



Shoulder stiffness after rotator cuff repair: the fate of stiff shoulders up to 9 years after rotator cuff repair

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Background: Stiffness and retear are 2 common complications of rotator cuff repair. McNamara et al found that postoperative stiffness was associated with lower retear rates at 6 months. This study aimed to determine if stiffness after rotator cuff repair protects the individual from retear up to 9 years after surgery.

Materials and methods: Two groups of patients, 69 with stiff and 63 with nonstiff shoulder, who underwent arthroscopic rotator cuff repair were created based on external rotation measurements at 6 weeks postoperatively. Patients had regular follow-up assessments at 6, 12, and 24 weeks and were instructed to return for a follow-up at least 2 years after surgery. Patients were assessed for range of motion, shoulder function, strength, and rotator cuff integrity using ultrasound.

Results: For patients with postoperative stiffness at 6 weeks, the retear rate at 6 months was 3%, whereas the rate for nonstiff patients was 19% ($P = .004$). This protective effect of postoperative stiffness persisted up to 9 years after surgery ($P = .002$). Postoperative stiffness resolved by 5 years after surgery for all measurements except external rotation (50° vs. 61°) ($P = .006$). Patients with postoperative stiffness had continued improvements in abduction ($P < .001$), internal rotation ($P = .020$), and all patient-ranked measurements from the 6-month follow-up to 5 years after surgery. Patients with stiff shoulder had greater overall satisfaction by the final follow-up ($P = .028$).

Conclusions: In patients experiencing stiffness after rotator cuff surgery, the repair is less likely to fail at 6 months. Although the stiffness generally resolves by 5 years, this protective effect still persists at 9 years after surgery.

Level of evidence: Level III; Retrospective Cohort Comparison; Treatment Study

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South Eastern Sydney Local Health District Human Research Ethics Committee approved this study (HREC 12/STG/106).

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Rotator cuff tendon tears are a leading cause of shoulder dysfunction and pain, with the prevalence in the general population estimated at 21%.^{10,30,31} Rotator cuff tear incidence increases substantially with age, becoming the most common cause of nontraumatic upper limb disability for individuals over 50 years old.^{4,20} Tears are most frequent in the supraspinatus tendon.⁷ Arthroscopic

rotator cuff repair is a common surgical procedure, with good to excellent functional outcomes in 90% of cases.^{6,28} Although there are often good functional outcomes, the procedure still has complications, most notably rotator cuff re-tear and postoperative stiffness. Rotator cuff re-tear is reported after 20%-90% of surgeries.^{8,12} Re-tear represents a failure to heal and can cause pain, weakness, and loss of function.³¹ Postoperative shoulder stiffness is another common complication, with reported rates between 2% and 33%.^{2,11,21,23-25,27} Although the effect of preoperative stiffness on rotator cuff repair outcomes has been addressed,^{5,13} few studies have considered how postoperative stiffness may affect rotator cuff outcomes.

McNamara et al.¹⁸ previously explored the relationship between shoulder stiffness and rotator cuff integrity in patients presenting to our institution, finding that the likelihood of rotator cuff re-tears occurring by 6 months after surgery was significantly lower in postoperatively stiff patients (7%) than in nonstiff patients (15%) ($P < .001$). These findings suggested a protective role for postoperative stiffness on rotator cuff healing up to 6 months after surgery. However, to our knowledge, no existing studies have explored how early postoperative stiffness affects rotator cuff integrity beyond 6 months after surgery. Addressing this question has the potential to change clinical attitudes toward rotator cuff repair complications, especially if early postoperative stiffness is associated with positive long-term outcomes.

Therefore, the current study aimed to follow up a portion of the McNamara et al cohort in order to determine (1) if a stiff shoulder after arthroscopic rotator cuff repair protects the individual from re-tear up to 9 years after surgery and (2) if postoperative stiffness resolves.

Materials and methods

Study design

This was a retrospective study of data collected prospectively from a cohort of patients who underwent arthroscopic rotator cuff repair by a single surgeon at our institution to determine whether early postoperative stiffness protects the individual from rotator cuff re-tear up to 9 years after surgery. As a secondary outcome, the study also attempted to determine if postoperative stiffness resolves by examining shoulder range of motion, patient-ranked measures of shoulder stiffness, and shoulder strength. All participants consented to the use of their medical data.

Inclusion and exclusion criteria

This study attempted to follow up 2 groups of patients from the McNamara et al cohort.¹⁸ Patients were considered for inclusion in the original study if they underwent a primary arthroscopic rotator cuff repair by the senior author (GACM) from June 2005 to December 2013 and had an ultrasound examination to assess

repair integrity at 6 months after surgery. Patients were excluded for a number of concurrent procedures outlined in the paper by McNamara et al.¹⁸

Additional inclusion and exclusion criteria were applied in this study to create 2 groups and mitigate confounding factors. Patients were stratified by calendar year to control for changes in surgical team experience, examiner technique, and rehabilitation management. Consistent with the McNamara et al study, stiffness was defined as degrees of examiner-measured passive external rotation at 6 weeks after surgery.¹⁸ Patients were included in the stiff group if they were measured in the *lower* 15th percentile of their calendar year of surgery for external rotation at 6 weeks after surgery. Patients were included in the nonstiff group if they were measured in the *upper* 15th percentile of their calendar year of surgery for external rotation at 6 weeks after surgery. Surgeries before 2007 were excluded because of the small number of patients in these year groups and the subsequent larger risk of including patients with relatively normal postoperative range of motion as patients with stiff shoulder. Patients who were unable to return were excluded.

Participant recruitment

Patients were followed preoperatively as well as at 6, 12, and 24 weeks after surgery in the original study.¹⁸ For the current study, patients were contacted by mail and telephone and requested to return to clinic for an additional long-term follow-up assessment. Patients who had previously returned for a long-term rotator cuff ultrasound and range of motion examination were eligible for inclusion due to the consistent data collection methods implemented at our institution. A long-term follow-up was defined as a minimum of 2 years after surgery.

Patient assessment

Patients were assessed for passive range of motion, patient-ranked shoulder stiffness, shoulder strength, and rotator cuff integrity using ultrasound. Further details of patient assessment, surgical technique, and rehabilitation management are available in the paper by McNamara et al.¹⁸

Statistical analysis

GraphPad Prism version 7 was used for statistical analysis. Fisher's exact test was used for evaluating demographic data including sex, operated side, tear thickness, revision surgery, and the re-tear rate between groups. Independent sample *t*-tests were used for analyzing age, tear size, number of anchors, years since operation to final follow-up, operative time, and range of motion data. To visualize the incidence of rotator cuff re-tears over time, a modified Kaplan-Meier survival curve analysis was conducted. A log-rank (Mantel-Cox) test was conducted to evaluate the difference between the curves. Statistical significance for internal rotation range of motion and patient-ranked shoulder function was determined by Mann-Whitney *U* tests for comparison between groups and by Wilcoxon signed-rank tests for comparison across timepoints. The threshold for statistical significance in this study was $P < .05$.

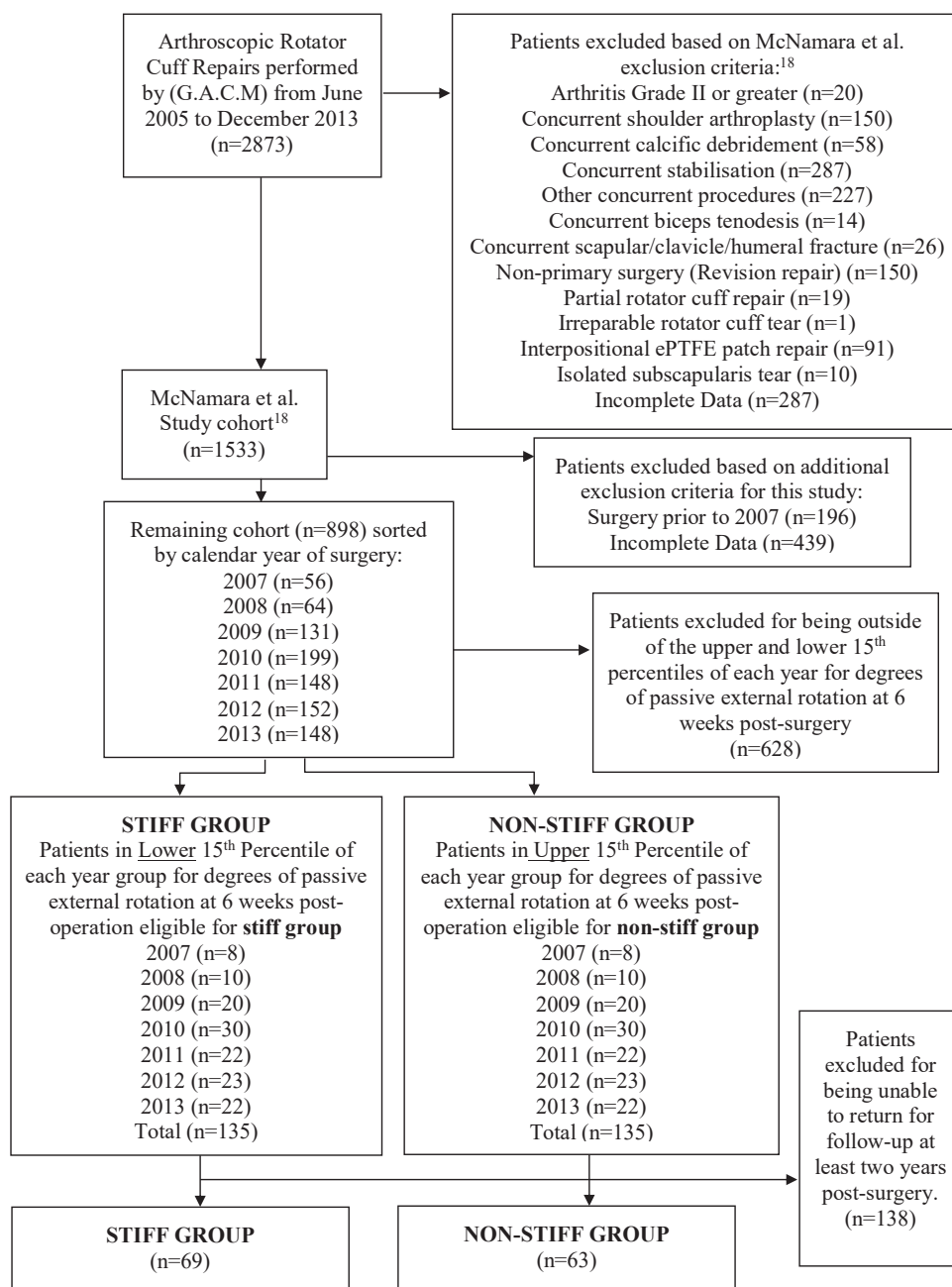


Figure 1 Participant selection for stiff and nonstiff groups. *ePTFE*, expanded polytetrafluoroethylene.

Results

Study group

From June 2005 to December 2013, a single surgeon (GACM) performed 2873 arthroscopic rotator cuff repairs for torn rotator cuffs. After the application of further inclusion and exclusion criteria, the current study obtained data for 69 patients with stiff shoulder and 63 patients with nonstiff shoulder (Fig. 1). The final mean follow-up for all patients combined was at 5.0 ± 0.2 years after surgery.

There were no statistically significant demographic differences between the 2 groups (Table I).

Primary outcome—retear

A modified Kaplan-Meier survival curve analysis was conducted, illustrating that postoperatively stiff shoulder patients were significantly less likely to experience rotator cuff re-tear over the course of the 9-year follow-up period than the nonstiff cohort ($P = .002$) (Fig. 2). Beyond 2 years after surgery, re-tears continued to occur in both groups,

Table I Demographics of stiff and nonstiff shoulder cohorts

	Whole sample, N (%)	Stiff shoulder group, N (%)	Nonstiff shoulder group, N (%)	Statistical significance analysis*, P
N	132 (100)	69 (52.3)	63 (47.3)	
Age				
Mean \pm SEM	56.7 \pm 1.0	57.4 \pm 1.3	55.9 \pm 1.5	.446
Range	18-83	25-83	18-82	
Operated side				
Right	75 (56.8)	39 (29.5)	36 (27.3)	>.999
Left	57 (43.2)	30 (22.7)	27 (20.5)	
Sex				
Male	76 (57.6)	37 (28.0)	39 (29.5)	.380
Female	56 (42.4)	32 (24.2)	24 (18.2)	
Tear size area (mm ²)				
Mean \pm SEM	338 \pm 31	355 \pm 47	320 \pm 40	.575
Range	4-2000	4-2000	36-1600	
Number of anchors				
Mean \pm SEM	2.1 \pm 0.1	2.1 \pm 0.1	2.1 \pm 0.1	.902
Range	1-6	1-6	1-4	
Years since operation of final follow-up				
Mean \pm SEM	5.0 \pm 0.2	5.1 \pm 0.3	4.7 \pm 0.3	.299
Range	2-9	2-9	2-9	
Tear thickness				
Full	71 (59.2)	37 (30.8)	34 (28.3)	.354
Partial	49 (41.8)	30 (25.0)	19 (15.8)	
Operative time				
Mean \pm SEM	20.2 \pm 0.9	19.8 \pm 1.3	20.6 \pm 1.4	.672
Range	4-50	5-50	4-50	

SEM, standard error of the mean.

* Statistical significance was assessed using Fisher's exact test or independent samples *t*-tests: *P* < .05.

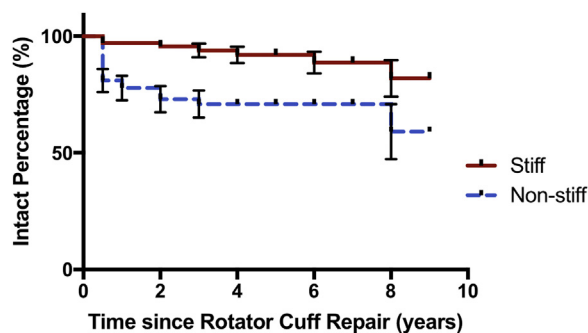


Figure 2 Intact rotator cuff repair survival in patients with postoperative stiff vs. nonstiff shoulders. Log-rank (Mantel-Cox) test: *P* = .002. Cuff integrity determined by ultrasound.

albeit less frequently than in the early postoperative phase. By the final timepoint at 9 years after surgery, the patients who experienced early postoperative stiffness had a higher likelihood of having an intact rotator cuff.

Additional analyses of retear rates and revision surgery were conducted using Fisher's exact tests (Table II). Patients with postoperative stiffness experienced a significantly lower rate of retears (10%) than the patients without

postoperative stiffness (30%) up until 9 years after surgery (*P* = .005). Patients with postoperative stiffness had a lower rate of retears (3%) than patients without stiffness (19%) occurring by 6 months postoperatively (*P* = .004), consistent with the findings of McNamara et al.¹⁸ There was no statistically significant difference between the groups in rotator cuff retears occurring beyond 6 months postoperatively (*P* = .359). The rate of revision surgery was significantly higher in the nonstiff group than the stiff group (*P* = .002).

Range of motion

At 6 weeks after surgery, the stiff group had significantly less range of motion than the nonstiff group in all 4 directions, including a 65° difference in passive external rotation. At the final follow-up, there was no significant difference between the stiff and nonstiff groups for internal rotation (*P* = .913), abduction (*P* = .597), and forward flexion (*P* = .636). The stiff group still had a lower mean external rotation (50° vs. 61°), which was statistically significant (*P* = .006). All range of motion measurements returned to preoperative levels or better for both groups.

Table II Comparison of rotator cuff integrity up to 9 years after surgery between stiff and nonstiff shoulder groups

	Whole sample, N (%)	Stiff shoulder group, N (%)	Nonstiff shoulder group, N (%)	Statistical significance analysis, <i>P</i>
N	132 (100)	69 (52.3)	63 (47.3)	
Cuff integrity up to 9 yr after surgery				
Retear	26 (19.7)	7 (5.3)	19 (14.4)	.005*
Intact	106 (80.3)	62 (47.0)	44 (33.3)	
Cuff integrity up until 6 mo after surgery				
Retear	14 (10.6)	2 (1.5)	12 (9.1)	.004*
Intact	118 (89.4)	67 (50.8)	51 (38.6)	
Cuff integrity up to 9 yr after surgery (excluding re-tears occurring by 6 mo)				
Retear	12 (9.1)	5 (3.8)	7 (5.3)	.359
Intact	106 (80.3)	62 (47.0)	44 (33.3)	
Revision surgery				
Yes	18 (13.6)	3 (2.3)	15 (11.4)	.002*
No	114 (86.4)	66 (50.0)	48 (36.4)	

* Statistical significance was assessed using Fisher's exact test: $P < .05$.

There was a significant improvement in abduction ($P < .001$) and internal rotation ($P < .001$) from before surgery to the final follow-up for the stiff shoulder group. There was also a significant improvement in both abduction ($P < .001$) and internal rotation ($P = .020$) from the 6-month follow-up to the final follow-up. There was no decline in range of motion beyond the 6-month point for either group. Patients with rotator cuff retears were excluded as a confounding factor from range of motion analysis (Fig. 3).

Patient-ranked shoulder function

Both groups experienced an improvement in shoulder stiffness, overhead activities, and reaching behind the back from before surgery to the final follow-up. In addition, the stiff group had a significant decrease in their perceived level of shoulder stiffness ($P = .002$) as well as a decrease in difficulty with overhead activities ($P < .001$) and reaching behind the back ($P < .001$) beyond 6 months after surgery. Subsequently, there was no difference between the 2 groups at the final follow-up for all 3 of these outcomes (Fig. 4).

There was no difference in the level of overall shoulder satisfaction between the shoulder groups up until 6 months after surgery when excluding those with retears (Fig. 4, D). Neither group improved significantly beyond 6 months after surgery. However, in comparing all patients, including those with retears, patients with stiffness after surgery were significantly more satisfied with their shoulders by the final follow-up ($P = .028$) (Fig. 5).

Discussion

This study found that patients with postoperative stiffness had significantly better rotator cuff repair survival up to 9 years after surgery. Patients with stiff shoulder experienced significantly fewer retears before 6 months, suggesting the first 6 months after surgery to be the critical period of rotator cuff healing. Stiffness during this critical period appears to have had a protective role in rotator cuff healing, the benefits of which persisted up to 9 years after surgery. In addition, this study found that postoperatively stiff patients had lower rates of revision surgery and higher satisfaction, and their stiffness generally resolved by the final follow-up, which may have important clinical implications for surgeons counseling patients with shoulder stiffness after rotator cuff repair.

To our knowledge, this is the first study to examine the effect of early postoperative shoulder stiffness on the outcomes of patients beyond 1 year. Parsons et al²² examined the relationship between stiffness and rotator cuff integrity up to 1 year after surgery, finding a lower rate of retears in patients with more stiffness after surgery, but without statistical significance. McNamara et al¹⁸ explored the same question up until 6 months after surgery, finding a significantly lower re-tear rate in patients with postoperative stiffness compared with patients without stiffness. The results of our study support the findings of McNamara et al and additionally demonstrate that the lower re-tear rate in stiff shoulders persists up to 9 years after surgery.

Early postoperative stiffness may be related to better rotator cuff healing for a number of mechanical and

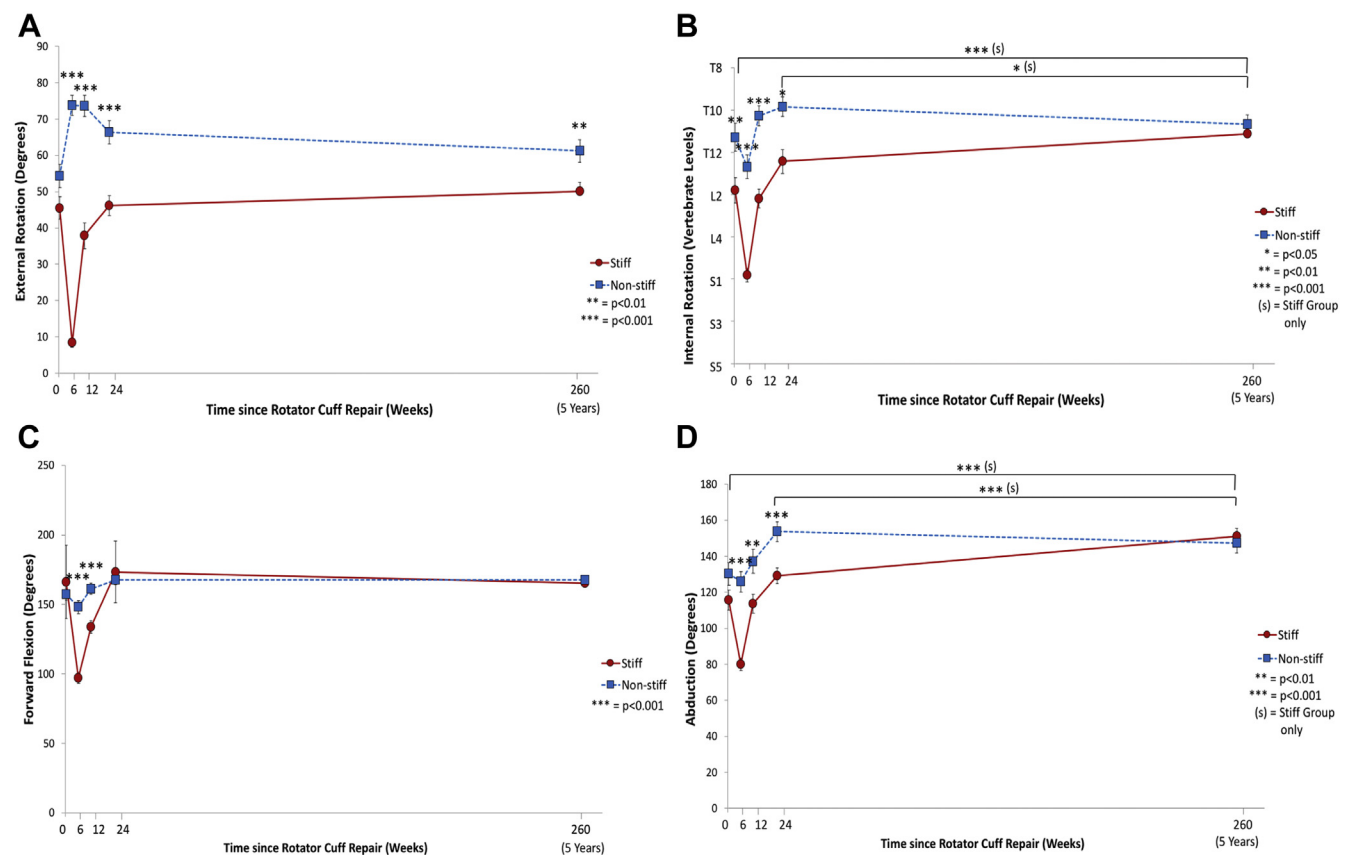


Figure 3 Comparison of passive range of motion between stiff and nonstiff groups up to 5 years after rotator cuff repair (mean \pm standard error of the mean), including external rotation (A), internal rotation (B), forward flexion (C), and abduction (D). Patients with retears were excluded.

biological reasons. Many surgeons argue that mechanical immobility of the shoulder due to stiffness prevents retear in much the same way as conservative rehabilitation.^{3,8} However, it should be noted that a recent analysis of systematic reviews found no statistically significant difference in retear rates between early and conservative rehabilitation of the shoulder after rotator cuff repair.¹⁵ Alternatively, stiffness may be the clinical manifestation of a strong biological healing response in the shoulder.¹⁹ Such an explanation may help explain the results of McGrath et al,¹⁶ finding much lower rates of retear in patients who underwent rotator cuff repair with capsular release due to stiffness than in patients without stiffness who underwent rotator cuff repair alone.

On balance, the results suggest that for particularly stiff patients after surgery, although stiffness does not fully resolve by 6 months, it does by 5 years. Resolution of stiffness was assessed based on a lack of significant differences between the groups for both passive range of motion and patient-ranked stiffness measures, as is previously described.^{26,27} For patients with postoperative stiffness, range of motion continued to improve beyond 6 months after surgery. These improvements resulted in no significant range of motion or patient-ranked stiffness

differences by the final follow-up, except for passive external rotation. A number of studies have found postoperative stiffness to resolve between 6 months and 2 years that is consistent with the results of our study.^{9,26,27} These conclusions in turn may help explain the primary outcome of this study. The protective effect of postoperative stiffness on rotator cuff healing appears to be most prominent in the first 6 months that may simply be because postoperative stiffness generally resolves by this point. This explanation fits our current understanding of tendon-to-bone healing as there is only a minimal change in rotator cuff structure beyond 6 months after surgery.¹⁴

The remaining difference in external rotation is difficult to explain. A longer follow-up time may have resulted in resolution of this deficit. However, this explanation conflicts with existing literature on the expected timeframe for postoperative stiffness resolution.^{9,26,27} Alternatively, the difference may have a methodological basis, in that our 2 groups of patients may have had pre-existing factors affecting their preinjury external rotation range of motion. This theory conflicts with our results that found no significant difference in external rotation between the groups before surgery (Fig. 3, A). However, the theory is strongly supported by

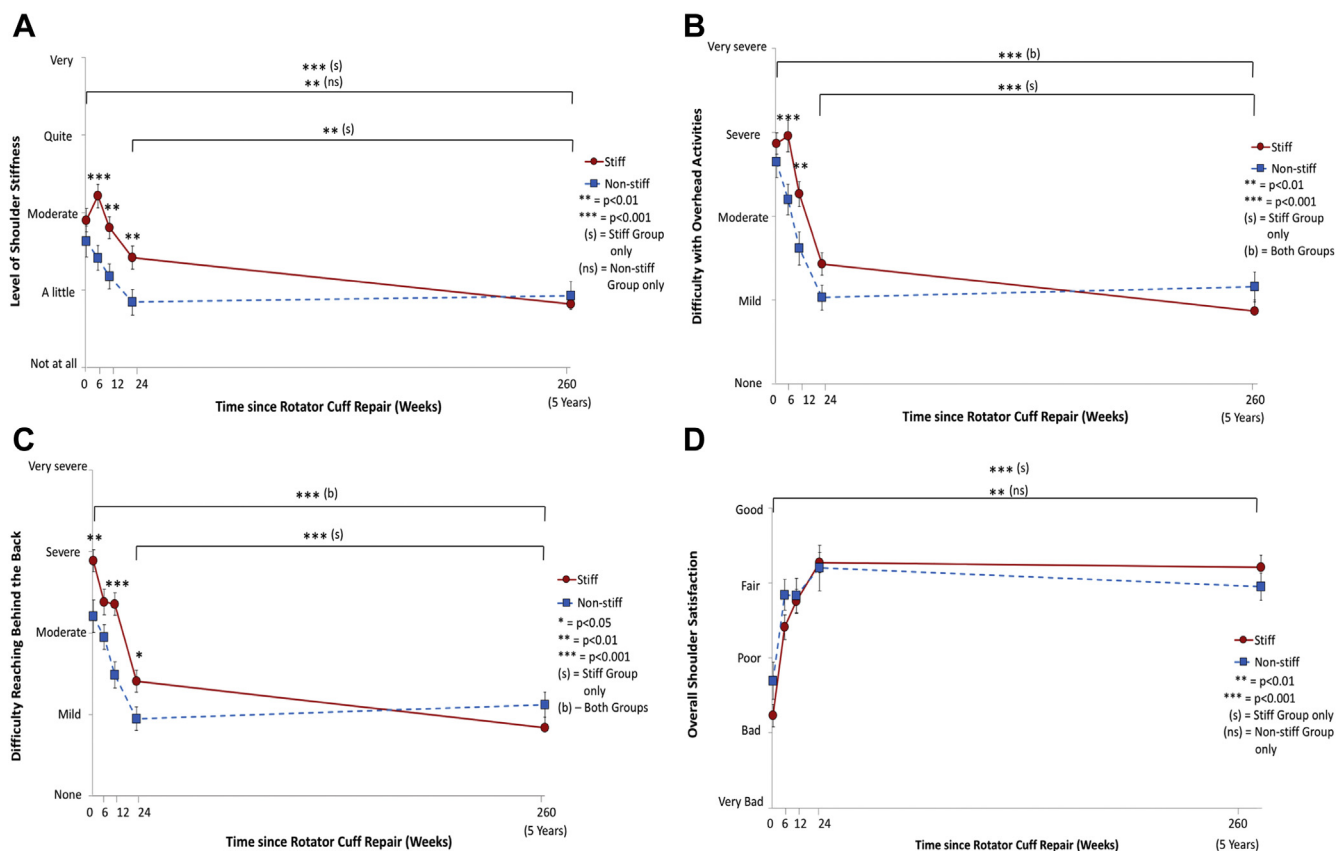


Figure 4 Comparison of patient-ranked shoulder function between stiff and nonstiff groups up to 5 years after rotator cuff repair, including level of shoulder stiffness (A), difficulty with overhead activities (B), difficulty reaching behind the back (C), and overall shoulder satisfaction (D). Patients with retears were excluded.

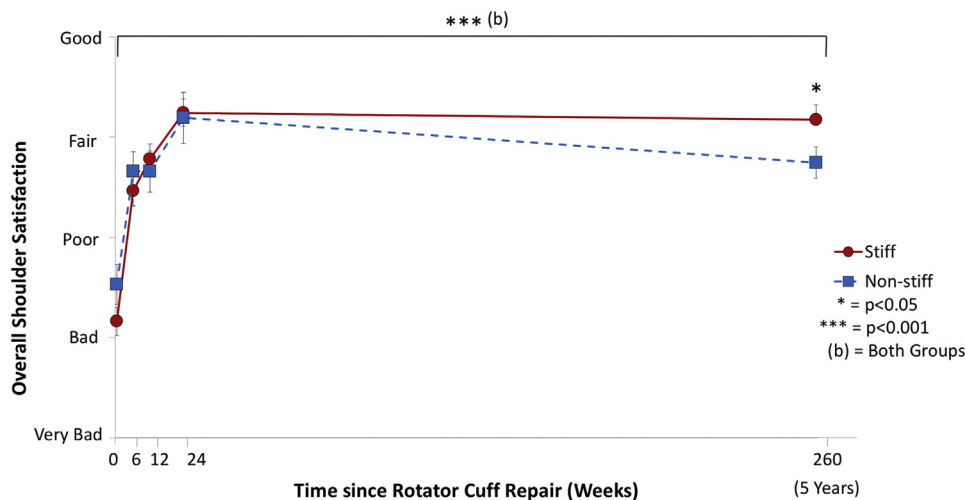


Figure 5 Overall shoulder satisfaction for stiff and nonstiff shoulder groups up to 5 years after rotator cuff repair, including patients with retears.

pre-existing evidence. Numerous studies have demonstrated that shoulder activity and specific interventions can affect range of motion.¹ In addition, range of motion varies naturally between individuals and between dominant and nondominant arms.^{17,29}

Interestingly, overall shoulder satisfaction was higher in the stiff group than the nonstiff group by the final follow-up when including all patients in the analysis. This result is likely a reflection of the pain and dysfunction that accompanies rotator cuff retears and subsequent revision

surgery, which were both more prevalent in the nonstiff group.³⁰ Higher overall satisfaction in postoperatively stiff patients, in combination with the evidence that stiffness ultimately resolves, may have far-reaching clinical consequences. Surgeons counseling patients with stiffness after rotator cuff repair can explain that the stiffness often resolves without further surgical intervention, leaving the patient with better overall outcomes.

The strengths of this study included the long follow-up time, the use of a single experienced musculoskeletal sonographer, and the variety of outcome measures used, giving an expansive view of how postoperative stiffness affects patient outcomes. In terms of the study methodology, passive external rotation at 6 weeks after surgery was ultimately validated as an appropriate timepoint for defining postoperative stiffness and is consistent with previous studies.^{18,22,26} Furthermore, a major strength of the study methodology was that by stratifying patients by year of surgery, it attempted to mitigate confounding factors such as changes in surgical team experience, examiner technique, and rehabilitation management.

However, this study also had a number of limitations. The rotator cuff repairs were conducted by a single surgeon at a single institute, limiting the external validity of the results of this study. A large number of patients were unable to return for follow-up or be contacted, which potentially represents a selection bias in the patients who did agree to participate. This study was also unable to define more accurately the timing of rotator cuff re-tears and postoperative stiffness resolution because serial measurements were not taken beyond 6 months after surgery. Inclusion of contralateral shoulder measurements in the institution protocol may have also aided analysis. Furthermore, the method of patient selection introduced an element of variability in patient groups due to variations in external rotation percentiles from year to year. Accurate selection of stiff and nonstiff patients was dependent on having large yearly patient numbers, which was not possible for patients with surgeries before 2007, necessitating the exclusion of these years.

Conclusions

This study contributes to emerging evidence that suggests stiffness after rotator cuff repair benefits tendon healing. Moreover, this study was able to show that the benefits of postoperative stiffness persist for 9 years after surgery. This study showed that the first 6 months after surgery is a critical period of healing for the rotator cuff and that stiffness during this critical period is correlated with fewer rotator cuff re-tears. This study also provides substantial evidence that postoperative stiffness resolves by 5 years after surgery. Although the exact mechanisms of the protective role of stiffness require further

exploration, the findings from this study potentially affect the clinical approach to postoperative stiffness. In the presence of postoperative stiffness, after ruling out potential negative complications such as re-tear, it may be beneficial to reassure patients that their stiffness likely represents a good healing response and should resolve over time.

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