



Stiffness: friend or foe? A cohort study evaluating the effect of early postoperative stiffness on the outcomes of patients who underwent superior labral repair

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Background and hypothesis: Postoperative stiffness is a commonly reported complication after type II superior labrum anterior-posterior (SLAP) repair. It is unclear whether patients with postoperative stiffness, classified as external rotation to the side of $\leq 20^\circ$, ultimately will have greater functional outcomes at ≥ 2 years after surgery. We hypothesized that postoperative stiffness would result in improved functional outcomes at ≥ 2 years after surgery.

Methods: Sixty-five consecutive arthroscopic SLAP repair cases performed by a single surgeon were retrospectively reviewed using prospectively collected patient-ranked outcomes and examiner-determined assessments preoperatively and at 1 week, 6 weeks, 24 weeks, and a minimum of 2 years after surgery. Patients were allocated to the stiff group and the non-stiff group based on their external rotation at 6 weeks after repair.

Results: Of the patients, 16 (27%) had $\leq 20^\circ$ of external rotation at 6 weeks postoperatively. These patients, comprising the stiff group, had more pain and more difficulty with overhead activities early on than patients in the non-stiff group (very severe vs. severe, $P < .05$), but by 2 years, they had less difficulty and less pain with overhead activities, less patient-reported stiffness, and less severe pain at night than isolated SLAP repair patients with $> 20^\circ$ of external rotation at 6 weeks ($P < .05$).

Conclusion: This study suggests that in patients who underwent SLAP repair, early postoperative stiffness (at 6 weeks as assessed by $\leq 20^\circ$ of external rotation), while problematic early, is associated with improved functional outcomes in the longer term, with patients in the stiff group reporting less pain and difficulty with overhead activities at ≥ 2 years after surgery.

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

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Superior labral tears, often referred to as superior labrum anterior-posterior (SLAP) lesions, involve detachment of the superior labrum from the underlying glenoid rim with

or without involvement of the long head of the biceps tendon. They have been noted to be present in 6%-12% of shoulder arthroscopies and can be associated with significant pain and disability.^{3,5,7,13}

Labral repair is a common management option for SLAP tears, involving the reattachment of the labrum to the glenoid rim.¹ Postoperative shoulder stiffness is a commonly reported complication of SLAP repairs. In a prospective cohort study, Schroder et al¹² (2012) reported that 14 of 107

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patients (13%) who underwent superior labral repair experienced postoperative stiffness. In a case series by Brockmeier et al² (2009), 4 of 47 patients (9%) experienced postoperative stiffness. All of the patients classified as having stiffness in their case series regained to within 15° of their preoperative range of shoulder motion. Neither of the aforementioned studies compared stiff vs. non-stiff patients or defined what the authors classified as postoperative stiffness. Consequently, it is unclear if stiffness following SLAP repair is beneficial or detrimental to patient outcomes.

No study, to our knowledge, has analyzed early postoperative stiffness and its relationship to longer-term outcomes in patients who have undergone SLAP repair. Nor has it been analyzed what predisposes SLAP repair patients to postoperative stiffness.

Consequently, our study aimed to determine whether postoperative stiffness might play a beneficial or detrimental role in the outcomes of SLAP repair, specifically the level of pain with overhead activities at ≥ 2 years after repair. Our secondary aim was to determine what preoperative and intraoperative factors are associated with stiffness after surgery. On the basis of previous literature on rotator cuff repair that found early postoperative stiffness was associated with decreased rates of retear on ultrasound, we hypothesized that postoperative stiffness would be beneficial at ≥ 2 years after surgery functional outcomes and that preoperative patient-reported stiffness would be predictive of patient-reported stiffness at 1 week, 6 weeks, and 6 months after repair.⁶

Materials and methods

Study design

We performed a retrospective cohort study using prospectively collected data.

Inclusion and exclusion criteria

Patients were included in this study if they underwent a type II SLAP repair performed by the senior author between January 2007 and May 2017. Patients were excluded if the operation was a revision labral surgical procedure or they had never answered the shoulder function assessment questionnaire; had glenohumeral arthritis (grade II or greater per the Outerbridge classification⁹) at surgery; had a concurrent fracture of the humerus, scapula, or clavicle; or underwent biceps tenodesis, anterior labral repair, calcific débridement, or rotator cuff repair. Patients who met the inclusion criteria were contacted via letter and telephone and asked to complete an assessment, either at the clinic or, if they were unable to attend a clinic appointment, by telephone.

Patient assessment

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

Shoulder function

Preoperatively and at 1 week, 6 weeks, 6 months, and ≥ 2 years postoperatively, patients answered a standardized questionnaire based on the L'Insalata Shoulder Rating Questionnaire using a 5-point Likert scale.⁴ The questions appraised the frequency of shoulder pain, the level of shoulder pain, the level of shoulder stiffness, difficulty with reaching the back, difficulty with overhead activities, and overall shoulder satisfaction.

Range of motion

Examiners measured passive shoulder range of motion preoperatively and at 6 weeks, 6 months, and ≥ 2 years postoperatively. The ranges of external rotation, forward flexion, abduction, and internal rotation were determined visually, according to a previously validated protocol.¹¹ External rotation range of motion was assessed with the patient's arm by the side. In patients who underwent the postoperative assessment at ≥ 2 years over the telephone, range of shoulder motion was not examined at this time point.

Operative procedure

All operations were performed by the senior author. Surgical procedures were performed with the patient in the beach-chair position under general anesthesia and a local interscalene nerve block. A standard posterior viewing portal was established followed by a routine diagnostic examination of the joint.

SLAP lesions (type II) were repaired via the trans-rotator cuff technique described by O'Brien et al (2002).⁸ An anterior-superior portal and a trans-rotator cuff portal were established under direct visualization with the use of a spinal needle (outside-in technique). After skin incision, a 5.5-mm disposable cannula was inserted. The anterior-superior portal was created anterior to the long head of the biceps in the rotator cuff interval. The trans-rotator cuff portal was created posterior to the biceps tendon and medial to the rotator cuff ligament. Next, a stab incision was made longitudinal to the supraspinatus tendon, and a trocar was introduced.

A probe was used to determine the amount of labral detachment and documented clockwise. Scar tissue was detached and the outer edge of the glenoid rim was roughened using an arthroscopic rasp. A Spectrum suture passer (ConMed, Utica, NY, USA) was used to pass a nylon No. 3-0 suture through the labrum. An arthroscopic grabber was used to pick up the wire through the second portal. Next, a FiberWire (96.5-cm [38-inch] blue; Arthrex, Naples, FL, USA) was tied to the nylon suture and shuttled through the labrum. An arthroscopic drill guide (Arthrex) was inserted and positioned on the edge of the glenoid at a 30°-45° angle anterior to the posterior border of the labral lesion. A hole was drilled using a 2.9-mm PushLock drill (Arthrex). The FiberWire (96.5-cm [38-inch] blue) was connected to the suture anchor, followed by insertion of the anchor according to the manufacturer's instructions. As many suture anchors as necessary were used to create a stable labrum and biceps anchor. The number of suture anchors used, as well as their position with regard to the glenoid, was noted.

Postoperative management

All patients with a labral repair underwent a standardized rehabilitation program. The patients were asked to wear a sling for 6

weeks. In phase I, on day 1, patients started arm pendulum exercises and scapular strengthening. The second week, patients could passively flex the shoulder. This was followed by passive horizontal flexion stretching and shoulder extension from 3 to 6 weeks postoperatively. Patients were assessed and instructed by a physical therapist for phase II of our rehabilitation protocol, from 6 weeks to 3 months postoperatively. In phase II, actively supported external rotation was initiated together with isometric strengthening exercises. At 3 months postoperatively, patients were seen by a physical therapist and were instructed to start phase III exercises until 6 months postoperatively. Phase III consisted of active TheraBand (Akron, OH, USA) exercises comprising rowing, external rotation, internal rotation, adduction, and shoulder extension, as well as straight arm lifts. The rehabilitation protocol concluded at 6 months after the operation.

Statistical analysis

All statistical analyses were performed on an intent-to-treat basis. Multiple regression analyses were used to determine the contribution of preoperative and intraoperative variables to patient-reported shoulder stiffness at 6 weeks, 6 months, and ≥ 2 years postoperatively. For these analyses, patient-reported shoulder stiffness was the dependent variable, and all demographic and preoperative patient-ranked outcome, examiner-assessed range-of-motion, and intraoperative data were included as potential independent variables.

A post hoc subgroup analysis of SLAP repair cases was performed based on examiner-assessed passive range of external rotation by the side at 6 weeks postoperatively. Patients were allocated to the stiff group if external rotation was $\leq 20^\circ$ or to the non-stiff group if external rotation was $> 20^\circ$. This criterion was decided based on previous studies examining postoperative stiffness.^{6,10}

The respective stiff and non-stiff groups were compared at each time point using the unpaired Student *t* test for continuous variables that had a normal distribution and Mann-Whitney *U* test for nonparametric data. The level of significance was set at $P < .05$ for all statistical analyses.

Results

Study group

Between January 2007 and May 2017, 157 SLAP repairs were performed by a single surgeon. We excluded 6 of these because they were revision labral repairs, 3 for the presence of glenohumeral arthritis that was grade II or greater, 66 for concurrent anterior labral repair, 14 for concurrent rotator cuff repair, and 2 for concurrent calcific débridement. One patient did not answer the shoulder function questionnaire. This left 65 shoulders in 65 patients; these patients formed the study cohort.

Cohort demographic characteristics

The demographic characteristics of the overall cohort are provided in Table I. There were more men than women, and

the average follow-up time was 4 years. Of the patients, 48% reported a work-related injury, with 23% being workers' compensation claims. Prior to injury, 40 patients (62%) played sports at a recreational level or higher, with 7 patients playing sports at a national level.

Factors that predict postoperative shoulder stiffness: regression analysis

To determine what factors were predictive of postoperative stiffness following SLAP repair, a multiple regression analysis was performed with the dependent variable being patient-reported stiffness at 6 weeks, 6 months, and ≥ 2 years postoperatively. We found that advancing age, greater preoperative patient-reported stiffness, and higher levels of preoperative pain with overhead activities were independent predictors of greater patient-reported stiffness at 6 weeks but not at the other time points ($P < .05$) (Table II). Time from symptom onset to surgery, nature of injury, whether the injury was work related, operative time, and number of anchors, as well as preoperative overall shoulder satisfaction and range of shoulder motion, were not predictive of postoperative patient-reported stiffness. These factors were incorporated into a predictive equation for patient-reported stiffness at 6 weeks after surgery: $\text{Logit } P = -0.348 + (0.042 \times \text{Age [in years]}) + (0.166 \times \text{Preoperative patient-reported stiffness}) + (0.136 \times \text{Preoperative level of pain with overhead activities})$. Preoperative patient-reported stiffness and the preoperative level of pain with overhead activities were rated by the patient from 0 to 4 using a Likert scale.

Stiff compared with non-stiff shoulders

A post hoc subgroup analysis of the isolated SLAP repair cohort was performed, based on examiner-assessed passive range of external rotation at 6 weeks postoperatively, to determine whether early postoperative stiffness affected the outcomes of patients who underwent an isolated SLAP repair. Patients were allocated to the stiff group if external rotation was $\leq 20^\circ$ or the non-stiff group if external rotation was $> 20^\circ$ based on previous studies examining postoperative shoulder stiffness.^{6,10} This analysis included 59 patients: 16 (27%) allocated to the stiff group and 43 (73%) allocated to the non-stiff group. No significant differences in demographic characteristics were found between the 2 groups ($P > .05$) (Table III).

Prior to surgery, there were no differences in patient-reported outcomes or range of shoulder motion between patients in the stiff group and those in the non-stiff group ($P < .05$). At 1 week after repair, patients who had decreased external rotation at 6 weeks reported increased pain and difficulty with overhead activities compared with those in the non-stiff group (very severe vs. severe, $P = .02$). At 6 weeks postoperatively, there was no longer a difference in

Table I Demographic characteristics of SLAP repair patients

	Data in SLAP repair group
Male/female sex, n	58/7
Age at surgery, mean (range), yr	37 (18-57)
Time from symptom onset to surgery, mean \pm SEM (range), mo	27 \pm 6 (1-259)
Affected shoulder on left/right side, n	25/40
Follow-up, mean \pm SEM (range), yr	4 \pm 0.3 (2-11)
Work-related injury, %	48
Workers compensation, %	23

SLAP, superior labrum anterior-posterior; SEM, standard error of mean.

Table II Independent predictors of patient-reported shoulder stiffness at 6 weeks postoperatively

Variable*	β Coefficient	P value
Older patient age	0.382	.03
Higher preoperative level of pain with overhead activities	0.266	.008
Higher preoperative patient-reported stiffness	0.211	.02

* In order of strength of predictive value.

pain and difficulty with overhead activities between the 2 groups ($P > .05$).

By ≥ 2 years after SLAP repair, patients in the stiff group reported less difficulty and pain with overhead activities than those in the non-stiff group (none vs. mild, $P = .002$, and mild vs. moderate, $P = .02$, respectively) (Fig. 1). The same cohort also reported having less difficulty reaching behind the back (none vs. mild, $P = .003$) and less pain at night (none vs. mild, $P = .04$), as well as less shoulder stiffness (none vs. a little, $P = .02$), at ≥ 2 years after surgery than patients in the non-stiff group, who had $>20^\circ$ of external rotation at 6 weeks after repair.

Patients with $\leq 20^\circ$ of external rotation at 6 weeks after repair exhibited less external rotation, internal rotation, abduction, and forward flexion range of shoulder motion than the non-stiff group at 6 weeks after surgery ($P < .05$).

The difference in range of shoulder motion between groups resolved by 6 months after repair (Table IV).

Discussion

This study showed that patients who underwent SLAP repair and the development of reduced shoulder range of motion in external rotation at 6 weeks after repair had less pain and less difficulty with overhead activities at ≥ 2 years after surgery than isolated SLAP repair patients with $>20^\circ$ of external rotation at 6 weeks.

The rate of postoperative stiffness in isolated SLAP repair patients was significantly higher (27%) in this study than in the previous literature on isolated SLAP repair (9%-12%).^{2,12} This difference in postoperative stiffness rates is

Table III Comparison of demographic characteristics between stiff and non-stiff groups

	Stiff group ($\leq 20^\circ$ of external rotation)	Non-stiff group ($>20^\circ$ of external rotation)	P value
Sex, male/female, n	15/1	37/6	.7
Age at surgery, mean (range), yr	36 (20-53)	37 (18-57)	.7
Time from symptom onset to surgery, mo, mean \pm SEM (range)	15 \pm 8 (2-125)	27 \pm 7 (1-259)	.3
Affected shoulder on left/right side, n	4/12	19/24	.2
Follow-up, mean \pm SEM (range), yr	5 \pm 0.5 (3-6)	4 \pm 0.4 (2-11)	.4
No. of anchors used, mean (range)	2 (1-3)	2 (1-5)	.8
Operation time, mean \pm SEM (range), min	26 \pm 4 (9-65)	27 \pm 2 (10-70)	.8
Work cover, %	13	30	.2

SEM, standard error of mean.

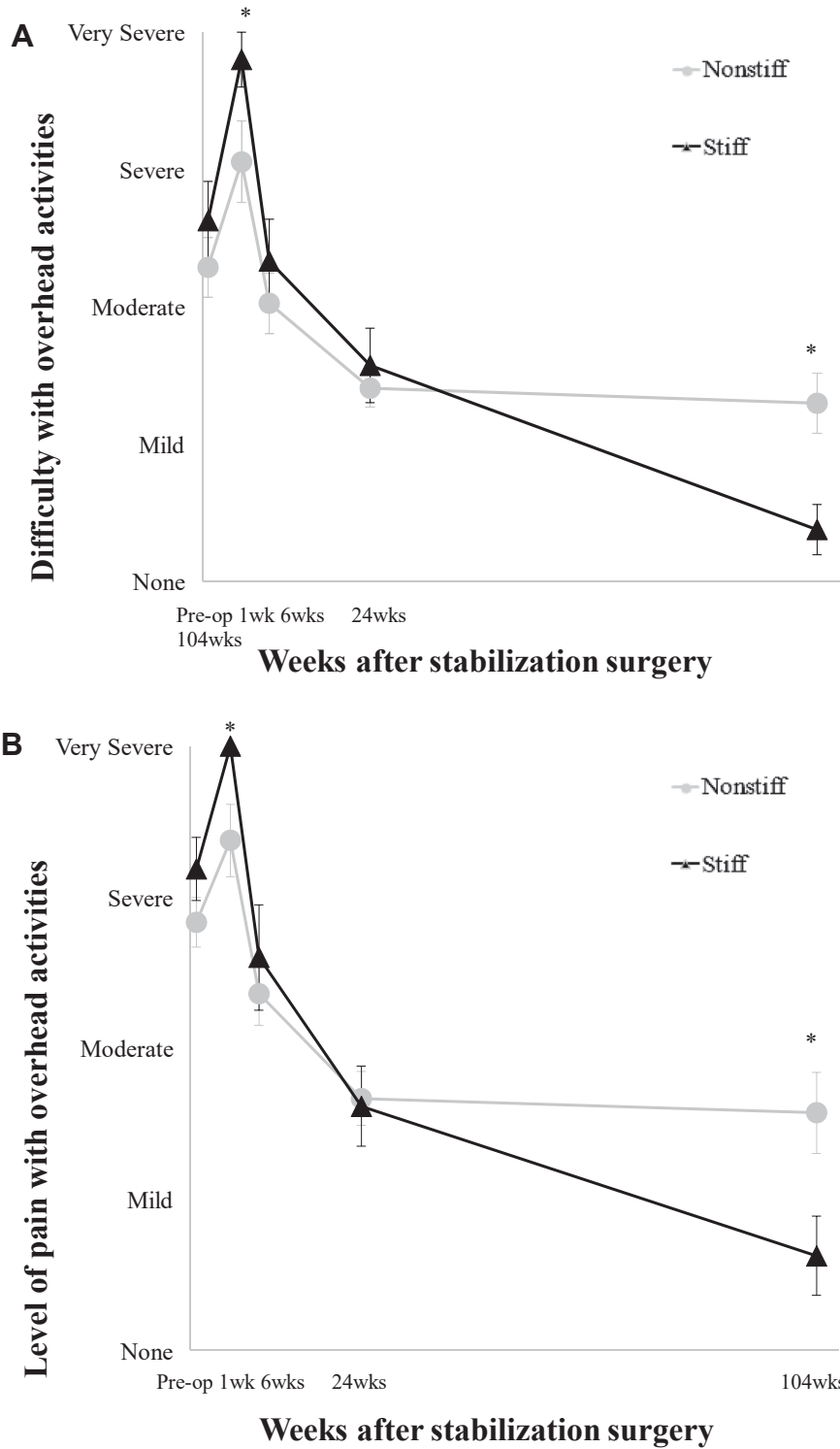


Figure 1 Difficulty with overhead activities (A) and level of shoulder pain (B) in isolated superior labrum anterior-posterior (SLAP) repair patients with $\leq 20^\circ$ of external rotation (stiff) and $>20^\circ$ of external rotation (non-stiff) at 6 weeks after repair. * $P < .05$ compared by Student 2-tailed t test. *Pre-op*, preoperatively.

likely a result of our classification of stiffness, as previous studies have not defined what constitutes postoperative stiffness. It is interesting to note that our rate of postoperative stiffness at 6 weeks in isolated SLAP repair

patients (27%) was comparable to the rate of stiffness reported in rotator cuff repair patients (23%-29%).^{6,10}

In patients undergoing SLAP repair, we found that postoperative stiffness resolved, with no difference in range

Table IV Average range of shoulder motion in SLAP repair patients with $\leq 20^\circ$ and $> 20^\circ$ of external rotation at 6 weeks after repair

	Preoperatively		Postoperatively			
	Stiff	Non-stiff	6 weeks		6 mo	
			Stiff	Non-stiff	Stiff	Non-stiff
FF, $^\circ$	153	156	116*	142*	163	164
ABD, $^\circ$	139	138	96	116	153	147
ER, $^\circ$	57	55	16*	49*	56	53
IR	L1	T12	L4*	L2*	T11	T11

SLAP, superior labrum anterior-posterior; FF, forward flexion; ABD, abduction; ER, external rotation; IR, internal rotation.

* $P < .05$ compared by Student 2-tailed t test.

of shoulder motion between the stiff and non-stiff groups by 6 months—findings similar to those in the 2009 case series by Brockmeier et al.² This result suggests that postoperative stiffness following SLAP repair is transient and will generally disappear by 6 months after surgery. Although postoperative stiffness after SLAP repair appears transient and beneficial in the long term, this may not be desirable for all patients, such as those wishing for an early return to sport.

Our study on SLAP repairs also has analogies to a previous study on rotator cuff repairs: McNamara et al.⁶ (2016) found that rotator cuff repair patients with $< 20^\circ$ of external rotation at 6 weeks after repair were less likely to have a re-tear on ultrasound at 6 months after surgery. In our study, SLAP repair patients with $\leq 20^\circ$ of external rotation at 6 weeks after repair had improved functional outcomes at ≥ 2 years postoperatively compared with non-stiff patients, particularly with overhead activities. The beneficial effect of postoperative stiffness on both rotator cuff repairs and SLAP repairs may be a sign that postoperative stiffness is a symptom of exuberant shoulder healing.

Finally, we found that patients who underwent isolated SLAP repair were more likely to report having a stiffer shoulder at 6 weeks after surgery if they were older, had higher preoperative pain with overhead activities, and had higher preoperative shoulder stiffness. Although our study shows that individuals with advancing age are more likely to report having a stiff shoulder after SLAP repair, we did not find that advancing age was an independent predictor of improved outcomes in the long term.

The strengths of this study were its clear inclusion and exclusion criteria and clear classification of postoperative stiffness: reduced external rotation, defined as $\leq 20^\circ$ of external rotation, at 6 weeks after surgery. The stiff group had less range of shoulder motion in almost every type of shoulder motion than the non-stiff group at 6 weeks postoperatively. The study also had high internal validity, with all labral tears being diagnosed and repaired by the same surgeon, although this may limit its applicability to external settings. Furthermore, all preoperative and postoperative patient data to 6 months were collected prospectively.

Several potential limitations of this study should be considered. The sample size in the stiff group was small, consisting of only 16 cases. Furthermore, we were unable to compare ≥ 2 -year range of shoulder motion because of an insufficient number of patients in the stiff group attending the ≥ 2 -year follow-up at the clinic. This was largely because of the demographic characteristics of the SLAP repair patients, with many individuals having moved away from the clinic or having commitments that prevented them from attending a clinic appointment. In addition, we were not able to determine whether stiffness influenced repair integrity as no postoperative imaging analysis was used in this study.

Conclusion

One-quarter of patients undergoing arthroscopic repair of SLAP tears had stiffness at 6 weeks postoperatively. Stiffness was more common in older patients who were experiencing more stiffness and pain with overhead activities preoperatively. In patients who underwent SLAP repair, early postoperative stiffness (at 6 weeks), while problematic early, is beneficial in the longer term as it is associated with less pain and less difficulty with overhead activities at ≥ 2 years after surgery. The data support the hypothesis that postoperative stiffness following SLAP repair is beneficial and likely represents an exuberant healing response that ultimately results in a better outcome, that is, friend rather than foe.

Disclaimer

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