



Stiffness after arthroscopic rotator cuff repair: a rehabilitation problem or a surgical indication?



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Hypothesis: The purpose of this study was to determine the incidence of clinically significant post-operative stiffness after arthroscopic rotator cuff repair and its resolution. The study also sought to determine clinical and surgical factors that may be associated with increased rates of postoperative stiffness.

Methods: We conducted a level III retrospective review of a consecutive series of arthroscopic rotator cuff repairs. During a 5-year period, the senior author (C.J.R.) performed 150 arthroscopic rotator cuff repairs at our institution. Demographic data, comorbid medical conditions, descriptions of rotator cuff tears (including size and level of retraction), and concomitant surgical procedures were evaluated on their correlation with stiffness. All office visits were reviewed to determine preoperative and post-operative motion. Patients were followed up at 1 week, 3 weeks, 6–8 weeks, 3 months, about 6 months, and 1 year postoperatively.

Results: In our analysis of tear types, we were unable to associate stiffness with the type of tear, the tendon torn, or the number of tendons torn or with whether the tendons were retracted. However, we were able to associate female sex, workers' compensation insurance, and a concomitant biceps procedure with stiffness at several time points. The incidence of stiffness was highest at 12 weeks, with 7.3% of patients presenting with stiffness. The rate of stiffness decreased with continued follow-up. Stiffness was found in 3.3% of patients at 16–24 weeks and in 1.6% of patients at 1 year.

Conclusions: Prolonged physical therapy will result in resolution of stiffness in the vast majority of cases, often obviating the return to the operating room for capsular release and lysis of adhesions or mobilization under anesthesia.

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Rotator cuff repairs have evolved over the past several decades. A procedure once performed in an open manner progressed to a mini-open repair and now is typically performed arthroscopically. With the increasing size of our aging population and increasing sports activities of said population, the incidence of rotator cuff injury has increased exponentially.⁸ The purpose of this study was 2-fold: (1) to report the incidence of shoulder stiffness after arthroscopic rotator cuff repair and (2) to report the timing of this complication and its course and/or resolution. Multiple studies have been published on the various techniques with good clinical results,^{2,3,5,9,11,16,20} whereas only a few articles have specifically

discussed complications of arthroscopic rotator cuff repair.^{9,13} A complication rate of 10.5% was illustrated in a review of 40 articles by Mansat et al.^{10,14,20} The most common complications reported included infection, iatrogenic nerve injury, repair failure, deep vein thrombosis, and postoperative stiffness.^{12,14,19}

Although the pathophysiology of stiffness after rotator cuff repair is not well understood, authors believe it is due to a combination of postsurgical adhesions to the surrounding soft tissues and capsular contracture.^{19,20} Reported risk factors associated with the development of postoperative stiffness are type I diabetes, workers' compensation insurance, a history of calcific tendinitis or adhesive capsulitis, partial articular-sided tendon avulsion, full-thickness tears, and a concomitant labral repair at the time of rotator cuff repair.^{6,10,18}

The incidence of stiffness as a complication of arthroscopic rotator cuff repair ranges from 4.9% to 39%.^{7,10,18} We found only 1 study that attempted to define the incidence at specific time

The Institutional Review Board of Nassau Health Care Corporation at Nassau University Medical Center approved this study (study no. 15:062).

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points.⁷ It is difficult to differentiate true postoperative stiffness from normal postoperative changes; therefore, a timeline to define the progression and resolution of stiffness has not been reported.

The purpose of this study was to first determine the incidence of postoperative shoulder stiffness at multiple distinct time points. Second, the study was performed to follow progression of shoulder stiffness through nonoperative means over a 1-year span. The age of the patient, size of the tear, risk factors, and concomitant procedures were all noted as well.

Methods

We performed a consecutive retrospective review of patients who underwent an arthroscopic rotator cuff repair performed by the senior author (C.J.R.) during a 5-year period. The findings from each patient's preoperative and follow-up visits were personally examined and recorded by the senior author. Having a single investigator allowed for a consistent visual evaluation of shoulder range of motion (ROM) in preoperative and postoperative patients. At the last preoperative visit, active and passive ROM was documented in forward flexion (FF), in external rotation (ER) with the arm abducted 90°, and in ER with the arm at the side. Patients were followed up at 6 time points postoperatively, with active and passive ROM being assessed in degrees: 1 week (T1), 3 weeks (T2), 6 weeks (T3), 3 months (T4), 4–6 months (T5), and 1 year (T6). The planes of motion tested were standing FF and ER with the arm abducted to 90°, as well as ER with the arm at the side. 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 superior labrum anterior-posterior repair, Bankart repair, acromioplasty, distal clavicle excision, coracoplasty, and biceps tenodesis vs. tenotomy. Additionally, medical comorbidities for each patient were recorded to assess for any potential medical risk factors for stiffness (Table I).

All patients initially underwent a diagnostic arthroscopy. For patients with evidence of impingement consistent with abrasion of the

periosteum on the undersurface of the acromion, an acromioplasty was performed. Patients with biceps pathology underwent an open biceps tenodesis if they were aged ≤ 50 years or a biceps tenotomy if they were aged > 50 years. All subscapularis repairs during this period were repairs using either 1 or 2 suture anchors in a single-row configuration. All rotator cuff tears of the supraspinatus and infraspinatus were repaired using a double-row technique, which varied depending on the size of the tear. For tears < 2 cm in size, repairs were performed with a double-loaded suture anchor placed at the medial aspect of the tuberosity. Sutures were passed through the tendon in a horizontal suture configuration. One set of sutures was tied, reapproximating the tendon to the medial aspect of the greater tuberosity. The other set of sutures was loaded on a lateral-row anchor, which was deployed lateral to the footprint, completing the double-row repair. In all repairs, tension was first assessed prior to passing the sutures so as not to over-tension the repair. For repairs > 2 cm and < 4 cm, 2 anchors were placed medially and 1 anchor was placed laterally. For repairs > 4 cm, 2-3 anchors were used medially and 2 anchors were used laterally.

A consistent rehabilitation program was prescribed to all patients following rotator cuff repair despite the cuff tear size. All patients were placed in an abduction sling for 4 weeks after the surgical procedure. All patients were seen the day after surgery and instructed on pendulum exercises, which they performed 5 times per day for 1 minute in each session. Patients all began formal physical therapy starting on postoperative day 3-4, consisting of passive motion emphasizing full forward elevation. Patients who underwent a concomitant subscapularis repair were restricted from ER > 30° and abduction-ER during the first 8 weeks. At 4 weeks postoperatively, patients were allowed to discontinue use of the sling. They started active-assisted ROM at physical therapy and home exercises including table slides and shoulder pulleys. Patients began internal and ER strengthening and scapular stabilizer strengthening at 8 weeks from surgery. Patients who achieved normal scapular-humeral rhythm and full motion were allowed to progress to supraspinatus strengthening at 12 weeks.

Table I
Analysis of risk factors, concomitant procedures, and incidence of shoulder stiffness distributed by follow-up visit

Risk factor	Time point 4 (12 weeks)			Time point 5 (16-24 weeks)			Time point 6 (52 weeks)		
	Stiff	Not stiff	P value	Stiff	Not stiff	P value	Stiff	Not stiff	P value
Age, mean (SD), yr	58.2 (8.5)	57.4 (7.3)	.74	51.8 (7.3)	57.6 (7.3)	.12	50.5 (12.0)	57.6 (7.3)	.18
Sex, n (%)									
Female	5 (55.6)	38 (32.5)	.27	3 (75.0)	40 (32.8)	.11	2 (100.0)	41 (33.1)	.11
Male	4 (44.44)	79 (67.5)		1 (25.0)	82 (67.2)		0 (0.0)	83 (66.9)	
Hyperlipidemia, n (%)									
Yes	1 (11.1)	26 (22.2)	.68	1 (25.0)	26 (21.3)	>.99	1 (50.0)	26 (21.0)	.38
No	8 (77.8)	91 (77.8)		3 (75.0)	96 (78.7)		1 (50.0)	98 (79.0)	
Hypertension, n (%)									
Yes	3 (33.3)	35 (29.9)	>.99	2 (50.0)	36 (29.5)	.58	1 (50.0)	37 (29.8)	.51
No	6 (66.7)	82 (70.1)		2 (50.0)	86 (70.5)		1 (50.0)	87 (70.2)	
Workers' compensation insurance, n (%)									
Yes	3 (33.3)	29 (24.8)	.69	1 (25.0)	31 (25.4)	>.99	0 (0.0)	32 (25.8)	>.99
No	6 (66.7)	88 (75.2)		3 (75.0)	91 (74.6)		2 (100.0)	92 (74.2)	
Subacromial decompression, n (%)									
Yes	6 (66.7)	82 (70.1)	>.99	2 (50.0)	86 (29.5)	.58	1 (50.0)	87 (70.2)	.51
No	3 (33.3)	35 (29.9)		2 (50.0)	36 (70.5)		1 (50.0)	37 (29.8)	
Débridement, n (%)									
Yes	2 (22.2)	25 (21.4)	>.99	1 (25.0)	26 (21.3)	>.99	0 (0.0)	27 (21.8)	>.99
No	7 (77.8)	92 (78.6)		3 (75.0)	96 (78.7)		2 (100.0)	97 (78.2)	
Biceps tenotomy or tenodesis, n (%)									
Yes	5 (55.6)	29 (24.8)	.06	2 (50.0)	32 (26.2)	.29	1 (50.0)	33 (26.6)	.47
No	4 (44.4)	88 (75.2)		2 (50.0)	90 (73.8)		1 (50.0)	91 (73.4)	
Total, n (%)	9 (7.1)	117 (92.9)		4 (3.2)	122 (96.8)		2 (1.6)	124 (98.4)	

SD, standard deviation.

Stiffness was defined as total range of motion between passive forward flexion and abducted external rotation ≤ 220°.

Table II
Post-rotator cuff repair shoulder stiffness by postsurgical follow-up visit

Follow-up visit	Stiff, n (%)	Not stiff, n (%)
Time point 4 (12 weeks)	9 (7.3)	117 (92.9)
Time point 5 (16–24 weeks)	4 (3.3)	122 (96.7)
Time point 6 (52 weeks)	2 (1.6)	124 (98.4)

Stiffness was defined as total range of motion between passive forward flexion and abducted external rotation $\leq 220^\circ$. The sample exclusion criteria were as follows: revision rotator cuff repair, history of labral repair, non-adherence to the postoperative protocol, and stiffness recurrence without resolution at final follow-up.

Many definitions of stiffness have been reported in the literature, with no consensus. Most definitions of stiffness are based on passive measurement of forward flexion (FF), ER with the arm at the side, internal rotation, abduction, or abducted ER or a combination of ≥ 2 of these planes of motion. Audigé et al¹ discovered 16 different definitions of shoulder stiffness reported in the literature in their review of shoulder stiffness published in 2015 and called for the need for a consensus objective definition of stiffness to accurately report rates of stiffness. By use of previous studies as guidelines, a definition of significant stiffness was created that takes into account multiple planes of motion and a combination of active and passive ROMs. Significant stiffness was defined by a sum of passive FF plus active ER at 90° of abduction $\leq 220^\circ$. Power analysis prior to data collection showed that a sample size of 108 patients was required for a minimum power of 0.8.

Results

Of the 150 arthroscopic rotator cuff repairs performed in the study period, 24 were excluded. The exclusion criteria included lack of appropriate follow-up (13), failure to comply with prescribed rehabilitation (3), patients who underwent suture capsulorrhaphy (2), patients who achieved full ROM postoperatively and then had a recurrence of stiffness without resolution by final follow-up (3), and revision rotator cuff repairs performed (3). We analyzed the overall distribution of demographic characteristics and potential risk factors in the patient cohort. This analysis helped identify which risk factors were prevalent enough in this cohort to be selected to examine their association with shoulder stiffness at 3 months, 4–6 months, and 1 year.

In brief, the average age of the cohort was 58 years (standard deviation, 7 years) and patients were predominantly men (66%). Regarding tear characteristics, among the supraspinatus, subscapularis, and infraspinatus tear types, 96% of patients had a tear of the supraspinatus tendon, 33% had a tear of the subscapularis tendon, and 13% had a tear of the infraspinatus tendon. In total, only 1 tendon was torn in 60% of patients, and only 9% had retraction. Moreover, 24% had ≥ 2 full-thickness tears, whereas 30% had ≥ 1 partial-thickness tear. At 12 weeks, 7.3% of patients experienced peak stiffness; 3.3%, at 16–24 weeks; and 1.6%, at 1 year (Table II).

Altogether, 67 unique comorbidities were recorded. The ability to investigate each of these risk factors, however, is limited by the number of patients who possess them. Only risk factors that had a patient count ≥ 30 were selected for the study, to ensure adequate power.

Therefore, we investigated 3 comorbidities (hyperlipidemia, hypertension, and workers' compensation) and 3 concurrent procedures (subacromial decompression, labral débridement, and proximal biceps procedure [tenotomy or tenodesis]) selected to be evaluated as potential risk factors for shoulder stiffness after rotator cuff repair. Patient sex was also evaluated as a potential risk factor for postoperative stiffness. We conducted χ^2 analysis to investigate

the relationship between comorbidities and postoperative shoulder stiffness.

In our analysis of tear types, we were unable to associate stiffness with the type of tear (partial or full thickness), location of tear (articular vs. bursal), tendon torn, and number of tendons torn, as well as whether the tendons were retracted (Table III). Additionally, we were unable to associate stiffness with any of the other risk factors or concomitant procedures investigated at any of the 3 analyzed follow-up visits (Table I).

Discussion

As part of the well-defined rehabilitation protocol, patients were immobilized in a sling and only allowed to participate in passive ROM exercises up to 4 weeks. Once the sling was discontinued at 4 weeks, patients were allowed to perform active-assisted ROM exercises with physical therapy and to begin a home exercise program. From there, patients progressed to internal rotation and ER strengthening as well as scapular stabilizer strengthening at 8 weeks. Once scapular-humeral rhythm was re-established, they were finally allowed to progress to strengthening of the supraspinatus at 12 weeks. We used 12 weeks to define a postoperatively stiff or normal condition with respect to ROM.

In previous studies, the stiffness rate ranged from 4.9% to 39%.^{7,10,18} Many definitions of stiffness have been reported in the literature, with no consensus. Most definitions of stiffness are based on passive measurement of FF, ER with the arm at the side, internal rotation, abduction, or abducted ER or a combination of ≥ 2 of these planes of motion. One study was found to use active motion to evaluate stiffness in the early postoperative phase.¹⁷ Tauro¹⁹ proposed a novel method of defining shoulder stiffness as the passive total ROM deficit. This method measured ROM in abduction, FF, ER, and internal rotation with stabilization of the scapula. Normal passive ROM was defined as 90° of FF, 90° of abduction, 90° of ER, and 90° of internal rotation. If the passive ROM in each measured plane was below the defined threshold of normal, the ROM values were added together to determine the total ROM deficit.

Audigé et al¹ performed a review of shoulder stiffness, published in 2015, that examined the definitions of shoulder stiffness. In their literature review, they found 16 definitions of shoulder stiffness, stiff painful shoulder, or frozen shoulder reported in the literature from 1992 through 2012. Most of these definitions required limitation in a defined passive ROM, whereas others required limitation in multiple planes of motion. Several studies have defined stiffness as passive FF ranging from 100° ¹⁸ to 120° ⁷ or less. Alternatively, it has been defined as $<30^\circ$ to 20° of passive ER with the arm at the side.⁷ Huberty et al¹⁰ defined stiffness by patient dissatisfaction based on a patient's perceived restriction of motion and not by an objective measurement of ROM. Another study reviewed suggested the presence of stiffness as early as 6 weeks postoperatively. Some of the definitions required that the symptoms persist for >1 –3 months, whereas another definition required 6 months to pass before considering stiffness; several other definitions did not discuss timing at all. Also discussed in the article by Audigé et al was that the definitions proposed by many of the authors were guided by significant clinical experience. Audigé et al suggested the need for an objective definition of stiffness to accurately report rates of stiffness. They went on to state that “the postoperative change in magnitude of shoulder stiffness from baseline preoperative motion status, as perceived by the patient, may determine the occurrence of stiffness as a surgical complication.”¹ This indeed would be helpful for surgeons looking to the literature for a way to educate both themselves and their patients on the natural process of stiffness after arthroscopic rotator cuff repair.

Table III
Analysis of tear characteristics and incidence of shoulder stiffness distributed by follow-up visit

Risk factor	Time point 4 (12 weeks)			Time point 5 (16-24 weeks)			Time point 6 (52 weeks)		
	Stiff, n (%)	Not stiff, n (%)	P value	Stiff, n (%)	Not stiff, n (%)	P value	Stiff, n (%)	Not stiff, n (%)	P value
Supraspinatus tear									
Full or partial tear	8 (88.9)	113 (96.6)	.31	3 (75.0)	118 (96.7)	.15	2 (100.0)	119 (96.0)	>.99
No tear	1 (11.1)	4 (3.4)		1 (25.0)	4 (3.3)		0 (0.0)	5 (4.0)	
Subscapularis tear									
Full or partial tear	3 (33.3)	40 (34.2)	>.99	1 (25.0)	42 (34.4)	>.99	0 (0.0)	43 (34.7)	.55
No tear	6 (66.7)	77 (65.8)		3 (75.0)	80 (65.6)		2 (100.0)	81 (65.3)	
Infraspinatus tear									
Full or partial tear	2 (22.2)	16 (13.7)	.62	1 (25.0)	17 (13.9)	.46	1 (50.0)	17 (13.7)	.27
No tear	7 (77.8)	101 (86.3)		3 (75.0)	105 (86.1)		1 (50.0)	107 (86.3)	
No. of tendons torn									
3	1 (11.1)	7 (6.0)	.50	0 (0.0)	8 (6.6)	>.99	0 (0.0)	8 (6.5)	>.99
2	2 (22.2)	38 (32.5)		1 (25.0)	39 (32.0)		1 (50.0)	39 (31.5)	
1	6 (66.7)	72 (61.5)		3 (75.0)	75 (61.5)		1 (50.0)	77 (62.1)	
No. of full tears									
3	1 (11.1)	7 (6.0)	.74	0 (0.0)	8 (6.6)	.72	0 (0.0)	8 (6.5)	.44
2	1 (11.1)	20 (17.1)		1 (25.0)	20 (16.4)		1 (50.0)	20 (16.1)	
1	5 (55.6)	69 (59.0)		2 (50.0)	72 (59.0)		1 (50.0)	73 (58.9)	
0	2 (22.2)	21 (18.0)		1 (25.0)	22 (18.0)		0 (0.0)	23 (18.6)	
No. of partial tears									
2	0 (0.0)	4 (3.4)	.78	0 (0.0)	4 (3.3)	>.99	0 (0.0)	4 (3.2)	>.99
1	3 (33.3)	31 (26.5)		1 (25.0)	33 (27.1)		0 (0.0)	34 (27.4)	
0	6 (66.7)	82 (70.1)		3 (75.0)	85 (69.7)		2 (100.0)	86 (69.4)	
Retraction									
Yes	1 (11.1)	10 (8.6)	.57	1 (25.0)	10 (8.2)	.31	1 (50.0)	10 (8.1)	.17
No	8 (88.9)	107 (91.5)		3 (75.0)	112 (91.8)		1 (50.0)	114 (91.9)	

Stiffness was defined as total range of motion between passive forward flexion and abducted external rotation $\leq 220^\circ$.

To compare our definition of stiffness with definitions in previous studies, we used a combination of several different definitions: passive FF $\leq 120^\circ$ or passive ER $\leq 20^\circ$ with the arm at the side. We found stiffness in 13 patients (11%) at T4, 2 (1.6%) at T5, and 1 (0.8%) at T6 (Table IV). The application of previous definitions demonstrated a much lower stiffness rate at both T5 and T6 but showed the same downward trend, as expected. We believe our definition is more stringent as it combines multiple planes of motion and it implies a minimum required sum of passive FF and ER at 90° of abduction totaling $\leq 220^\circ$.

As we expected, stiffness rates declined over time, with a significant decrease at 1 year. McNamara et al¹⁵ actually found that shoulders with stiffness that developed in the first 6-12 weeks were more likely to heal than those in which stiffness did not develop in the first 3 months. One might be able to reason that early stiffness is due to disorganized healing tendon, and as the tendon starts to remodel, stiffness resolves. Chung et al,⁷ using multivariate analysis, found that late-onset stiffness at final follow-up was statistically significant for retear at 1 year. In addition, one must consider factors other than retear that may lead to recurrence of stiffness. One such factor would be the existence of workers' compensation benefits as patients' final loss determination occurs at 1 year postoperatively. Another factor could be a new onset of adhesive capsulitis that is unrelated to rotator cuff repair. For these reasons, we excluded individuals in whom stiffness re-developed after the achievement of full motion at a previous visit. Of note, 1 individual whose shoulder remained stiff at 1 year had several of the risk factors classically associated with frozen shoulder including Crohn disease, thyroid disorder, myocardial infarction, and age > 50 years. In the second patient with unresolved post-operative stiffness at T6, the ROM and information recorded were the same as those recorded at the T4 visit. Both patients were women; neither underwent a secondary procedure after 1 year, with both reporting satisfaction with their results.

Taking a patient back to the operating room for an additional surgical procedure in the absence of the need to revise the rotator cuff repair is a controversial subject, especially regarding the timing

Table IV
Shoulder stiffness after rotator cuff repair using previous definitions of stiffness

Follow-up visit	Stiff, n (%)	Not stiff, n (%)
Time point 4 (12 weeks)	13 (11)	113 (89)
Time point 5 (16-24 weeks)	2 (1.6)	122 (96.8)
Time point 6 (52 weeks)	1 (0.8)	124 (99.2)

Stiffness was defined as passive forward flexion $\leq 120^\circ$ or as passive external rotation $\leq 20^\circ$ with the arm at the side. The sample exclusion criteria were as follows: revision rotator cuff repair, history of labral repair, non-adherence to the postoperative protocol, and stiffness recurrence without resolution at final follow-up.

of the procedure. Brislin et al⁴ in their study were able to treat 21 of 23 patients with stiffness without recommending any surgical intervention. All were treated with prolonged physical therapy, and 14 of 23 patients had resolution of stiffness by 5 months post-operatively, with the remaining 9 having some degree of passive motion deficit. One patient refused further physical therapy and elected to undergo arthroscopic release; she regained full motion by 4.5 months after reoperation. In the series from Huberty et al,¹⁰ they reported significant subjective stiffness in 24 of 489 patients, all of whom underwent secondary release procedures. At the time of their second-look arthroscopy, performed at 9 months post-operatively on average, all 24 patients had subacromial adhesions. Of the patients who underwent the second procedure, 2 were lost to follow-up; all 22 remaining patients were satisfied with the result of their surgical procedures. Data suggest that there is usefulness in performing closed manipulation under anesthesia and lysis of adhesions or capsular release in primary frozen shoulders. The data on surgical treatment of postoperative stiffness after rotator cuff repair are very limited.

The strengths of our study were the clear documentation and description of the rotator cuff tears, a standardized physical therapy rehabilitation protocol, and the low threshold for defining clinical stiffness. All repairs were performed by a single fellowship-trained surgeon with extensive experience in arthroscopic shoulder surgery who also assessed all preoperative and postoperative ROM.

This made our study very consistent in quality of repair and post-operative protocol.

There are several possible limitations to our series. First, all of the clinical examinations were performed by the operative surgeon; thereby, some level of bias could be imparted into the ROM recorded at each postoperative follow-up. Second, given the retrospective nature of the study, patients did not all undergo follow-up at appropriate time intervals. Once an individual regained his or her motion, measurement of the ROM was not routinely performed unless the patient reported pain or stiffness.

Conclusion

This study shows that postoperative stiffness after rotator cuff tears peaks at approximately 3 months (T4), with a precipitous decrease in stiffness at 4–6 months (T5); stiffness continues to decrease at 1 year (T6) postoperatively. This study serves as a means to allow us to educate patients and reassure them of their continued improvement through 1 year postoperatively after arthroscopic rotator cuff repair.

Disclaimer

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