Incidence and Treatment of Postoperative Stiffness Following Arthroscopic Rotator Cuff Repair

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Purpose: The purpose of this study was to determine the incidence of clinically significant postoperative stiffness following arthroscopic rotator cuff repair. This study also sought to determine the clinical and surgical factors that were associated with higher rates of postoperative stiffness. Finally, we analyzed the result of arthroscopic lysis of adhesions and capsular release for treatment of patients who developed refractory postoperative stiffness 4 to 19 months (median, 8 months) following arthroscopic rotator cuff repair. **Methods:** A retrospective review of a consecutive series of arthroscopic rotator cuff repairs was conducted. During a 3-year time period, the senior author (S.S.B.) performed 489 arthroscopic rotator cuff repairs. The operative indications, technique of the rotator cuff repair, and the rehabilitation protocol were essentially unchanged during this time period. Demographic data, comorbid medical conditions, rotator cuff tear description, technique of repair, and concomitant surgical procedures were evaluated for their effect on stiffness. All office evaluations were reviewed to determine the pre- and postoperative motion, pain scores, functional strength, and patient satisfaction. Patients who were dissatisfied because of the development of postoperative stiffness underwent secondary arthroscopic lysis of adhesions. The final result of the secondary lysis of adhesions and capsular release were analyzed. **Results:** In total, 24 patients (4.9%) were dissatisfied with the result of their procedure because of the development of postoperative stiffness, which was more likely ($P < .05$) to develop in patients with Workers' Compensation insurance (8.6%), patients younger than 50 years of age (8.6%), those with a coexisting diagnosis of calcific tendonitis (16.7%) or adhesive capsulitis (15.0%) requiring additional postoperative therapy, partial articular-sided tendon avulsion (PASTA) type rotator cuff tear (13.5%), or concomitant labral repair (11.0%). Patients with concomitant coracoplasty (2.3%) or tears larger in size and/or involving more tendons were less likely ($P < .05$) to develop postoperative stiffness. Among 90 patients positive for selected risk factors (adhesive capsulitis, excision of calcific deposits, single-tendon repair, PASTA repair, or any labral repair without a concomitant coracoplasty), 12 (13.3%) developed postoperative stiffness ($P < .001$). This overall clinical risk factor combined with Workers' Compensation insurance identified 16 of the 24 cases resulting in a sensitivity of 66.7% and a specificity of 64.5%. All 24 patients who experienced postoperative stiffness elected to undergo arthroscopic lysis of adhesions and capsular release, which was performed from 4 to 19 months (median, 8 months) after the rotator cuff repair. During second-look arthroscopy, 23 patients (95.8%) were noted to have complete healing of the original pathology. Following capsular release, all 24 patients were satisfied with the overall result of their treatment. **Conclusions:** In a series of 489 consecutive arthroscopic rotator cuff repairs, we found that 24 patients (4.9%) developed postoperative stiffness. Risk factors for postoperative stiffness were calcific tendinitis, adhesive capsulitis, single-tendon cuff repair, PASTA repair, being under 50 years of age, and having Workers' Compensation insurance. Twenty-three of 24 patients (95.8%) showed complete healing of the rotator cuff. Arthroscopic release resulted in normal motion in all cases. **Level of Evidence:** Level IV, therapeutic case series. **Key Words:** Complications—Postoperative stiffness—Rotator cuff—Rotator cuff repair—Stiffness.

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Arthroscopic rotator cuff repair has undergone considerable advancement over the last decade, to the point where this technique is becoming the preferred method of treatment of rotator cuff pathology. There are numerous published descriptions of arthroscopic rotator cuff repair techniques and the outstanding clinical results achieved.[1-7] Very few studies, however, have been directed to examine the complications of arthroscopic rotator cuff repair[8-10] and specifically postoperative stiffness.[11,12,13] Failure of surgical treatment of rotator cuff pathology is usually attributed to disruption of the repair itself. Patient dissatisfaction, however, may be related to postoperative adhesions and capsular contracture. Previous studies have not clearly established the prevalence of painful stiffness following arthroscopic rotator cuff repair.

The postoperative rehabilitation program is a critical aspect in the surgical treatment of rotator cuff injury. The rehabilitation program that best allows for tendon-to-bone healing while preventing shoulder stiffness has not been established. Burkhart and Lo[3,14-16] have previously examined how to optimize the tendon-to-bone repair construct. In this study, we consider the postoperative rehabilitation protocol as it relates to healing of the rotator cuff and the development of postoperative adhesions and clinical restriction of motion.

Patients judged to have a disabling lack of motion were included in this study. In analyzing that group, they were found to have statistically significant restriction of motion.

Our experience has confirmed that following arthroscopic rotator cuff repair, the best clinical results (restoration of strength, motion, and relief of pain) are achieved after a durable repair of tendon to bone that heals in its entirety. Consequently, the senior author (S.S.B.) has adopted a very conservative rehabilitation protocol following arthroscopic rotator cuff repair, with the goal being to maximize the potential for tendon-to-bone healing. This philosophy is based on a primate study that suggests that at least 3 months are required for Sharpey fibers to develop at the tendon–bone reattachment site.[17] In addition to allowing for more complete healing, there is strong evidence that postoperative immobilization after rotator cuff repair promotes superior mechanical properties in the healing tissues.[18,19] For these reasons, the senior author has used a consistent surgical technique of arthroscopic rotator cuff repair and a consistent and conservative rehabilitation protocol since January 2001.

There were 3 goals for this study. First, we sought to determine the incidence of postoperative adhesions and clinically significant stiffness (that which required reoperation) following arthroscopic rotator cuff repair and a conservative rehabilitation protocol. Next, we sought to determine which demographic factors, medical comorbidities, and surgical factors were associated with a higher incidence of significant stiffness. Finally, we determined the results of the second operation (lysis of adhesions and capsular release) with regard to ultimate patient outcome and satisfaction, and we report the findings at the time of second-look shoulder arthroscopy. Our hypotheses were that postoperative stiffness following our conservative rehabilitation regimen would be within an acceptable range, and that patients who became stiff could be adequately treated with an arthroscopic capsular release and lysis of adhesions.

METHODS

A consecutive series of patients who underwent an arthroscopic rotator cuff repair performed by the senior author (S.S.B.) during a 3-year time period from January 1, 2003, to December 31, 2005 were reviewed retrospectively. The techniques used have been well described elsewhere.[3,14-16,20-25] The same surgeon individually examined each patient and personally recorded the results at all follow-up visits. The follow-up examination included an analysis of active and passive motion measured in degrees (seated forward flexion, external rotation with arms adducted to side, internal rotation behind the back and with the arm at 90° of abduction) and manual strength assessment (internal and external rotation strength with arms adducted to side and elbows at 90° of flexion), and patient-specific factors. Range of motion measurements represented combined glenohumeral and scapulothoracic motion to give a total arc of motion. At each follow-up visit, patients completed the visual analog pain scale survey and modified University of California–Los Angeles (UCLA) score questionnaire. The rehabilitation protocol (described below) was unchanged during this time period. The complete medical records of all patients were retrospectively reviewed following appropriate institutional approval. Demographic data—including age, sex, dominant shoulder, and Workers' Compensation status—were collected. Comorbid medical conditions previously implicated as high risk factors for the development of shoulder stiffness (diabetes, hypothyroidism, calcific tendonitis, and adhesive capsulitis) were also noted. All office evaluations were reviewed to determine the pre- and postoperative motion, pain scores, functional strength, and

patient satisfaction. Surgical records were reviewed to determine the size of the rotator cuff tears, which tendons were torn, the number of anchors and technique of repair, and all concomitant surgical procedures performed including SLAP repair, Bankart repair, acromioplasty, distal clavicle excision, coracoplasty, biceps tenodesis, and interval slides for contracture release. The size of the rotator cuff tear was considered an important variable in the analysis. The rotator cuff tear was measured from anterior to posterior using an instrument of known diameter (4.5-mm shaver). Double-row footprint repair of the rotator cuff was done whenever possible. Single-row repair was performed for partial thickness rotator cuff tears and for tears with insufficient lateral excursion to permit double-row repair. Patients who were dissatisfied because of the development of adhesions and postoperative stiffness were identified and further analyzed. We believe that our decision to define stiffness as the patients' dissatisfaction with their range of motion is clinically the most relevant way to define stiffness. Furthermore, this method increases the incidence of stiffness by including patients that have a bothersome motion deficit in a single direction, such as internal rotation. Such patients might not have been identified under a threshold system that tends to emphasize forward flexion or elevation.

The final result (strength, motion, pain, function, and UCLA score) of the secondary lysis of adhesions and capsular release were examined. Finally, a statistical analysis was conducted to determine which variables when considered individually were associated with an increased incidence of stiffness based on χ-square or Fisher exact tests for dichotomous parameters, the Mann-Whitney U test for counts of tendon tears and anchors, and the Student t test for age and range of motion measures. After the most significant combination of clinical risk factors for postoperative stiffness was identified, multivariable logistic regression was performed to determine if any other factor modeled with the primary factor was statistically significant. For all statistical tests, $P < .05$ was considered significant. Statistical analysis was performed using SPSS 15.0 software (SPSS, Chicago, IL).

During the time period of this study, the senior author (S.S.B.) used a consistent rehabilitation protocol following arthroscopic rotator cuff repair (Table 1). During the first 6 weeks, no overhead motion is allowed. The sling is discontinued after 6 weeks. Beginning in the seventh and progressing though the twelfth postoperative weeks, all patients are instructed to perform passive overhead stretches with a rope and pulley. Patients are also encouraged to perform full passive external rotation (no limits) with the arm at the side during this time.

Table 1. *Rehabilitation Protocol Following Arthroscopic Rotator Cuff Repair*

Preoperatively
Surgeon-directed counseling on rehabilitation plan
Give patient therapy kit and instructions on initial use
Therapy kit: PVC cane, rope and pulley, and graduated elastic strengthening bands
Immediate postoperative period
Patient placed in sling with small pillow
Surgeon gives patient and family specifics of rehabilitation plan
Postoperative weeks 0 to 6
Postoperative days 1 to 10: At initial follow-up, surgeon-directed reinforcement of home rehabilitation plan
Remove sling 3 times per day for the following:
Active motion of hand, wrist, and elbow
Passive external rotation of shoulder with arm at side (use PVC cane)
Limited to 45° for small to large posterior–superior cuff tears
Limited to 0° (straight ahead) for massive tears and subscap tears
No active assisted motion
No passive overhead motion
Exception: calcific tendinitis and adhesive capsulitis patients
Begin passive rope and pulley overhead and internal rotation stretch
Postoperative weeks 7 to 12
Surgeon-directed reinforcement of home rehabilitation plan
Discontinuation of sling and continue previous exercises:
Advance passive external rotation with cane (limit at external rotation of opposite shoulder)
Begin rope and pulley overhead stretch
Begin rope and pulley behind back internal rotation stretch
Still no active assisted motion
No strengthening
Postoperative months 3 to 6
Surgeon-directed reinforcement of rehabilitation plan
Continue previous stretching exercises
Begin strengthening program with graduated elastic bands:
Internal and external rotation with arm at side (deltoid and rotator cuff)
Curl and low row exercise (biceps and periscapular muscles)
No heavy overhead lifting and no acceleration of arm in sport
Patient is given option of using therapist to assist in implementation of our plan
Postoperative months 6 to 12
May progress to light weights in gym
Clearance to full activity given based on examination
Massive cuff tear patients continue overhead lifting and sport restriction until 1 year postoperatively

At 3 to 4 months postoperatively, patients begin strengthening exercises with elastic bands. The strengthening phase of rehabilitation is delayed until 4 months postoperatively in patients with massive 3-tendon rotator cuff tears or tears greater than 5 cm in maximum diameter.

During the first 6 months postoperatively, patients are restricted from performing any heavy overhead lifting and any aggressive activity that requires acceleration of the arm (golf, tennis, or overhand throw). Patients are typically allowed to return to unlimited activities at 6 months postoperatively with the exception of massive 3-tendon tear patients, who are allowed unlimited activities at 1 year.

RESULTS

During the 3-year study period from January 1, 2003, through December 31, 2005, the senior author performed 489 arthroscopic rotator cuff repairs. Ranging from 4 to 19 months (median, 8 months) following the rotator cuff repair, 24 (4.9%) of these patients were dissatisfied with their result because of a restriction of motion. These patients were identified as having developed significant postoperative adhesions and clinical stiffness despite excellent strength and a presumed intact rotator cuff repair. Each of these patients elected to undergo a second arthroscopic surgery for lysis of adhesions and capsular release. Table 2 lists the observed incidence and statistical significance for possible risk factors for development of stiffness.

Demographic factors and other possible risk factors were examined to evaluate their effect on the incidence of postoperative adhesions and stiffness (Table 2). No statistically significant effects were noted when considering the patient sex or dominant versus nondominant extremity. However, patients who developed stiffness had an average age that was 4.6 years younger than patients who did not require a capsular release ($P = .050$), and 13 of 153 (8.5%) patients under 50 years of age were more likely to develop stiffness ($P = .013$). Patients who had Workers' Compensation insurance had a significantly higher incidence of development of postoperative adhesions and clinically significant restriction of motion ($P = .034$). Ten out of 116 (8.6%) patients with Workers' Compensation insurance developed postoperative stiffness and required a secondary release.

Several comorbid medical conditions are considered to be risk factors for the development of postoperative adhesions and motion restriction. Our patients were reviewed to determine if they carried a diagnosis of diabetes, hypothyroidism, adhesive capsulitis, and calcific tendonitis at the time of the rotator cuff repair operation. Fifty-three of 489 (10.8%) patients carried the diagnosis of diabetes at the time of the rotator cuff repair. Only 1 of 53 (1.9%) patients with diabetes developed postoperative motion restriction following arthroscopic rotator cuff repair. Eighteen patients held the diagnosis of hypothyroidism, and 1 developed postoperative stiffness (5.6%). Both adhesive capsulitis ($P = .068$) and calcific tendonitis ($P = .113$) were observed to have a marginally increased incidence of postoperative adhesion and restriction of motion despite an accelerated stretching program. Three of 20 (15.0%) patients with preoperative or intraoperative diagnosis of adhesive capsulitis and 2 of 12 (16.7%) patients with calcific tendonitis developed a restriction of motion and required a secondary arthroscopic release. Because these 2 conditions were mutually exclusive, rare, and required additional therapy following the rotator cuff repair, they were combined as a single comorbidity, for which 5 of 32 (15.6%) patients developed postoperative stiffness, an increased prevalence that was statistically significant ($P = .015$).

The tear was also described in terms of the percentage of each tendon involved in the tear. For the entire sample, the size of rotator cuff tears ranged from 1 to 9 cm (median, 3 cm) from anterior to posterior and involved 1 to 4 tendons (median, 2 tendons). Patients who developed postoperative adhesions and clinical restriction of motion had significantly smaller tears ($P = .028$) involving significantly fewer tendons ($P = .033$) compared to the patients who did not report postoperative stiffness. For the stiffness cases, tears ranged in size from 1 to 10 cm (median, 2 cm) and involved 1 to 4 tendons (median, 1 tendon). Overall, there were 191 (39.1%) 1-tendon tears, 150 (30.7%) 2-tendon tears, and 148 (30.3%) 3- to 4-tendon tears. The number and prevalence of stiffness cases associated with the number of tendon tears was 14 (7.3%) for 1-tendon tears, 7 (4.7%) for 2-tendon tears, and 3 (2.0%) for 3- to 4-tendon tears. Thirty-seven (7.6%) patients had PASTA type tears, of which 5 (13.5%) developed postoperative stiffness, which was a significantly increased prevalence ($P = .028$).

Several factors related to the arthroscopic rotator cuff repair itself were evaluated. All repairs were performed with the use of the bioabsorbable anchors (Bio-Corkscrew and Bio-Corkscrew FT; Arthrex, Naples, FL). A range of 0 to 9 anchors (median, 3 anchors) was used to complete the repairs. In the 24 patients who developed stiffness, a range of 1 to 8

TABLE 2. *Prevalence of Possible Risk Factors for Incidence of Postoperative Stiffness Observed for 24 of 489 Patients (4.9%) With Rotator Cuff Repairs*

Variable	Patients With Variable, n (%)	Incidence of Stiffness in This Group (%)	*P*
Maximum clinical risk*	90 (18.4)	12/90 (13.3)	<.001
Demographics			
Male	328 (67.1)	17/328 (5.2)	.688
Female	161 (32.9)	7/161 (4.3)	NA
Age in yrs (range, 18 to 85)	Median, 55 yrs	Median, 48.5 yrs	.050
Age <50 yrs	153 (31.3)	13/153 (8.5)	.013
Dominant shoulder	306 (62.6)	15/306 (4.9)	.994
Nondominant shoulder	183 (37.4)	9/183 (4.9)	NA
Workers' Compensation insurance	116 (23.7)	10/116 (8.6)	.034
Comorbid medical conditions			
Diabetes	53 (10.8)	1/53 (1.9)	.242
Hypothyroidism	18 (3.7)	1/18 (5.6)	.602
Adhesive capsulitis	20 (4.1)	3/20 (15.0)	.068
Calcific tendonitis	12 (2.5)	2/12 (16.7)	.113
Adhesive capsulitis or calcific tendonitis	32 (6.5)	5/32 (15.6)	.015
Rotator cuff tear			
Tear size (range, 1-10 cm)	Median, 3 cm	Median, 2 cm	.028
No. of tendons involved (range, 1 to 4)	Median, 2 tendons	Median, 1 tendon	.033
1-tendon tears (*v* 2 or more)	191 (39.1)	14/191 (7.3)	.047
2-tendon tears	150 (30.7)	7/150 (4.7)	NA
3- or 4-tendon tears (*v* 1 or 2)	148 (30.3)	3/148 (2.0)	.052
PASTA type tears	37 (7.6)	5/37 (13.5)	.028
Supraspinatus tear	444 (90.8)	21/444 (4.7)	.383
Subscapularis tear	252 (51.5)	8/252 (3.2)	.067
Rotator cuff repair			
No. of anchors used (range, 0 to 9)	Median, 3 anchors	Median, 2 anchors	.323
Double row repair used	372 (76.1)	18/372 (4.8)	.899
Revision rotator cuff repair	47 (9.6)	0/47 (0)	.083
Concomitant surgical procedures			
Subacromial decompression	462 (94.5)	23/462 (5.0)	.612
Distal clavicle excision	205 (41.9)	11/205 (5.4)	.690
Coracoplasty	213 (43.6)	5/213 (2.3)	.021
Interval slides (contracture release)	141 (28.8)	6/141 (4.3)	.671
Biceps tenodesis	114 (23.3)	3/114 (2.6)	.199
SLAP repair	74 (15.1)	6/74 (8.1)	.138
Bankart repair	15 (3.1)	3/15 (20.0)	.032
Any labral repair	82 (16.8)	9/82 (11.0)	.010

Abbreviations: NA, not applicable; PASTA, partial articular-sided tendon avulsion.
*Patients with concomitant adhesive capsulitis, excision of calcific deposits, single-tendon repair, PASTA repair, or labral repair.

anchors (median, 2 anchors) was used in the repair. A double row repair was performed for 372 (76.1%) patients in the sample, of which 18 (4.8%) developed postoperative adhesions and restriction of motion. In 47 patients, the index operation by the senior author (S.S.B.) was an arthroscopic revision rotator cuff repair (previous failed rotator cuff repair). None of these patients developed postoperative stiffness.

At the time of arthroscopic rotator cuff repair, many additional arthroscopic procedures were performed, and the effect of these procedures on the incidence of postoperative motion restriction was investigated. Concomitant subacromial decompression (acromioplasty), distal clavicle excision, biceps tenodesis, and interval slide technique of contracture release did not significantly impact the incidence of postoperative stiffness. Nine of 82 (11.0%) patients receiving a labral repair combined with a rotator cuff repair experienced postoperative adhesions and motion restriction, resulting in a significantly increased incidence

rate ($P = .010$). The 82 patients with combined labral repairs included 67 with SLAP only, 8 with Bankart only, and 7 with both procedures. Postoperative stiffness was observed in 6 (9.0%) patients with SLAP only, 3 (37.5%) patients with Bankart only, and none with both procedures. The combination of a labral repair with rotator cuff repair increased the prevalence of postoperative stiffness.

For the purpose of determining the overall risk of stiffness associated with the previously identified comorbidity and combined procedure risk factors, patients were classified as negative for comorbidity and not receiving a combined procedure versus positive for comorbidity and/or undergoing a combined procedure (positive for adhesive capsulitis or calcific tendonitis, and/or combined labral repair without concomitant coracoplasty) with a goal of maximizing sensitivity and specificity in predicting postoperative stiffness. Twelve of 399 (3.0%) risk-negatives versus 12 of 90 (13.3%) risk-positives developed a painful restriction of motion, representing a significant fourfold increase in incidence ($P < .001$); however, further analyses were performed to try to increase the observed sensitivity of 50.0% (95% confidence interval [CI], 29.1% to 70.9%) above 60.0% without decreasing the observed specificity of 83.2% (95% CI, 79.5% to 86.5%) below 60.0%. A series of multivariable logistic regressions were performed to fit a 2-factor model combining the primary risk factor with one other individual risk factor from the remaining list of items shown to have significant association with outcome (<50 years of age, Workers' Compensation insurance, tear size, number of tendons involved, and PASTA type tear). Any model for which the goodness of fit test had $P > .10$ and both factors had odds ratios with $P < .10$ was considered important. The only multivariable logistic regression model meeting these criteria was the second model combining the primary clinical risk factor, which had an odds ratio of 4.82 (95% CI, 2.07 to 11.17; $P < .001$), and Workers' Compensation insurance, which had an odds ratio of 2.29 (95% CI, 0.97 to 5.40; $P = .059$). The Hosmer–Lemeshow test for this model indicated a good fit ($P = .803$). After incorporating Workers' Compensation insurance into the definition of risk for stiffness—so that patients were classified as positive for risk if they had Workers' Compensation insurance, were diagnosed with adhesive capsulitis or calcific tendonitis, or had a labral repair without a concomitant coracoplasty—then 16 of 181 (8.8%) of positives and 8 of 308 (2.6%) of negatives experienced postoperative stiffness, representing a significant difference in incidence ($P = .002$) and a sensitivity of 66.7% (95% CI, 44.7% to 84.4%) with a specificity of 64.5% (95% CI, 60.0% to 68.9%).

When reviewing the patient charts, forward flexion angles were available for 484 (99.0%) patients and external rotation measures were recorded for 470 (96.1%) cases; however, internal rotation represented by vertebrae location was noted for only 264 (54.0%) patients, while internal rotation represented in degrees was recorded for only 246 (50.3%) patients. Because 99 patients had both types of internal rotation measures, only 411 (84.0%) patients had any internal rotation measure. As a result, internal rotation was classified as normal (vertebrae location L1 or higher or an angle >45°) or impaired. Therefore, the pre- and postoperative motion mean results reported in Table 3 were restricted to forward flexion and external rotation, while internal rotation was represented by the percentage of impaired cases. Among the 24 patients reporting postoperative stiffness who required a secondary release, complete data were available for postrepair forward flexion and external rotation, with means ± standard deviations (SDs) of 137.5° ± 26.0° and 32.3° ± 20.5°, respectively. Postoperative internal rotation was also recorded for 22 patients, and 21 (95.5%) were classified as impaired. Following capsular release, change in motion data were available for 19 patients, who significantly improved by an average of 28.2° ± 18.9° for forward flexion and 22.1° ± 17.6° for external rotation ($P < .001$). Internal rotation measures were also collected for 16 of the 21 patients classified as impaired before capsular release, and 9 (56.3%) of these resulted in normal internal rotation ($P = .004$).

At the time of second-look arthroscopy, 23 of 24 patients had complete healing of the original pathology. One patient had a remaining defect in the rotator cuff with healing of 60% of the repaired footprint. In addition to capsular restriction, all 24 patients had varying degrees of subacromial adhesions. Post–capsular release follow-up data were available for 22 of these patients. They were surveyed from 14 to 41 months (median, 32 months) after capsular release and reported visual analog pain scores ranging from 0 to 3 (median, 1) and UCLA scores ranging from 28 to 35 (median, 33), and all 22 were satisfied with the result of their procedures.

DISCUSSION

There are many benefits in using arthroscopic techniques to treat rotator cuff pathology. One of the

TABLE 3. *Evaluation of Motion*

Mean ± SD for preoperative FF and ER motion and percent with preoperative impaired IR motion in patients			
	Normal (no postoperative stiffness) Group (n = 465)	Postoperative Stiffness Group (n = 24)	*P*
FF	151.9° ± 45.1° (n = 460)	150.2° ± 37.9° (n = 24)	.857
ER	55.5° ± 18.7° (n = 447)	54.4° ± 19.2° (n = 23)	.789
IR	46.9% (n = 390)	42.9% (n = 21)	.716
Mean ± SD for postoperative FF and ER motion and percent with postoperative impaired IR motion in patients overall and comparing 1-tendon tears with multiple-tendon tears			
	Normal (no postoperative stiffness) Group (n = 465)	Postoperative Stiffness Group (n = 24)	*P*
Overall			
FF	162.0° ± 30.8° (n = 412)	137.5° ± 26.0° (n = 24)	<.001
ER	57.7° ± 14.9° (n = 398)	32.3° ± 20.5° (n = 24)	<.001
IR	39.0% (n = 364)	95.5% (n = 22)	<.001
	Normal (no postoperative stiffness) Group (n = 177)	Postoperative Stiffness Group (n = 14)	
1-tendon tear			
FF	167.5° ± 24.8° (n = 163)	133.6° ± 27.1° (n = 14)	<.001
ER	60.8° ± 13.0° (n = 163)	30.4° ± 18.1° (n = 14)	<.001
IR	37.8% (n = 156)	100.0% (n = 12)	<.001
	Normal (no postoperative stiffness) Group (n = 288)	Postoperative Stiffness Group (n = 10)	
Multiple-tendon tears			
FF	158.4° ± 33.7° (n = 249)	143.0° ± 24.5° (n = 10)	.154
ER	55.6° ± 15.7° (n = 235)	35.0° ± 24.3° (n = 10)	.025
IR	39.9% (n = 208)	90.0% (n = 10)	.002
	Normal (no postoperative stiffness) Group (n = 32)	Postoperative Stiffness Group (n = 5)	
PASTA tears			
FF	156.9° ± 33.2° (n = 30)	145.0° ± 21.8° (n = 5)	.449
ER	54.3° ± 14.6° (n = 30)	26.0° ± 16.4° (n = 5)	<.001
IR	44.4% (n = 27)	100.0% (n = 5)	.031
Motion following capsular release for postoperative stiffness group (24 patients)			
	Final Results	Improvement From Previous	
FF	166.1° ± 13.4° (n = 19)	28.2° ± 18.9° (n = 19)	<.001
ER	52.6° ± 15.0° (n = 19)	22.1° ± 17.6° (n = 19)	<.001
IR	47.4% (n = 19)	9 made normal out of 16 impaired	.004

Abbreviations: ER, external rotation; FF, forward flexion; IR, internal rotation; SD, standard deviation.

greatest, however, is the limited nature of dissection across tissue planes, and consequently less scar tissue and adhesion formation results. This tendency toward less scar formation supports the use of a very conservative rehabilitation program after arthroscopic cuff repair, one that will maximize the opportunity for tendon-to-bone healing to occur.

In the medical literature, there have been very few studies that have evaluated the incidence of stiffness following rotator cuff repair.[8-11] Warner and Greis[12] conducted a review of rotator cuff repair studies that occurred over 2 decades. The techniques of repair were highly varied (open, mini-open, and arthroscopic-assisted) as were the rehabilitation protocols. In this review,[12] 21 out of 500 patients (4%) had a painful loss of motion that was thought to be caused

by postoperative adhesions. Cameron et al.[26] reported a 32% incidence of significant persistent postoperative stiffness after mini-open rotator cuff repair. Severud et al.[26] reported a comparative outcome analysis between their arthroscopic and mini-open rotator cuff repairs. Despite using the same early motion protocols, they found a 14% incidence of postoperative adhesions and stiffness in the mini-open group and a 0% incidence in the arthroscopic group. A multicenter study from France with 576 arthroscopic rotator cuff repair cases found persistent postoperative stiffness problematic in 3.1% of patients.[27] Tauro[11] recently performed a retrospective review of 72 patients who underwent arthroscopic rotator cuff repair and an early postoperative motion protocol. He found that 3 of these patients (4.3%) required a secondary arthroscopic lysis of adhesions at an average of 5.5 months post–rotator cuff repair. Each of these patients had a preoperative range of motion deficit of $\geq 70^\circ$ (total arc). Two of 3 had a diagnosis of diabetes, and all 3 patients had evidence of capsular synovitis and thickening (adhesive capsulitis) at the time of the initial operation. These traits were considered risk factors for the development of postoperative stiffness.

We chose to treat our patients with 6 weeks of immobilization with no overhead stretches for 6 weeks in order to avoid potentially destructive high strains at the repair site[28,29] and to encourage more parallel collagen orientation and improved mechanical properties in the healed rotator cuff.[19] Furthermore, we delayed strengthening until 3 to 4 months postoperatively, the point at which Sharpey fibers have been observed to form after rotator cuff repair in primates.[17]

Despite our conservative rehabilitation protocol, our study has a comparable overall rate (4.9%) of postoperative adhesion formation and motion restriction requiring a secondary arthroscopic release. Interestingly, during this same time period, only 5 other patients (1.0%) required reoperation for other reasons. Four patients required reoperation for a revision of failed rotator cuff repair, and 1 patient secondary to reformation of a large acromial spur (heterotopic ossification). This is not to say that the remaining 460 patients had completely healed rotator cuff tears, but that these patients had clinical improvement in their strength, motion, and pain such that they were satisfied with the result.

Contrary to Tauro's study,[11] preoperative motion restriction was not found to be a predisposing risk factor for the development of postoperative stiffness. Preoperative motion was not significantly different between the normal (465 patients) and the postoperative stiffness groups (24 patients; Table 3).

When considering the demographic factors, patient sex and shoulder dominance did not significantly impact the incidence of postoperative stiffness (Table 2). Patients under 50 years of age had a significantly higher incidence of stiffness (8.6%). Patients with Workers' Compensation insurance were also associated with a significantly increased incidence of motion restriction (8.6%). This finding was not surprising given that other studies have reported inferior results of rotator cuff repair in patients with Workers' Compensation insurance.[30,31]

Several medical conditions are suspected to contribute to the development of the stiff shoulder. Diabetes and hypothyroidism have been implicated as frequent coexisting factors in patients who develop idiopathic adhesive capsulitis (frozen shoulder) and postoperative shoulder stiffness.[32] Arthroscopic evacuation of calcific deposits from the bursae or rotator cuff tendon creates a crystalline cloud within the subacromial space that can potentially result in a synovitic reaction and subsequent shoulder stiffness. These medical comorbidities were considered risk factors and were identified within our patient population at the time of arthroscopic rotator cuff repair. We found that patients with either adhesive capsulitis or calcific tendonitis confirmed and treated at the time of rotator cuff repair were associated with a significantly increased incidence of 15.6% for postoperative adhesion formation and stiffness. Surprisingly, within our study group, patients with diabetes or hypothyroidism were not associated with increased incidence of postoperative stiffness.

We felt that it was critical to study the rotator cuff tear itself to evaluate how the number of tendons involved in the tear would affect the incidence of postoperative stiffness. To our knowledge, this has not been considered in the past. We found that the particular tendon or tendons involved (supraspinatus versus subscapularis for example) did not affect the incidence of postoperative stiffness (Table 2). We were surprised to find, however, that smaller 1-tendon tears and PASTA type tears were associated with an increased incidence of postoperative adhesions and restriction of motion (7.4% and 13.5%, respectively). Intuitively, we suspected that massive 3-tendon tears would have had more of a problem with stiffness. These repairs typically require greater dissection, the creation of a much larger bleeding bone surface, and a longer delay before active motion was started (according to our rehabilitation protocol). However, the mas-

sive tears had fewer problems with stiffness than the single-tendon tears. Regardless of the cause, this finding has prompted us to alter our rehabilitation protocol. We now treat single-tendon and PASTA type repairs with an early motion protocol. In fact, we have expanded this early motion protocol to all the stiffness-prone groups (calcific tendinitis, adhesive capsulitis, associated labral repair, single-tendon tears, and PASTA lesions). These patients start passive overhead stretches by means of closed-chain table slides along with the standard external rotation stretches on day 1 postoperatively.

We felt that it was important to consider 3 factors related to the operative repair itself. First, biodegradable implants have anecdotally been postulated to cause sporadic cases of capsular synovitis, pain, and stiffness.[33-35] All the patients in this study had repairs performed with the Bio-Corkscrew, Bio-Corkscrew FT suture anchor, and BioTenodesis screw (Arthrex). However, no significant association was observed between the volume of biodegradable implant and incidence of stiffness. Secondly, we wanted to see if there was any association between double row repair of rotator cuff tears and postoperative stiffness. In this patient series, a double row repair technique was used whenever possible (when tendon length would allow coverage of footprint in a tension-free manner), resulting in double row repairs for 372 (76.1%) patients. The incidence of postoperative adhesions and motion restriction in this group was 4.8%, indicating no significant association between double row repair and stiffness. Finally, 47 (9.6%) patients in this study underwent an arthroscopic revision rotator cuff repair as the index procedure. Revision rotator cuff repairs (particularly open technique) have been associated with lower success and higher complication rates.[30] Burkhart et al.[23] have previously reported encouraging results following an arthroscopic revision rotator cuff repair. In this series of 47 arthroscopic revision rotator cuff repairs, no patients developed a restriction of motion requiring a secondary release.

One of the major benefits of an arthroscopic approach to treating shoulder ailments relates to the ability to evaluate and treat the entire shoulder. Visualization is virtually limitless. In this group of patients who underwent arthroscopic rotator cuff repairs, many other diagnoses were established or confirmed, and the necessary treatments were carried out during the same operative event. Certain procedures, such as an acromioplasty or distal clavicle excision, create large bleeding bone surfaces that may contribute to postoperative bleeding, swelling, pain, and potentially stiffness. Other procedures, such as labral repairs/intracapsular work and biceps tenodesis could also contribute to the development of stiffness. We felt that it was important to evaluate these procedural variables to establish their effect on the incidence of postoperative stiffness. We found that an acromioplasty, distal clavicle excision, interval slides for contracture release, and biceps tenodesis did not significantly impact the overall incidence of postoperative stiffness (Table 2). Nine of 82 (11.0%) patients who underwent arthroscopic rotator cuff repair and concomitant capsulolabral repair were much more likely to develop postoperative adhesions and motion restriction, while 5 of 213 (2.3%) patients who had concomitant coracoplasty were less likely to develop stiffness. Among 20 patients who received a labral repair and coracoplasty, only 1 developed stiffness, while 8 of 62 (13.3%) patients undergoing a labral repair unaccompanied by a coracoplasty experienced postoperative stiffness. The finding of stiffness after combined labral repair and rotator cuff repair may be related to altered tensioning of the capsulolabral restraints, coupled with significant dissection (causing irritation) on both sides of the shoulder capsule and rotator cuff. Regardless, this finding has also prompted us to use a more advanced motion protocol in this patient population. Patients with small rotator cuff tears (repaired with double row technique) and concomitant labral repair now begin passive closed-chain overhead and limited external rotation stretches on day 1 postoperatively. We are generally confident that the double row repair for a small rotator cuff tear has sufficient strength to withstand early closed-chain passive motion protocols. We are currently reviewing our results from this selective modification of our postoperative protocol to see if it will result in a decreased incidence of postoperative stiffness.

In this study population, at an average of 9 months postrepair, 24 patients had a symptomatic restriction of motion such that they elected to undergo a second arthroscopic operation. These patients had failed conservative efforts to restore motion and were noted to have reached a plateau with regard to making motion gains. At 14 to 41 months (median, 32 months) after arthroscopic release, pain scores and range of motion measures were normal. In these cases, we routinely found thickening of the capsule and extensive adhesion formation in the subacromial space. We were impressed by the consistent finding of complete healing of the original pathology (the main benefit of the conservative rehabilitation protocol). Anecdotally, we have found patients to be more accepting of the need for a

second surgical procedure if postoperative functional deficits are related to excessive scar tissue formation (perceived by the patient as an excellent though excessive healing response) rather than recurrent rotator cuff tear (perceived by the patient as failure of the surgery).

This study is a retrospective data analysis and therefore has the limitations of a retrospective review. The patients were treated and evaluated by a single surgeon, and complete range of motion data were not available for a few of the patients that did not develop symptomatic stiffness. Additional weaknesses include the small number of cases in the study and the lack of a control group.

CONCLUSIONS

In a series of 489 consecutive arthroscopic rotator cuff repairs, we found that 24 patients (4.9%) developed postoperative stiffness. Risk factors for postoperative stiffness were calcific tendinitis, adhesive capsulitis, single-tendon cuff repair, PASTA repair, being <50 years of age, and having Workers' Compensation insurance. Twenty-three of 24 patients (95.8%) showed complete healing of the rotator cuff. Arthroscopic release resulted in normal motion in all cases.

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