Reduction of Postoperative Stiffness After Arthroscopic Rotator Cuff Repair: Results of a Customized Physical Therapy Regimen Based on Risk Factors for Stiffness

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Purpose: The purpose of this study was to determine the benefits of a modified rehabilitation protocol (incorporating early closed-chain overhead stretching) in reducing the risk of postoperative stiffness after arthroscopic rotator cuff repair. **Methods:** During a 17-month period, we performed primary arthroscopic rotator cuff repairs in 152 patients. After surgery, patients with risk factors identified in the previous study (calcific tendonitis, adhesive capsulitis, PASTA [partial articular surface tendon avulsion]–type rotator cuff repair, concomitant labral repair, or single-tendon cuff repair) were enrolled in a modified rehabilitation protocol that added early overhead closed-chain passive motion exercises to our standard protocol; alternatively, patients without risk factors received a standard conservative rehabilitation program. Historical controls were used and comprised patients in the senior author's practice who all received the conservative rehabilitation protocol. The prevalence of postoperative stiffness was compared between the historical cohort and current study patients by use of Fisher exact tests. **Results:** Among the 152 patients studied, 79 were positive for at least 1 of the specified risk factors and received the modified protocol. Postoperative stiffness developed in none of the 79 patients enrolled in the modified program. This finding represented a significant improvement (Fisher exact test, $P = .004$) over the historical controls, in which 18 of the 231 at-risk patients had significant postoperative stiffness develop. **Conclusions:** In at-risk patients (with calcific tendonitis, adhesive capsulitis, PASTA repair, concomitant labral repair, and single-tendon repair), a postoperative rehabilitation regimen that incorporates early closed-chain passive overhead motion can reduce the incidence of postoperative stiffness after arthroscopic rotator cuff repair. **Level of Evidence:** Level IV, therapeutic case series.

The postoperative rehabilitation program is critical to the success of the surgical treatment of rotator cuff injury. A rehabilitation program that best allows for tendon-to-bone healing while preventing shoulder stiffness has not been definitively established. Our experience has been that the best clinical results (restoration of strength, motion, and relief of pain) after rotator cuff repair are achieved after a durable repair of tendon to bone that heals in its entirety. To maximize the prospects of achieving this kind of healing, the senior author (S.S.B.) has adopted a conservative rehabilitation protocol after arthroscopic rotator cuff repair, which limits motion during the first 6 weeks.[1] This approach is based on studies that have shown that significantly increased stresses at the site of repair can occur with range of motion.[2,3] However, when using

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this type of conservative rehabilitation protocol, one must be concerned about the potential for increased postoperative stiffness.

In the article that was the precursor to this study, Huberty et al.[1] found an overall 4.9% incidence of postoperative stiffness after arthroscopic rotator cuff repair in a consecutive series of 489 patients using a conservative postoperative rehabilitation protocol. From that study, 5 risk factors (calcific tendinitis, adhesive capsulitis, PASTA [partial articular surface tendon avulsion] repair, concomitant labral repair, and single-tendon repair) were identified that increased the prevalence of postoperative stiffness to 7.8% for patients who possessed 1 or more of those traits. Analysis of these risk factors showed that patients with coexisting calcific tendinitis faced a 16.7% risk of postoperative stiffness developing, which required capsular release; adhesive capsulitis, a 15% risk; PASTA-type rotator cuff repair, a 13.5% risk; concomitant labral repair, a 11% risk; and single-tendon rotator cuff repair, a 7.3% risk. Of the 489 patients in that study, a total of 231 patients were positive for at least 1 of these conditions. Stiffness developed in 18 (7.8%) of these patients, whereas stiffness developed in only 6 (2.3%) of the 258 patients negative for all of these risk factors.[1]

The purpose of this study was to determine the benefits of a modified rehabilitation protocol (incorporating early closed-chain passive overhead stretching) in reducing the risk of postoperative stiffness after arthroscopic rotator cuff repair for patients having at least 1 of the 5 risk factors mentioned previously. Our hypothesis was that the incidence of postoperative stiffness would be decreased in the at-risk group if they were subjected to this modified rehabilitation protocol.

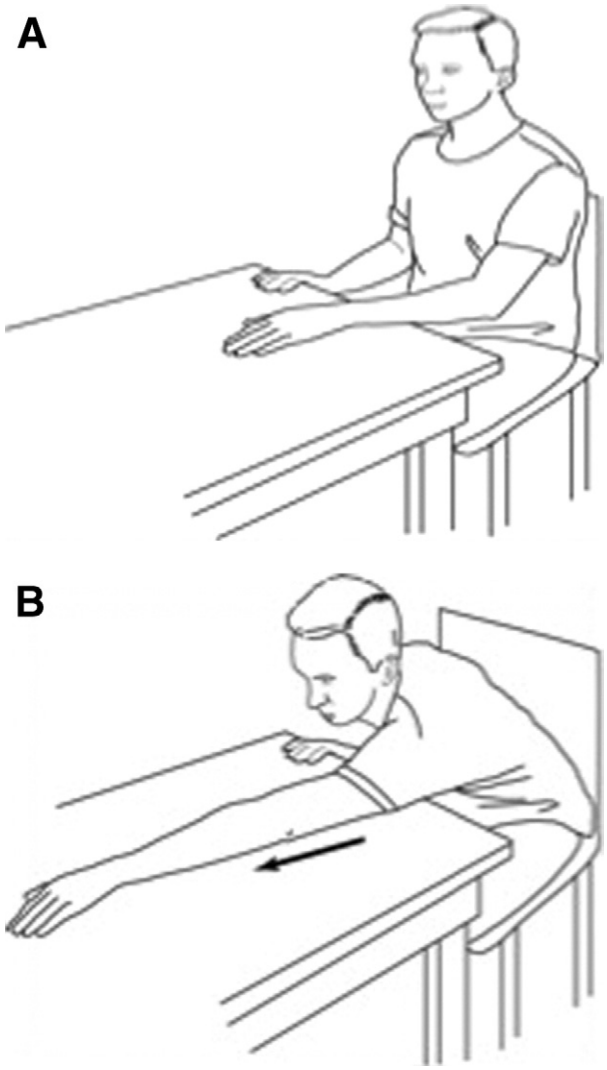

FIGURE 1. Table slide. (A) Starting position. While seated at a table, the patient places the hand of the affected shoulder on a sliding surface (e.g., a magazine that slides over a smooth table surface). (B) Ending position. The patient slides the hand forward, maintaining contact with the table, while the head and chest advance toward the table.

METHODS

A consecutive series of 192 patients who underwent arthroscopic rotator cuff repair by the senior author during a 17-month period from September 2006 to January 2008 were examined for the study. Patients who were undergoing revision surgeries, those with less than 4 months of follow-up at the conclusion of the study, or those with incomplete follow-up data were excluded. This left us with 152 patients for analysis. After surgery, patients who possessed 1 or more of the 5 risk factors (calcific tendonitis, adhesive capsulitis, PASTA-type rotator cuff repairs, concomitant labral repair, or single-tendon tear) identified in the previous study were prospectively assigned to the modified rehabilitation program, which added early closed-chain passive overhead stretching to our standard rehabilitation protocol. This closed-chain passive overhead stretching was done in the form of table slides (Fig 1). Patients who did not possess any risk factors were assigned to our traditional conservative therapy regimen. In the absence of a subscapularis tear, passive external rotation was performed in the same way it had been done in the historical controls. Except for the addition of early overhead closed-chain stretching in the at-risk group, all patients in both

TABLE 1. *Modified Rehabilitation Protocol After Arthroscopic Rotator Cuff Repair*

Preoperatively
Surgeon-directed counseling on rehabilitation plan
Give patient therapy kit and instruct on initial use
Therapy kit: PVC cane, rope and pulley, graduated elastic strengthening bands
Immediate postoperative period
Patient's extremity placed in sling with small pillow
Surgeon gives patient and family specifics of rehabilitation plan
Postoperative weeks 0-6
POD 1-10 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 subscapularis tears
No active assisted motion
Table slides for passive overhead motion*
Postoperative weeks 7-12
Discontinuation of sling and continue previous exercises
Advance passive external rotation with cane (limit at ER of opposite shoulder)
Continue with table slides and add rope-and-pulley overhead stretch
No strengthening
Postoperative months 3-6
Continue previous stretching exercises
Add internal rotation stretches
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
For massive tears and revision repairs, delay strengthening until 4 months postoperatively
Patient is given option of using therapist to assist in implementation of our plan
Postoperative months 6-12
May progress to light weights in gym
Clearance to full activity given based on examination
Massive cuff tear patients continue restriction on overhead lifting and sport restriction until 1 year

Abbreviations: PVC, polyvinyl chloride; POD, postoperative day; ER, external rotation.
*Change from the conservative rehabilitation program.

groups followed our standard rehabilitation protocol as outlined in Table 1.

The senior author individually examined each patient and personally recorded the physical examination findings at all follow-up visits. The medical records of all patients were reviewed after appropriate institutional approval. Demographic data including age, sex, dominant shoulder, and Workers' Compensation status were collected. Comorbid medical conditions previously implicated as possible risk factors for the development of shoulder stiffness (diabetes, hypothyroidism, calcific tendonitis, and adhesive capsulitis) were also noted. Surgical records were reviewed to determine the size of rotator cuff tears, the tendons torn, the number of anchors used, and all concomitant surgical procedures performed including SLAP repair, Bankart repair, acromioplasty, distal clavicle excision, coracoplasty, and biceps tenodesis. These data are summarized in Table 2. Relevant comparison of these patient characteristics between the enhanced rehabilitation group and the conservative group was made by use of χ^2 or Fisher exact tests as appropriate. In addition, the frequency of risk factors was reported for enhanced therapy patients.

Follow-up examination included measurement of passive range of motion in the operative extremity recorded in degrees (seated forward flexion, external rotation with arms adducted to side, and internal rotation behind the back). Range-of-motion measurements represented combined glenohumeral and scapulothoracic motion to give a total arc of motion and were measured independent of comparison with the contralateral side. Patients who were dissatisfied with their postoperative motion were considered to have postoperative stiffness. This was the same criterion used by Huberty et al.[1] in their study. The reason we chose to define stiffness in this manner, rather than using a physical examination threshold system, is because we believe that a patient's dissatisfaction with his or her range of motion is clinically the most relevant way to define stiffness. In fact, this patient-defined criterion for stiffness is extremely demanding because it increases the incidence of stiffness by including patients who have a bothersome motion deficit in a single direction, such as internal rotation. These patients might not have been identified under a threshold system that tends to emphasize forward flexion or elevation.

The data from this current cohort were compared against historical controls from our previous study. Statistical analysis of these data was limited to a comparison of the incidence of postoperative stiffness in the historical controls versus the current study by use of Fisher exact tests. Comparisons were made for all patients and for patients stratified by the rehabili-

TABLE 2. *Discrete Comparisons for Prospective Postoperative Rehabilitation Program Assignment for 152 Patients With Rotator Cuff Repairs*

Variable	Standard Patients (n = 73)	Enhanced Patients (n = 79)	Significance Level
Demographics			
Male patients	47 (64.4%)	48 (60.8%)	$P = .645$
Female patients	26 (35.6%)	31 (39.2%)	
Age (yr) (range, 14-86 yr)	Median, 62	Median, 53	$P < .001$
Age <55 yr	15 (20.5%)	46 (58.2%)	$P < .001$
Dominant shoulders	48 (65.8%)	50 (63.3%)	$P = .751$
Nondominant shoulders	25 (34.2%)	29 (36.7%)	
Workers' Compensation	2 (2.7%)	4 (5.1%)	$P = .683$
Comorbid medical conditions			
Diabetes	5 (6.8%)	5 (6.3%)	$P > .999$
Hypothyroidism	7 (9.6%)	6 (7.6%)	$P = .661$
Adhesive capsulitis	NA	6 (7.6%)	
Calcific tendonitis	NA	6 (7.6%)	
Adhesive capsulitis or calcific tendonitis	NA	12 (15.2%)	
Rotator cuff tear			
Tear size (range, 1-10 cm)	Median, 6 cm	Median, 3 cm	$P < .001$
No. of tendons involved (range, 1-4)	Median, 3	Median, 1	$P < .001$
1-tendon tears ($v \geq 2$)	NA	71 (89.9%)	
2-tendon tears	33 (45.2%)	7 (8.9%)	
3- or 4-tendon tears (v 1 or 2)	40 (54.8%)	1 (1.3%)	
PASTA type tears	NA	15 (19.0%)	
Supraspinatus tear	73 (100%)	66 (83.5%)	$P < .001$
Subscapularis tear	49 (67.1%)	11 (13.9%)	$P < .001$
No. of anchors used for rotator cuff repair (range, 1-11)	Median, 4	Median, 2	$P < .001$
Concomitant surgical procedures			
Subacromial decompression	70 (95.9%)	69 (87.3%)	$P = .060$
Distal clavicle excision	17 (23.3%)	28 (35.4%)	$P = .101$
Coracoplasty	29 (39.7%)	13 (16.5%)	$P = .001$
Interval slides (contracture release)	34 (46.6%)	23 (29.1%)	$P = .026$
Biceps tenodesis	43 (58.9%)	21 (26.6%)	$P < .001$
SLAP repair	NA	9 (11.4%)	
Bankart repair	NA	6 (7.6%)	
Any labral repair	NA	10 (12.7%)	

Abbreviation: NA, risk factor used to assign patients to enhanced group.

tation protocol classification. For all statistical tests, $P < .05$ was considered significant.

RESULTS

Among the 152 patients with primary rotator cuff tears that were arthroscopically repaired by the senior author, 73 did not possess any risk factors for stiffness and were assigned to the conservative rehabilitation protocol. The remaining 79 patients possessed 1 or more of the risk factors and were started on the modified protocol. Respective therapy program frequencies for patient characteristics are reported in Table 2. Because patients with single-tendon tears were excluded from the conservative rehabilitation protocol, these patients had significantly larger tears, more tendons involved, and more anchors used than enhanced therapy patients ($P < .001$). In addition, conservative therapy patients were older and more likely to receive a coracoplasty and/or biceps tenodesis procedure ($P < .001$).

Postoperative stiffness developed in none of the 73 conservative therapy patients, an incidence that was not significantly different from the 2.3% risk for historical controls ($P = .221$). Final follow-up data for the conservative group were collected at a median of 8 months postoperatively, with a range of 4 to 25 months. Among the 79 patients assigned to the modified protocol, the occurrences of described risk factors were as follows: adhesive capsulitis, 6; calcific tendinitis, 6; concomitant labral repair, 10, PASTA-type rotator cuff tear, 15, and single-tendon rotator

cuff tear, 71. Twenty-three patients were positive for more than one risk factor. None of these patients had postoperative stiffness develop, which was significantly lower than the 7.8% incidence from the historical controls ($P = .003$). Final follow-up data for the modified group were collected at a median of 11 months postoperatively, with a range of 4 to 23 months. Taken as a whole, the absence of postoperative stiffness out of 152 repairs defined an overall incidence that was significantly lower than the 4.9% risk reported for historical controls ($P = .002$).

Diabetes and hypothyroidism have been reported as risk factors for the development of postoperative adhesions and motion restriction. Among the 152 patients, 10 (6.6%) had diabetes and 13 (8.6%) had hypothyroidism, but postoperative stiffness developed in none of these.

DISCUSSION

A review of the literature shows the risk of postoperative stiffness after rotator cuff repair to range anywhere from 0% to 14%.[4-7] Despite a conservative rehabilitation protocol, the results from Huberty et al.[1] showed a comparable overall risk (4.9%) of postoperative stiffness requiring secondary arthroscopic release. From this previous study, risk factors associated with an increased incidence of stiffness among patients included calcific tendonitis (16.7% incidence of stiffness among those who had the risk factor), adhesive capsulitis (15%), PASTA-type rotator cuff repair (13.5%), concomitant labral repair (11%), or single-tendon rotator cuff repair (7.3%).

Numerous rehabilitation protocols for rehabilitation after rotator cuff repair exist and are based primarily on clinical observation. In a recent article, Millett et al.[8] described a commonly used rehabilitation protocol consisting of passive range of motion for the first 6 weeks followed by active range of motion starting in the seventh postoperative week. Many surgeons start aggressive rehabilitation early to try to prevent postoperative stiffness. However, early motion, even passive motion, may result in devastating consequences. In the presence of rotator cuff muscle atrophy, protocols that include early postoperative motion have reported a 25% to 94% rate of retearing.[9,10]

The conservative rehabilitation protocol used for the current and previous studies by the senior author avoids potentially destructive high strains at the repair site in the early postoperative period[1-3] and theoretically encourages more parallel collagen orientation and improved mechanical properties in the healed rotator cuff.[11] Furthermore, by delaying strengthening until 3 to 4 months postoperatively, the conservative protocol allows Sharpey fibers to form (as previously shown in primates) before stressing the repair with resistive exercises.[12]

This study prospectively assigned the modified or conservative rehabilitation program to patients based on the findings at the time of arthroscopy, and the results were directly compared with a retrospective 3-year case series involving 3 times as many patients who were prescribed the conservative rehabilitation program exclusively. Because all patients were treated and evaluated by a single surgeon, the retrospective case series served as historical controls for the current study. Given that the postoperative stiffness incidence for low-risk historical controls was only 2.3%, the sample size of 73 low-risk patients for the current prospective study had an expected frequency of only 1 case in which stiffness would develop. However, the stiffness incidence for high-risk historical controls was 7.8%, so the expected stiffness frequency for the sample size of 79 high-risk patients would have been 6 cases if the conservative rehabilitation program had been used.

In this study the modified rehabilitation protocol for high-risk patients effectively reduced the incidence of postoperative stiffness so that none of the 152 patients required a secondary arthroscopic release. Given these results, a rehabilitation program that begins early closed-chained overhead stretches (table slides) for groups at risk for the development of stiffness is a valid way to avoid loss of motion without potentially increasing the risk for rerupture in the early postoperative period. This study also shows that patients with large to massive tears who do not possess any of the listed risk factors are at low risk for stiffness when prescribed a conservative rehabilitation protocol and thus do not need early overhead passive motion, which could strain the repair and cause it to fail.

Weaknesses of the study include the fact that historical controls were taken from a retrospective case series instead of using concurrent prospective controls. However, because we were using an intent-to-treat model for this cohort, we did not believe that randomizing at-risk patients to a conservative protocol would be appropriate. We also believed that our historical controls represented a reasonable standard for comparison because they were treated by the same surgeon (S.S.B.) in a similar fashion of arthroscopic rotator cuff repair and received the same conservative protocol we used in the low-risk group for this study. It is also plausible that not using an independent

observer to collect the physical examination data introduces the possibility of measurement and observer bias; however, given the duration of the study, using an outside observer was not feasible for us. We also recognize that documentation of actual healing would have improved the premise of our study; however, ultrasound was not available to us during the study period, and magnetic resonance imaging would have proven too costly because none of the patients in the study had unacceptable strength or functional recovery parameters.

CONCLUSIONS

In at-risk patients (those with calcific tendonitis, adhesive capsulitis, PASTA repair, concomitant labral repair, and single-tendon repair), a postoperative rehabilitation regimen that incorporates early closed-chain passive overhead motion can reduce the incidence of postoperative stiffness after arthroscopic rotator cuff repair.

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