% and poorer outcomes in those with unhealed repairs. We found in our evaluation of those with "massive" tears, five out of seven (71%) had no re-tears at a minimum of 1 year of ultrasound evaluation. This corresponded to a 71% healing rate of massive tears. Of the two patients with ultrasound evidence of a non-intact repair, their SSV's were 84% and 90%, ASES scores were 93.3 and 78.0, and Constant scores were 62 and 69, respectively; they rated their satisfaction, however, as 5 out of 5 and both had a VAS of 0 out of 10. Our differing results compared to other studies of "massive" tears most likely represents the acuity of repair, controlling for the poorer predictors of tendon healing such as poor tendon quality and advanced fatty infiltration and degeneration.

We also found that Goutallier scores for fatty infiltration potentially influenced healing rates. When those with a Goutallier score other than stage 0 were assessed for healing, however, 50% (two out of four) had a failure of complete repair, compared to 100% (twelve out of twelve) intact with a Goutallier score of stage 0. When looking at retraction, comparatively, five out of seven (72%) of those with ≥ stage 3 retraction healed; and again, the two that did not heal in this group had a Goutallier score other than stage 0. Thus, even though these patients with acute tears had relatively healthy musculo-tendonous units with low degrees of fatty infiltration, the muscle and tendon quality correlated with repair integrity rates.

CONCLUSION

In summation, follow-up evaluation with ultrasound of tendon healing showed an overall repair integrity rate of 87%, with a 100% integrity rate for those with stage 1 or 2 retraction, and a rate of 72% for those with a stage 3 or stage 4 retracted tear. While these rates are not the same, with the numbers available in the study, we could not statistically prove a difference. However, even with failure of complete healing in a minority of our patients studied, subjective and objective outcomes improved, patients were satisfied with the surgery and would have it again. In the "acute" setting, a patient who had an injury to the rotator cuff that occurred within 6 weeks before surgery, large retraction should not be a contraindication for repairing the torn rotator cuff in the setting of a low Goutallier score (2 or less). Excellent outcomes can be achieved, as shown in this study, with all sizes of tears that are retracted as far medially as the glenoid. Therefore, in acute rotator cuff tears, expectations of high patient satisfaction, low pain scores, near the normal range of motion and strength, and improved outcome measures should be expected with surgical repair despite the level of retraction.

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