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The Relationship Between Shoulder Stiffness and Rotator Cuff Healing

A Study of 1,533 Consecutive Arthroscopic Rotator Cuff Repairs

William J. McNamara, Patrick H. Lam, PhD, and George A.C. Murrell, MD, DPhil

Investigation performed at the Orthopaedic Research Institute, St. George Hospital Campus, University of New South Wales, Sydney, New South Wales, Australia

Background: Retear and stiffness are not uncommon outcomes of rotator cuff repair. The purpose of this study was to evaluate the relationship between rotator cuff repair healing and shoulder stiffness.

Methods: A total of 1,533 consecutive shoulders had an arthroscopic rotator cuff repair by a single surgeon. Patients assessed their shoulder stiffness using a Likert scale preoperatively and at 1, 6, 12, and 24 weeks (6 months) postoperatively, and examiners evaluated passive range of motion preoperatively and at 6, 12, and 24 weeks postoperatively. Repair integrity was determined by ultrasound evaluation at 6 months.

Results: After rotator cuff repair, there was an overall significant loss of patient-ranked and examiner-assessed shoulder motion at 6 weeks compared with preoperative measurements ($p < 0.0001$), a partial recovery at 12 weeks, and a full recovery at 24 weeks. Shoulders that were stiff before surgery were more likely to be stiff at 6, 12, and, to a lesser extent, 24 weeks after surgery ($r = 0.10$ to 0.31; $p < 0.0001$). A stiffer shoulder at 6 and 12 weeks (but not 24 weeks) postoperatively correlated with better rotator cuff integrity at 6 months postoperatively ($r = 0.11$ to 0.18; $p < 0.001$). The retear rate of patients with ≤20° of external rotation at 6 weeks postoperatively was 7%, while the retear rate of patients with >20° of external rotation at 6 weeks was 15% ($p < 0.001$).

Conclusions: In patients who developed stiffness after surgery, a rotator cuff repair was more likely to heal.

Level of Evidence: Therapeutic Level III. See Instructions for Authors for a complete description of levels of evidence.

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Rotator cuff tear is a common shoulder pathology that causes pain and loss of shoulder function, accounting for almost 50% of major shoulder disorders[1]. The overall prevalence in the general population is 21%[2], and the incidence increases with age[3]. Treatment of rotator cuff tears with arthroscopic rotator cuff repair[4] has yielded excellent short to long-term results[5-9]. Although such treatment is often successful, failure to heal or retear is relatively common, with rates ranging between 11% and 94%[10].

Stiffness and limited range of shoulder motion are common findings preoperatively and postoperatively[11-13]. Some studies have suggested that stiffness[14] and mechanical immobilization[15] in the short term makes little difference to long-term functional outcomes. Some surgeons defer rotator cuff repair until any stiffness has resolved, in the hope of improving outcomes. However, little is known about the relationship between stiffness and rotator cuff repair healing[16-18].

The purpose of the current study was to determine if preoperative and/or postoperative stiffness might play a beneficial or detrimental role in healing of the rotator cuff and, specifically, to determine the association between preoperative

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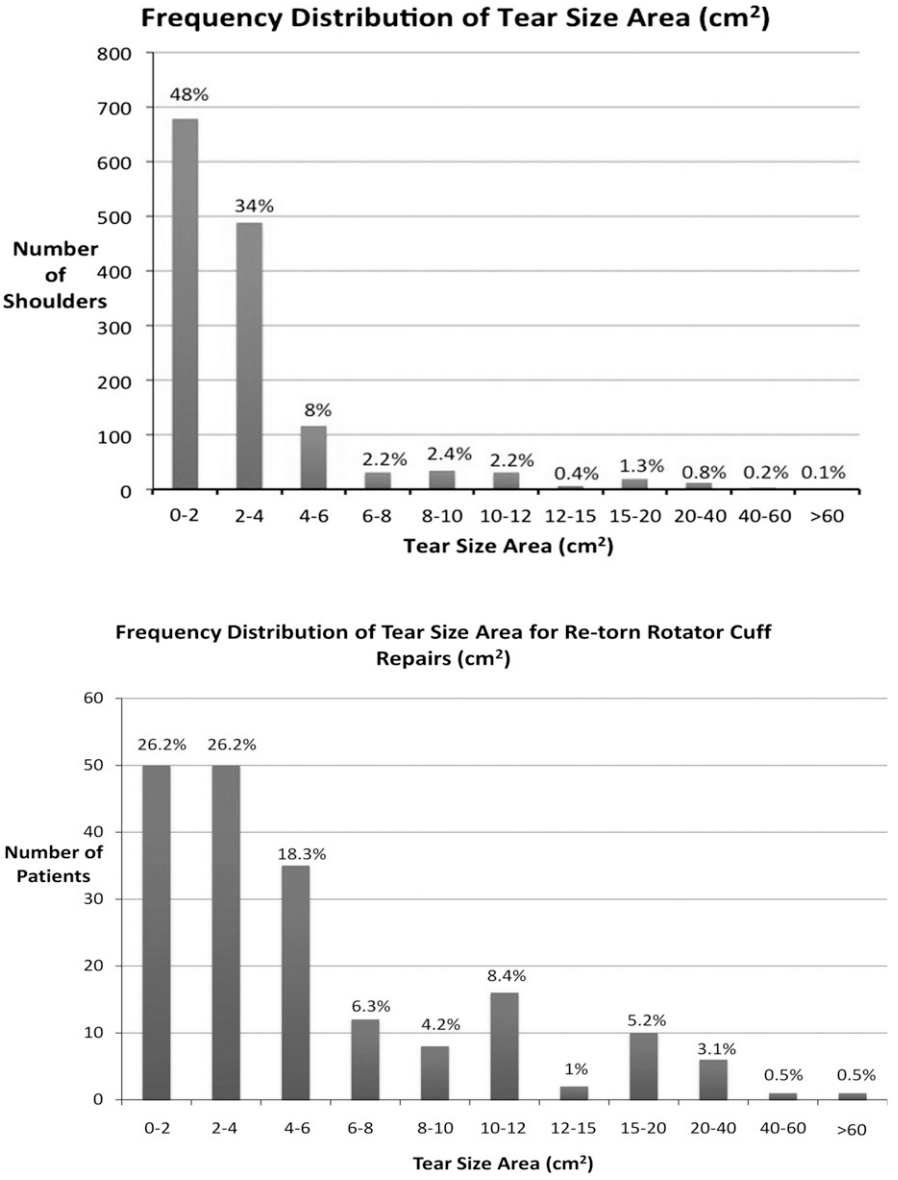

Fig. 1

Frequency distribution of preoperative tear-size area for the whole cohort (upper panel) and for those with retears (lower panel).

and/or postoperative shoulder stiffness and repair integrity in patients who had an arthroscopic rotator cuff repair.

Materials and Methods

Following ethics approval at our institution, we performed a retrospective study involving prospectively collected data.

Inclusion and Exclusion Criteria

Patients were included in this study if they underwent arthroscopic repair of a primary rotator cuff tear (defined as any tear that had not previously been surgically treated) and had an ultrasound examination at 6 months postoperatively to determine repair integrity. Excluded were those who had an isolated subscapularis tear; rotator cuff repair with an interpositional polytetrafluoroethylene (PTFE) patch; revision or partial rotator cuff repair; irreparable rotator cuff tear; glenohumeral arthritis (of grade II or greater)[19]; and concurrent fracture of the humerus, scapula, or clavicle; arthroplasty; arthroscopic glenohumeral joint stabilization; biceps tenodesis; calcific debridement; or other concurrent procedures.

Study Group

Between June 2005 and December 2013, 2,873 consecutive arthroscopic rotator cuff repairs were performed by a single surgeon. Of these, we excluded 10 for isolated subscapularis tears; 19 for partial rotator cuff repair; 1 for an irreparable rotator cuff tear; 91 for rotator cuff repair with an interpositional PTFE patch; 150 for revision rotator cuff repair; 20 for the presence of glenohumeral arthritis that was grade II or greater; 26 for concurrent fracture of the humerus, scapula, or clavicle; 150 for concurrent shoulder arthroplasty; 287 for concurrent glenohumeral stabilization; 58 for concurrent calcific debridement; 14 for concurrent biceps tenodesis; 227 for other concurrent procedures; and 287 for incomplete data. This left a study cohort of 1,533 shoulders (1,483 patients).

TABLE I Correlation of Retear with Examiner-Assessed Passive Range of Motion*

	6 Wk. Postop.		12 Wk. Postop.	
Range of Motion	R Value	P Value	R Value	P Value
External rotation	0.18	<0.0001	0.15	<0.0001
Internal rotation	0.12	<0.0001	0.13	<0.0001
Abduction	0.14	<0.0001	0.12	<0.0001
Forward flexion	0.14	<0.0001	0.11	0.001

*Pearson or Spearman (for internal rotation) correlation coefficient.

Cohort Demographics

There were 843 male and 640 female patients, with a mean age (and standard error of the mean [SEM]) of 59 ± 0.32 years (range, 18 to 91 years) and a mean duration of symptoms of 21 ± 1.35 months (range, 0 to 518 months). Thirty-two percent of the patients reported a specific traumatic event, and 68% reported no specific traumatic event. Repair was performed on 911 right and 622 left shoulders.

Intraoperatively, 62% of the shoulders were noted to have a full-thickness tear and 38% had a partial-thickness tear, with a mean tear-size area of 3.5 ± 1.4 cm^2 (range, 0 to 64 cm^2; Fig. 1). An undersurface repair technique was used in 58% of the repairs, while 19% were bursal and 23% required both approaches. The average number of anchors needed for repair was 2 (range, 1 to 6). The mean operative time was 23 ± 0.33 minutes (range, 4 to 90 minutes). Concurrent acromioplasty was performed in 84 patients. Public hospital surgeries made up 11% of the repairs, and 13% of the patients had work-related injuries.

Patient Assessment

Preoperative Assessment

At presentation, each patient completed a questionnaire that asked when the problem began, whether it was related to a specific traumatic injury, and whether it was work-related.

Shoulder Function

In addition to the above, patients completed a standardized questionnaire that was based on the L'Insalata Shoulder Rating Questionnaire[20] and appraised patient-ranked shoulder stiffness using a Likert scale preoperatively and at 1 week, 6 weeks, 12 weeks, and 6 months postoperatively.

Range of Motion

Examiners measured passive shoulder range of motion preoperatively and at 6 weeks, 12 weeks, and 6 months postoperatively. The ranges of external rotation, forward flexion, abduction, and internal rotation were determined visually, according to a previously validated protocol[21]. The examiners were not blinded to patients' operative and clinical data.

A post hoc subgroup analysis was also performed on the basis of examiner-assessed passive range of external rotation at 6 weeks postoperatively. Patients were allocated to the "stiff" group, if external rotation was ≤20°, or to the "nonstiff" group, if external rotation was >20°. These criteria were decided post hoc, as 20° of external rotation at 6 weeks postoperatively was the most discriminatory with respect to rotator cuff integrity at 6 months postoperatively.

Shoulder Strength

Examiners tested the strength of shoulder external rotation, internal rotation, adduction, lift-off, and abduction in the scapular plane (supraspinatus) with a handheld dynamometer according to validated protocols[22] preoperatively and at 6, 12, and 24 weeks postoperatively.

Rotator Cuff Integrity

Ultrasound examination of the rotator cuff was performed at 6 months postoperatively by a single experienced musculoskeletal ultrasonographer[23,24] who was blinded to the clinical results. Real-time ultrasound examination was performed using either a Logiq 9 or Logiq E9 machine (General Electric) with a 12-MHz linear transducer, according to a standardized protocol[23]. The location, size, and thickness of any tear of the rotator cuff were recorded on a standardized form[23]. A retear was defined as a rotator cuff repair with an identifiable hypoechoic gap on ultrasound. This assessment was made irrespective of the original tear size[23-25].

Operative Procedure and Rehabilitation

Following appropriate visualization, intra-articular assessment, and location of the tendon tear using an arthroscope, tears were debrided and partial-thickness tears were converted to full-thickness tears using an arthroscopic shaver (either 4.0 or 5.5 mm in diameter). Repairs were visualized either from within the glenohumeral joint (undersurface[26]), from within the subacromial bursa (bursal[27]), or via both approaches. Repair was conducted using sutures and knotless suture anchors (OPUS SmartStitch and OPUS Magnum-2 knotless anchor; ArthroCare) in a single-row inverted mattress configuration. Anteroposterior and mediolateral tear

TABLE II Independent Predictors of Retear Ranked by Strength of Predictive Value

Variable	Wald Statistic	P Value
Anteroposterior tear size	14	<0.001
Full-thickness vs. partial-thickness tear	12	<0.001
Patient-ranked shoulder stiffness at 6 wk. postop.	11	<0.001
Public vs. private hospital	10	0.001
Operative time	8	0.004
Preop. supraspinatus strength	8	0.004
Specific traumatic injury	6	0.015

TABLE III Correlation of Patient-Ranked Shoulder Stiffness with Examiner-Assessed Passive Range of Shoulder Motion*

Examiner-Assessed Passive Shoulder Motion	Patient-Ranked Shoulder Stiffness							
	Preop.		6 Wk. Postop.		12 Wk. Postop.		6 Mo. Postop.	
	R Value	P Value	R Value	P Value	R Value	P Value	R Value	P Value
Forward flexion	0.29	<0.0001	0.32	<0.0001	0.40	<0.0001	0.43	<0.0001
Abduction	0.27	<0.0001	0.30	<0.0001	0.39	<0.0001	0.41	<0.0001
External rotation	0.17	<0.0001	0.27	<0.0001	0.28	<0.0001	0.26	<0.0001
Internal rotation	0.25	<0.0001	0.29	<0.0001	0.39	<0.0001	0.37	<0.0001

*Pearson and Spearman (for internal rotation) correlation coefficient.

TABLE IV Correlation of Preoperative Stiffness with Postoperative Stiffness*

Preop. Outcome	1 Wk. Postop.		6 Wk. Postop.		12 Wk. Postop.		6 Mo. Postop.	
	R Value	P Value	R Value	P Value	R Value	P Value	R Value	P Value
Forward flexion	—	—	0.13	<0.0001	0.17	<0.0001	0.22	<0.0001
Abduction	—	—	0.12	<0.0001	0.16	<0.0001	0.18	<0.0001
External rotation	—	—	0.11	<0.0001	0.10	<0.0001	0.14	<0.0001
Internal rotation	—	—	0.16	<0.0001	0.17	<0.0001	0.18	<0.0001
Patient-ranked shoulder stiffness	0.17	<0.0001	0.31	<0.0001	0.26	<0.0001	0.30	<0.0001

*Pearson and Spearman (for internal rotation) correlation coefficient.

measurements were calculated intraoperatively by visually comparing the known diameter of the shaver with the tear. Tear thickness was estimated on visualization of the torn area, whereby a full-thickness tear was denoted as 100% torn.

The patients were immobilized for 6 weeks with use of a sling with a small abduction pillow (UltraSling; DJO Global).

Postoperatively, patients completed a progression of rehabilitation exercises closely monitored by their physiotherapist over 4 to 6 months. They followed a standardized, gradually progressive, home rehabilitation program[28]. Pendulum exercises were started on the first day after surgery. On postoperative day 8, passive forward flexion, external rotation, and abduction exercises of the shoulder were begun. At 6 weeks, active shoulder motion and isometric strengthening were started. At 12 weeks postoperatively, patients were allowed to commence overhead activities and lift >5 kg of weight. They were encouraged to return to full activities at 6 months.

Statistical Analysis

Comparisons were made within the overall cohort and within the respective "stiff" and "nonstiff" groups at each time point using repeated-measures analysis of variance (ANOVA) for continuous variables that had a normal distribution and Wilcoxon signed-rank tests for categorical data. Comparisons between the stiff and nonstiff groups were made at each time point using unpaired Student t tests for continuous variables that had a normal distribution and Mann-Whitney U tests for categorical data. In the subgroup analysis, a Fisher exact test for dichotomous data was conducted to determine if the independent variable affected the dependent variable. Bivariate Pearson and Spearman tests for correlation were conducted to determine a relationship between different variables taken from the preoperative, intraoperative, and postoperative data for the overall cohort. Multiple logistic regression analysis was performed to identify variables that independently affected retear and shoulder stiffness in the overall cohort. For the respective analyses, retear and examiner-assessed range of motion were the dependent variables, and all demographic and preoperative, patient-ranked, examiner-assessed strength, and intraoperative data already previously mentioned were included as potential independent variables. The level of significance was set at $p < 0.05$ for all statistical analyses.

Results

Retear Rate

Retears were found in 15% (226 of the 1,533 rotator cuffs) at the ultrasound examination 6 months after rotator cuff repair. Figure 1 shows the frequency distribution of preoperative tear-size for the whole cohort (upper panel) and for those

TABLE V Independent Predictors of Patient-Reported Shoulder Stiffness at 6 Weeks Postoperatively*

Variable	P Value
Shorter operative time	<0.001
No specific traumatic injury	<0.001
Undersurface > bursal side repair	<0.001

*In order of strength of predictive value.

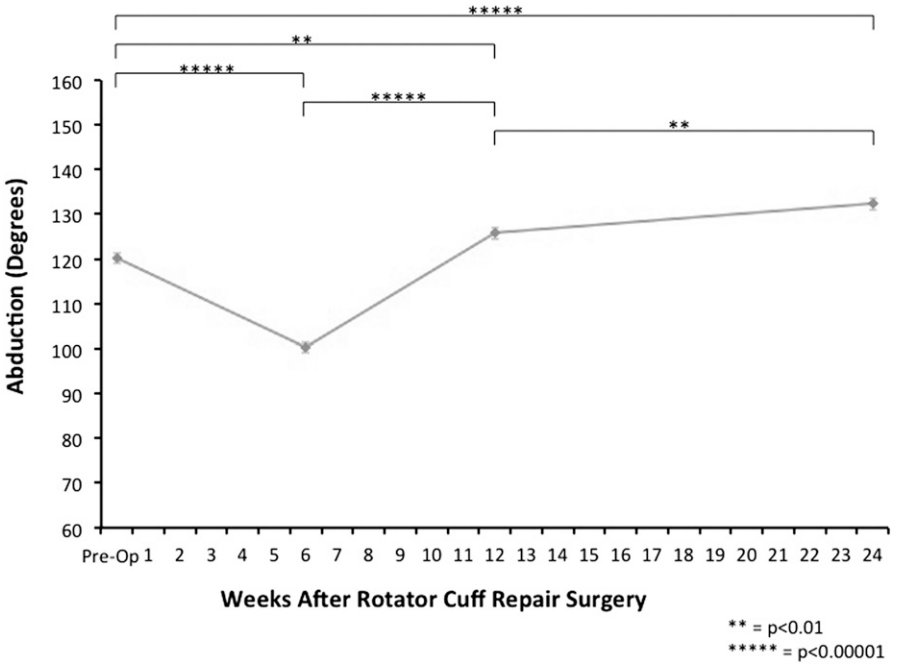

Fig. 2-A

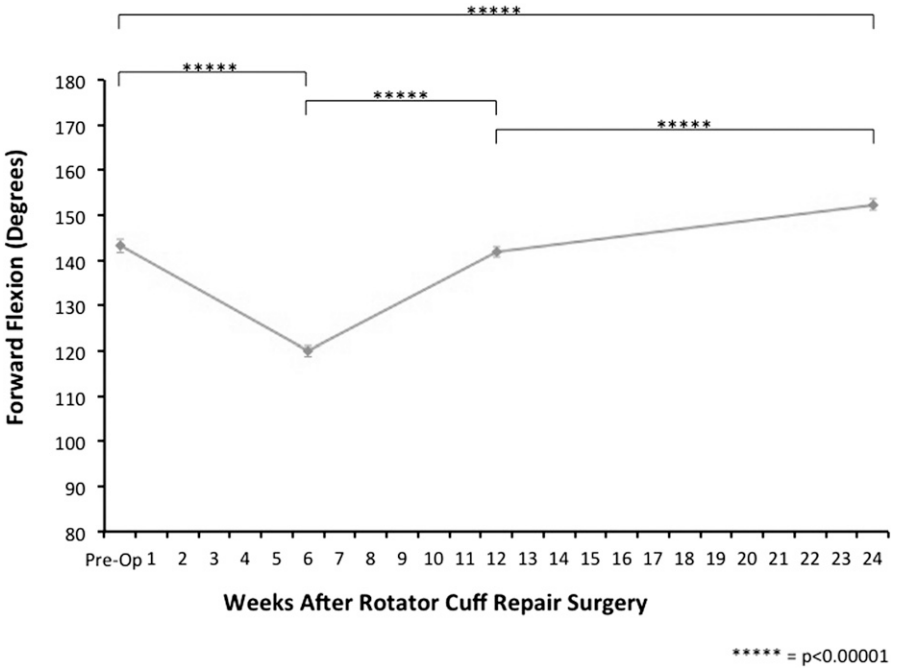

Fig. 2-B

who had a retear at 6 months (lower panel). Larger tears were associated with a higher retear rate ($r = 0.255$; $p < 0.0001$).

Examiner-Assessed Passive Range of Shoulder Motion

At 6 weeks after rotator cuff repair, there was a significant loss of range of motion compared with preoperative measurements of passive external rotation (mean loss of 9°; 95% confidence interval [CI], 5.9° to 11.2°; $p < 0.00001$), forward flexion (mean loss of 24°; 95% CI, 19.9° to 28.2°; $p < 0.00001$), abduction (mean loss of 20°; 95% CI, 15.1° to 24.3°; $p < 0.00001$), and internal rotation (mean loss of 3 spine levels; 95% CI, 2 to 3 levels; $p < 0.0001$) at 6 weeks (Figs. 2-A through 2-D).

Correlations with Retear

An assessment was made to determine if retears were associated with range of motion preoperatively and/or postoperatively. A lower retear rate correlated significantly with decreased range of motion for all measurements of passive shoulder motion at

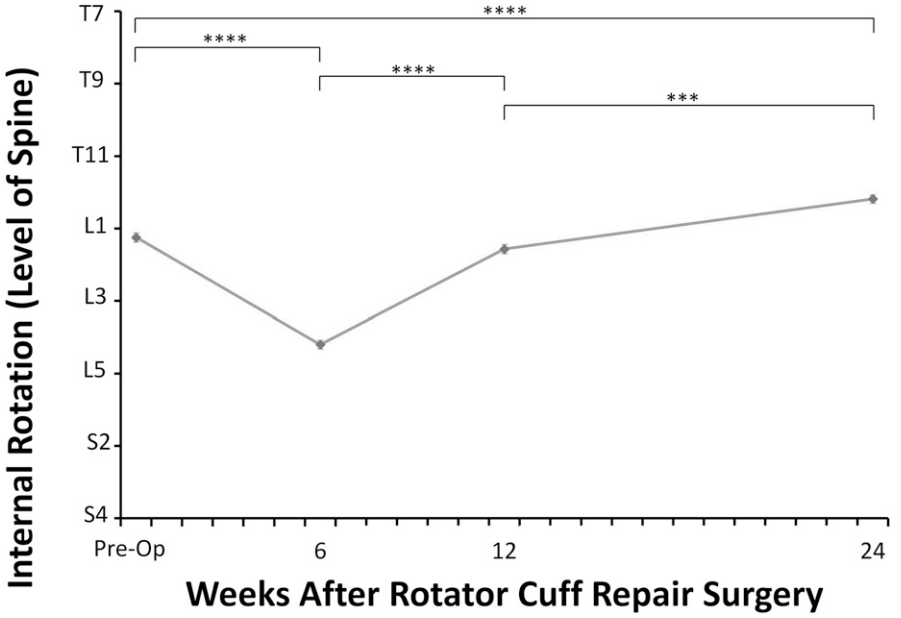

Fig. 2-C

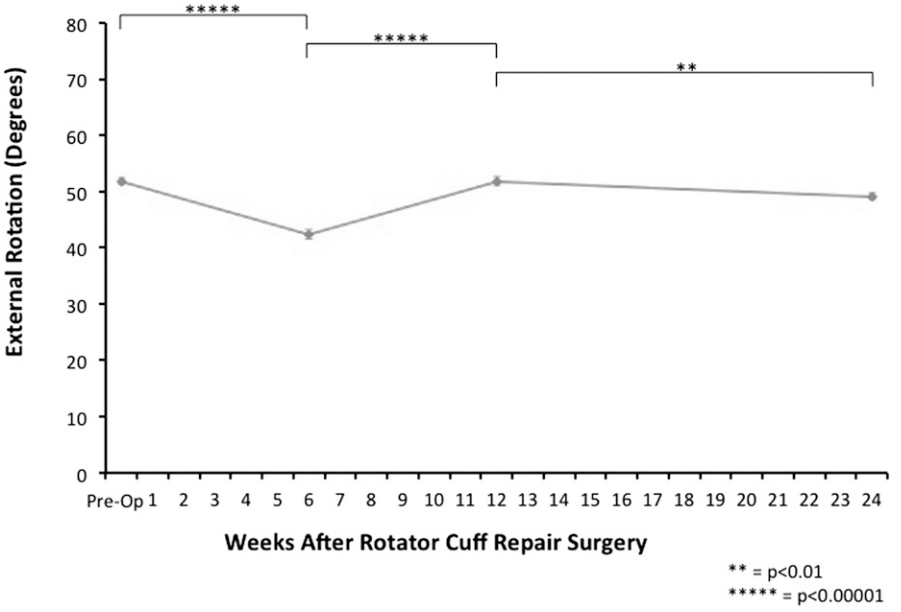

Fig. 2-D

Figs. 2-A through 2-D Passive range of motion (mean and SEM) over time, including abduction (**Fig. 2-A**), forward flexion (**Fig. 2-B**), internal rotation (**Fig. 2-C**), and external rotation (**Fig. 2-D**). **P < 0.01, ***P < 0.001, ****p < 0.0001, and *****p < 0.00001 (1-way repeated-measures ANOVA).

6 and 12 weeks postoperatively (p = 0.001 to < 0.0001) (Table I). There was no association between preoperative range of motion and the retear rate at 6 months postoperatively (p > 0.05).

Multiple logistic regression was used to determine the variables with the greatest independent effect on the likelihood of retear and showed that larger anteroposterior tear size, full-thickness tears, public hospital surgeries, patients who ranked their shoulders as less stiff at 6 weeks postoperatively, a longer operative time, specific traumatic injury, and lower preoperative supraspinatus strength were associated with retear. Concomitant acromioplasty and patient age were not predictors of retear. Table II ranks these factors in the order of the strength of their prediction.

Associations with Shoulder Stiffness

Examiner-Assessed Range of Motion and Patient-Ranked Shoulder Stiffness

We found moderate agreement between patient-ranked stiffness and examiner-assessed loss of passive shoulder motion at all time points (r = 0.17 to 0.43; p < 0.0001) (Table III).

TABLE VI Independent Predictors of Patient-Reported Shoulder Stiffness at 6 Months Postoperatively*

Variable	P Value
Smaller anteroposterior tear size	<0.001
Lower preop. strength in external rotation	<0.001

*In order of strength of predictive value.

Preoperative and Postoperative Stiffness

The shoulders that were stiff before surgery were significantly more likely to be stiff at 6 weeks, 12 weeks, and, to a lesser extent, 24 weeks postoperatively ($r = 0.10$ to 0.31; $p < 0.0001$) (Table IV).

Regression Analysis

Multiple regression analysis was used to determine the factors associated with patient-reported shoulder stiffness at 6 weeks postoperatively. We found that a shorter operative time, no specific preoperative injury, and rotator cuff repair using an undersurface technique were independent predictors of greater patient-reported shoulder stiffness at 6 weeks postoperatively (Table V).

Regression analysis showed that, at 6 months postoperatively, patient-ranked stiffness was associated with smaller anteroposterior tear size and lower preoperative strength in external rotation (Table VI).

Stiff Compared with Nonstiff Shoulders

A post hoc subgroup analysis was performed on the basis of examiner-assessed passive range of external rotation at 6 weeks postoperatively. Patients were allocated to the "stiff" group if external rotation was ≤20° or to the "nonstiff" group if external rotation was >20°. This analysis included a total of 999 patients; 285 patients were allocated to the stiff group and 714 patients were allocated to the nonstiff group. There were no significant demographic differences between

TABLE VII Subgroup Cohort Characteristics*

	Stiff Group (≤20° of External Rotation)	Nonstiff Group (>20° of External Rotation)
Age† *(yr)*	57 ± 0.72 (22-83)	60 ± 0.45 (18-91)
Sex *(no.)*		
Male	147	407
Female	138	307
Duration of symptoms† *(mo.)*	23 ± 4.7 (1-295)	20 ± 1.6 (0-306)
Affected side *(no.)*		
Right	165	432
Left	120	282
Tear thickness		
Full	57%	59%
Partial	43%	41%
Tear size† *(cm^2)*	3.4 ± 0.3 (0-56)	3.3 ± 0.2 (0-64)
Repair approach		
Undersurface	59%	67%
Bursal	16%	15%
Both	25%	18%
No. of anchors†	2 (1-6)	2 (1-6)
Operative time† *(min)*	20 ± 0.69 (4-78)	21 ± 0.44 (4-75)
Concurrent acromioplasty *(no.)*		
Yes	14	32
No	271	682
Work-related	7%	10%
Surgery environment		
Public	9%	12%
Private	91%	88%

*Subgroups defined by measurements of examiner-assessed passive range of motion at 6 weeks postoperatively. †The values are given as the mean and the standard error of the mean, with the range in parentheses.

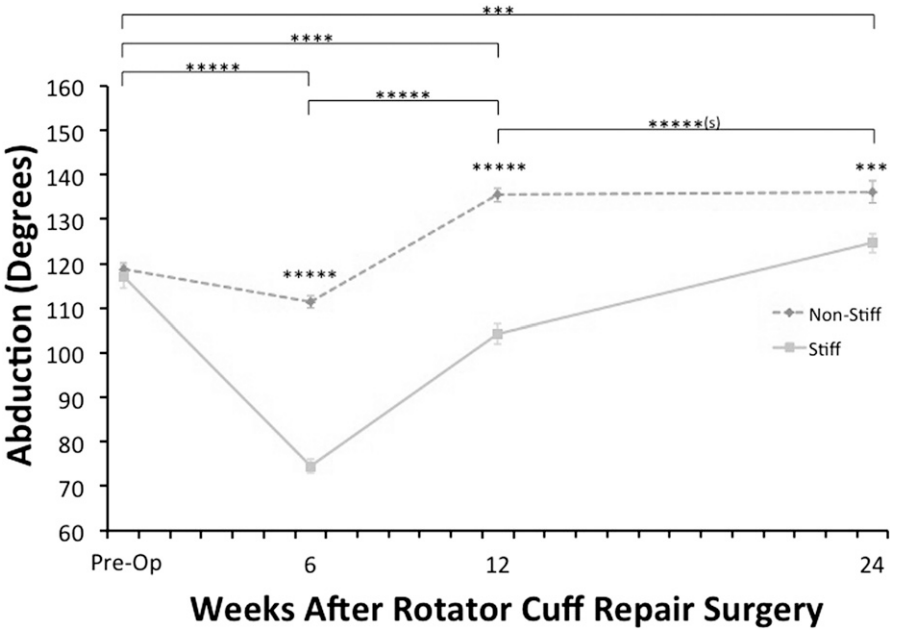

Fig. 3-A

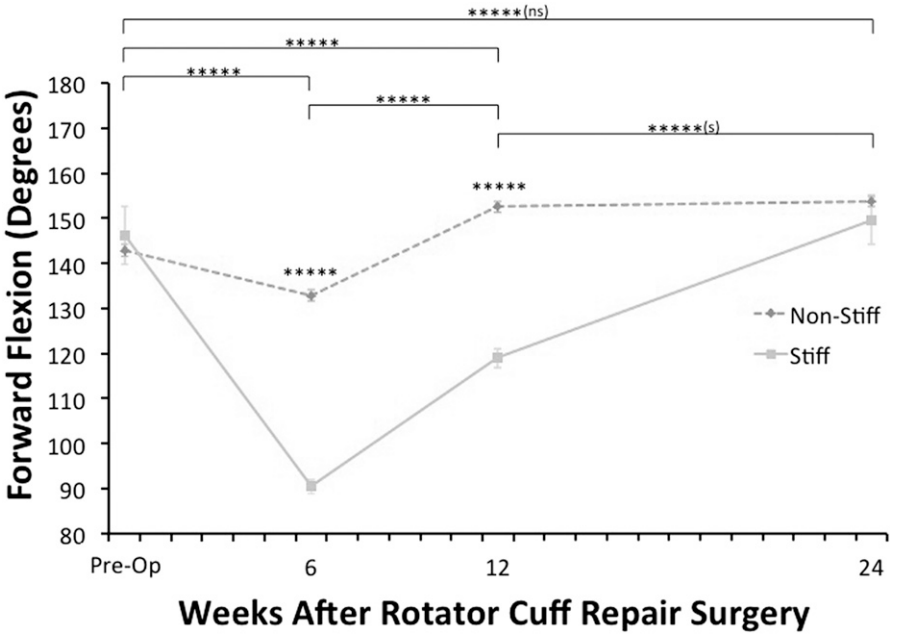

Fig. 3-B

the 2 groups ($p > 0.05$). Table VII summarizes the demographic and intraoperative characteristics of both groups.

Following rotator cuff repair, both groups demonstrated a loss of shoulder motion at 6 weeks, with a full recovery by 6 months. The stiff group had less range of motion compared with the nonstiff group at almost every postoperative time point ($p < 0.01$ to < 0.00001) (Figs. 3-A through 3-D).

The stiff group also reported more shoulder stiffness than the nonstiff group at 6, 12, and 24 weeks postoperatively ($p < 0.0001$). Both groups reported a gradual reduction in shoulder stiffness from 6 to 12 weeks and 12 to 24 weeks ($p < 0.0001$) (Fig. 4).

Lastly, there was a significantly lower retear rate in the stiff shoulder cohort (19 of 285, 7%) compared with the nonstiff shoulder cohort (107 of 714, 15%) ($p < 0.001$).

Discussion

This study showed that, in patients who developed stiffness at 6 and 12 weeks postoperatively, a rotator cuff repair was more likely to heal than in those who did not develop stiffness postoperatively. To our knowledge, this is the first study to

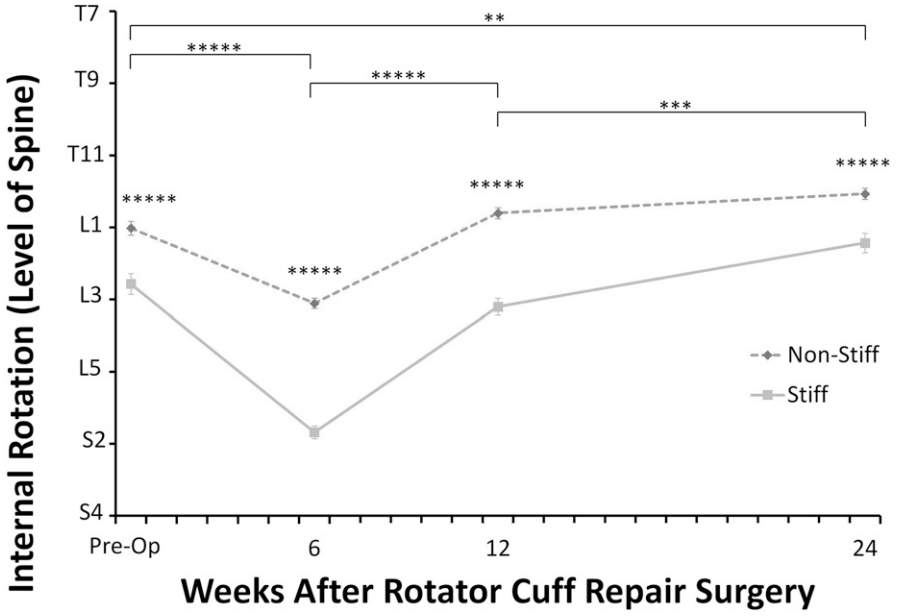

Fig. 3-C

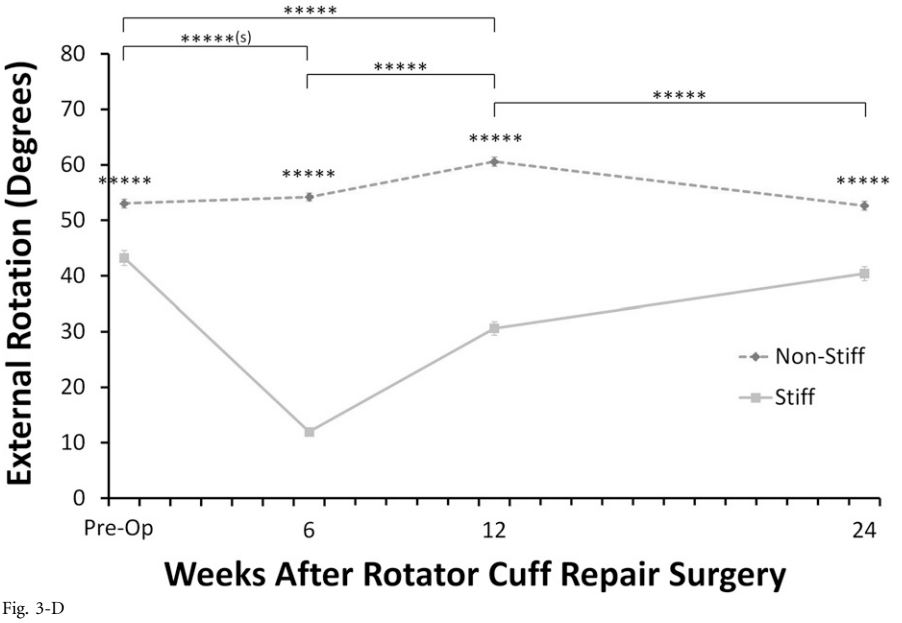

Fig. 3-D

Figs. 3-A through 3-D Comparison of passive range of motion (mean and SEM) between stiff and nonstiff shoulder groups over time, including abduction (**Fig. 3-A**), forward flexion (**Fig. 3-B**), internal rotation (**Fig. 3-C**), and external rotation (**Fig. 3-D**). **P < 0.01, ***P < 0.001, ****p < 0.0001, *****p < 0.00001 (unpaired Student t test), (s) = a significant difference within the stiff shoulder group only, and (ns) = a significant difference within the nonstiff shoulder group only.

show that postoperative stiffness is associated with improved rotator cuff tendon-to-bone healing.

A number of studies have identified stiffness as a relatively common complication of rotator cuff tear and arthroscopic repair[12,13,18]. However, beyond noting the prevalence of stiffness, most studies have not considered or focused on stiffness. One study found substantial preoperative shoulder stiffness in 81% of 74 patients undergoing rotator cuff repair[11].

In the current study, we found that patients who had preoperative stiffness were more likely to develop postoperative stiffness. We also found that there was moderate agreement between patient-ranked shoulder stiffness and examiner-assessed limitation of range of motion, thus confirming that this approach to determining stiffness has some validity.

Several studies have shown that age and the presence of fatty degeneration of the cuff muscles are important negative prognostic factors for retear[3,29] and that tear size is the greatest

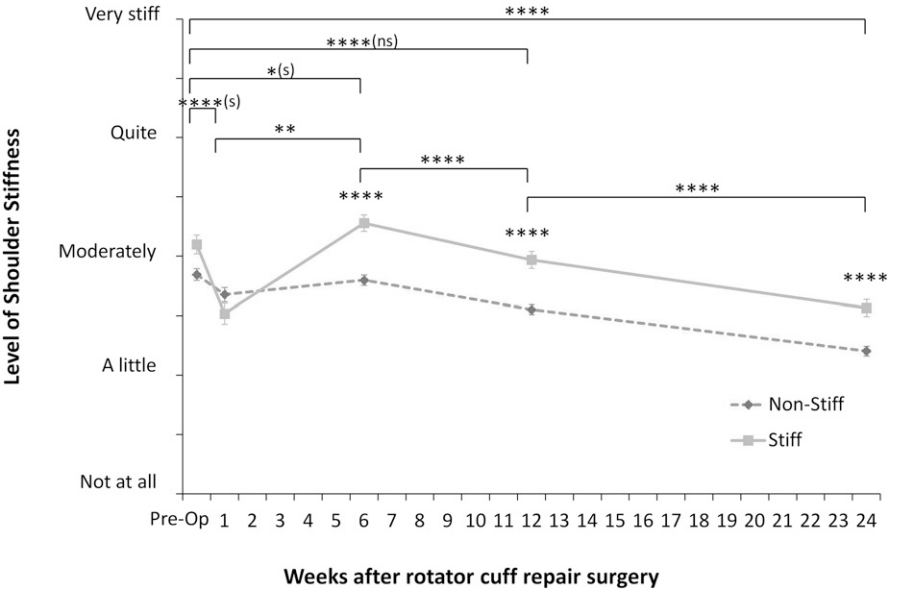

Fig. 4

Comparison of patient-ranked level of shoulder stiffness (mean and SEM) between stiff and nonstiff shoulder groups. *P < 0.05, **p < 0.01, **** p < 0.0001 (Mann-Whitney U test), (s) = significant difference within the stiff shoulder group only, and (ns) = significant difference within the nonstiff shoulder group only.

predictive factor for likelihood of retear[30]. Conversely, in this study, we identified a factor (stiffness) that was associated with enhanced tendon healing. Parsons et al. noted a trend in this direction in their cohort of 43 rotator cuff repair patients (70% intact in the stiff group versus 36% in the nonstiff group; $p = 0.079$)[14]. Our study of 1,533 rotator cuff repairs (93% intact in the stiff group versus 85% in the nonstiff group; $p = 0.001$) confirmed the association between stiffness and repair integrity.

Keener et al. compared 124 patients randomized to a traditional rehabilitation group with early range of motion or to an immobilization group, for whom range of motion was delayed until after 6 weeks postoperatively[15]. The authors found that the immobilized group was stiffer at 12 weeks postoperatively; however, there were no significant differences between the groups in motion and cuff integrity at 12 months postoperatively, suggesting that the stiffness associated with 6 weeks of immobilization is not the same as the stiffness that occurred in the patients in our study. In another study, we compared the results of 170 patients who had rotator cuff surgery with those of 25 patients who underwent a glenohumeral joint capsule release at the time of rotator cuff repair[16]. The repairs in the group who had concomitant capsular release were all intact at 2 years postoperatively, compared with 80% in the rotator cuff repair-only group. The current study also supports the concept that capsulitis is associated with better healing of the rotator cuff[15,16].

We included patients with either full or partial-thickness tears in our study. Multiple logistic regression demonstrated that full-thickness tears were more likely to retear compared with partial-thickness tears. We investigated this further and found that, despite there being a difference in retear rate between these 2 groups, whether the tear was a partial-thickness tear or a full-thickness tear did not affect the difference in retear rate between the stiff and nonstiff shoulder groups; stiff shoulders still had a significantly lower retear rate compared with nonstiff shoulders ($p < 0.001$). Interestingly, our findings showed traumatic rotator cuff tears were more likely to retear, which was in contrast to what we expected: that atraumatic tears would have more reruptures.

The strengths of our study were the large sample size, the clear inclusion and exclusion criteria for rotator cuff tears and arthroscopic rotator cuff repair, and the regular collection of patient-ranked and examiner-assessed data. Additionally, a single musculoskeletal ultrasonographer with extensive experience in imaging of shoulder pathologies performed all ultrasound examinations, and a single surgeon with extensive experience in arthroscopic shoulder surgery performed all of the procedures. However, these factors (single surgeon, single sonographer) may limit the applicability of the findings to other surgeons and other centers.

There were several potential weaknesses and limitations of this study that should be considered. This study did not examine the effect of healing and stiffness on patient-reported outcomes, which could be helpful in determining whether a stiff shoulder with an intact repair or a nonstiff shoulder with a retear is a preferred outcome from the patient's point of view. Our protocol did not include the collection of data from the contralateral shoulder. It would have been interesting to compare range of motion data with the uninjured shoulder to observe any changes in range of motion relative to the individual patient. Further considerations are that, while many of

the associations had very significant p values, the correlation coefficients were relatively low, meaning that the association is weak to moderate.

In conclusion, this study showed that postoperative shoulder stiffness was associated with better healing of the rotator cuff after arthroscopic rotator cuff repair. Our data are consistent with the hypothesis that patients who develop stiffness 6 weeks after repair of a rotator cuff tear have a more exuberant healing response. This information has changed our clinical practice in the sense that, when patients return at 3 to 12 weeks after rotator cuff repair with increased pain and stiffness, our approach is to rule out a rotator cuff tear with ultrasound and then reassure them that their stiffness is likely a manifestation of an exuberant healing response and they are the ones most likely to have an intact rotator cuff repair. ■

William J. McNamara[1]
Patrick H. Lam, PhD[1]
George A.C. Murrell, MD, DPhil[1]

[1]Orthopaedic Research Institute, St. George Hospital Campus, University of New South Wales, Sydney, New South Wales, Australia

E-mail address for G.A.C. Murrell: murrell.g@ori.org.au

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