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SHOULDER

Combined SLAP repair and biceps tenodesis for superior labral anterior–posterior tears

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Abstract
Purpose Long-head biceps tenodesis has been suggested as an alternative to superior labral anterior–posterior (SLAP) repair. However, an unrepaired superior labral tear may increase glenohumeral translation, and thus, labral repair may be considered in the setting of biceps tenodesis.
Methods Patients who underwent tenodesis, SLAP repair, or combined tenodesis and labral repair for SLAP tears were included. The indication for combined tenodesis and labral repair was biceps tendonitis in the setting of a SLAP lesion with labral instability. Demographics, range of motion, return to work, return to sport, American Shoulder and Elbow Surgeons (ASES) scores, and visual analogue pain scale (VAS) scores were recorded.
Results Eighty-six patients were included: 18 underwent combined tenodesis and labral repair, 45 underwent SLAP repair alone, and 23 underwent tenodesis alone. There were no significant differences in rates of return to pre-operative level of play (n.s.) or return to full duties at work (n.s.). These groups differed significantly in ASES scores ($p = 0.015$) and VAS scores ($p = 0.019$) with combined tenodesis and labral repair patients having lower scores than patients undergoing either tenodesis or SLAP repair alone. A subgroup analysis of patients who did not have Worker's Compensation claims demonstrated similar results with significant differences in ASES scores, which were lowest among the combined tenodesis and labral repair cohort ($p = 0.045$).
Conclusions High-demand patients with biceps tendonitis in the setting of a SLAP lesion with labral instability who undergo combined tenodesis and SLAP repair have significantly worse outcomes than patients who undergo either isolated labral repair for type II SLAP tears or isolated biceps tenodesis for a SLAP tear and biceps tendonitis.
Level of evidence Treatment, Level III.

Keywords Superior labral anterior–posterior tears · Biceps tenodesis · Worker's Compensation · Return to play

Introduction

Superior labral anterior–posterior (SLAP) tears, first described by Andrews et al. [2] and classified by Snyder et al. [19], are present in 26 % of shoulder arthroscopies [12]. SLAP tears may cause shoulder pain and disability [4, 6, 8]. A variety of treatments have been proposed for SLAP tears including non-operative treatment [8], debridement [18], repair of the SLAP tear [4, 6, 22], and biceps tenodesis [4, 9, 11]. Outcomes of SLAP repair have been mixed, with disappointing outcomes in athletes [4, 6, 8, 21, 22]. Return to play rates following SLAP repair have been cited at 73 %, with lower rates of return to play in overhead athletes at 22–64 % [10]. Reasons for failure include failure of labral healing, residual pain [1] from concomitant biceps tendonitis [11], stiffening of the labrum [20], and residual instability [6]. Recently, several authors have suggested tenodesis as an alternative to SLAP repair [4, 9, 11]. While

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some studies have found higher rates of return to play after tenodesis [4], others have not [9].

In cases in which tenodesis is performed, surgeons have typically not concomitantly repaired the superior labral tear [4, 9, 11]. Clinically, SLAP tears are associated with arthroscopic signs of glenohumeral instability, and biomechanical studies have demonstrated that SLAP tears are associated with increased humeral head translation [16, 17, 20]. Tears of the superior labrum cause more humeral head translation than biceps tenotomy alone [17, 20], suggesting that the superior labrum may play an important role in glenohumeral stability independent of the biceps tendon. These biomechanical findings support the "circle concept" [16] of instability and the concavity-compression mechanism [13]. Based on these findings, we have performed combined labral repair and tenodesis in high-demand patients with SLAP tears and clinical signs of bicipital tendonitis. However, the clinical outcomes of patients who undergo combined labral repair and tenodesis have not been previously described, and these patients have not been compared with those undergo tenodesis or SLAP repair. Describing the outcome of this procedure could assist in understanding the relative indications for tenodesis, SLAP repair, and combined tenodesis and labral repair.

The purpose of this study was to report clinical outcomes following combined tenodesis and labral repair in comparison with isolated tenodesis or SLAP repair in the treatment of SLAP lesions of the shoulder. The hypothesis was that combined tenodesis, and labral repair would result in improved clinical outcomes in comparison with isolated tenodesis or SLAP repair.

Materials and methods

This study was a retrospective comparative cohort study. The operative logs of the five senior authors were reviewed from 2004 until 2013. All patients who underwent tenodesis, isolated SLAP repair, or combined tenodesis and SLAP repair for treatment of a type I, II, III, or IV SLAP tear were included. Indications for tenodesis were any type of SLAP tear with pre-operative bicipital tendonitis symptoms (i.e. anterior shoulder pain and tenderness to palpation at the bicipital groove). Indications for combined tenodesis and labral repair were high-demand patients (i.e. athletes or overhead labourers) with a type II or IV SLAP lesion who were felt to be at risk of glenohumeral instability based on examination with pre-operative bicipital tendonitis symptoms (i.e. anterior shoulder pain and tenderness to palpation at the bicipital groove). SLAP repair alone was performed in patients with isolated type II SLAP lesions with no pre-operative biceps symptoms. Exclusionary criteria included patients with incomplete medical records, patients with partial or full-thickness rotator cuff tears, patients with <1-year follow-up, revision operative SLAP treatment, or extension of the labral tear into the anterior-inferior location, typical of Bankart tears [3].

Data collection

Data was recorded in Excel X (Microsoft, Redmond, WA.) In all cases, data were collected by an independent observer in a standardized fashion. Demographic and pre-operative data were collected (Table 1). Operative data were obtained concerning concomitant diagnoses and procedures, the method of bicipital fixation used, and SLAP subtype using the Snyder et al. [19] classification. Post-operative data included need for revision surgery and patient-reported ability to return to pre-injury level of work and sport where applicable. Rates of return to play are reported only for the athletic subgroup of each group as not all study participants were athletes and the groups differed in the number of athletes. The following clinical data were collected pre-operatively and at final follow-up: range of motion (ROM, reported to within 1°), the visual analogue pain scale (VAS, reported to within 0.1 mm) score, the simple shoulder test (SST, reported to within 0.1 points), and the American Shoulder and Elbow Surgeons (ASES, reported to within 1 point) score.

Surgical technique for combined tenodesis and labral repair and post-operative rehabilitation

Combined tenodesis and labral repair procedures were performed in both the lateral decubitus and beach chair positions depending upon the preference of the surgeon. An arthroscopic evaluation of the labrum and for impingement was conducted during a limited range of motion of the shoulder. Longitudinal traction was then placed on the arm. An anterior portal was created, and an 8.25-mm cannula was inserted. A biceps tenotomy was performed, and the superior labrum was assessed for stability. The lesional bed was debrided with a shaver and hooded burr. The labrum was fixed to the prepared rim of the glenoid either with a knotless suture anchor technique or with tied sutures from typical arthroscopic suture anchors. For the knotless technique, a suture passer was inserted through the anterior cannula and around the labrum. After passage, sutures were then brought through knotless anchors placed through a portal placed at the musculotendinous junction of the rotator cuff with a 5-mm metal cannula following drilling. For the knotted suture anchor technique, the anchors were first inserted percutaneously; the sutures passed around the labrum and then tied as far medially as possible to keep the knot stack away from the articular surface. All tenodesis procedures were performed with an open subpectoral

Table 1 Pre-operative and intra-operative data

Variable	Biceps tenodesis	SLAP repair	Combined labral repair and tenodesis	*p* value
Number of shoulders	23	45	18	Not applicable
Per cent male	63 %	68 %	82 %	n.s.
Per cent dominant extremity	100 %	61 %	59 %	0.006
Worker's Compensation	38 %	2 %	47 %	<0.001
Manual labourers	63 %	45 %	71 %	n.s.
Per cent athletes	25 %	59 %	74 %	0.001
Per cent overhead athlete	71 %	70 %	73 %	n.s.
Age (years)	45 ± 13 (19–67)	35 ± 13 (15–64)	39 ± 12 (13–52)	0.019
Simple shoulder test	6.5 ± 3.9	9.2 ± 1.7	8.4 ± 3.4	n.s.
ASES score	61 ± 26	69 ± 17	70 ± 12	n.s.
Visual analogue pain scale	3.8 ± 2.3	2.7 ± 2.1	5.1 ± 3.0	n.s.
Active forward elevation	134 ± 34	157 ± 39	153 ± 27	n.s.
External rotation in adduction	64 ± 19	61 ± 25	70 ± 17	n.s.
Internal rotation in abduction	56 ± 27	57 ± 15	66 ± 18	n.s.
Abduction	145 ± 31	150 ± 0	147 ± 34	n.s.
SLAP type				<0.001
I	13 (54 %)	0	0	
II	9 (38 %)	0 43 (100 %)	15 (88 %)	
III	1 (4 %)	0	0	
IV	1 (4 %)	0	2 (12 %)	

All continuous data are reported as mean ± standard deviation (range in selected cases)

Per cent overhead athletes are presented as a proportion of total number of athletes

ASES American Shoulder and Elbow Surgeons, *NS* not significant

approach utilizing a previously published surgical technique [14, 15]. In patients undergoing SLAP repair or tenodesis alone, surgical technique was the same as the aforementioned procedures.

Post-operatively, patients were immobilized in a sling for the first 4 weeks. For those undergoing SLAP repair, patients were allowed to begin limited range of motion immediately, but were instructed to avoid internal rotation to their back, external rotation behind their head, and resisted forward flexion for the first 4 weeks. At 6 weeks following surgery, patients began isometric strengthening advancing towards light weights at 8 weeks, eccentric resisted strengthening at 12 weeks, and sport-specific protocols thereafter. Overhead throwers began throwing at 4.5 months and began throwing from the mound at 6 months. After tenodesis, patients immediately began with ROM without limitations. For tenodesis and combined tenodesis and labral repair patients, a similar strengthening programme as was used for SLAP repair was employed, although patients avoided resisted elbow flexion or forearm supination for the first 4 weeks to protect the tenodesis [5].

This study was approved by the Rush University Medical Center Institutional Review Board as protocol # 11050602.

Statistical analysis

All statistical analyses were performed using SPSS 21 (IBM, Armonk, NY). Descriptive statistics were analysed and reported. Planned statistical analyses included Kolmogorov–Smirnov testing to analyse data normality and then analysis of variance (ANOVA) or Kruskal–Wallis tests as appropriate to compare pre-operative and post-operative demographics, ROM, VAS, SST, and ASES scores between SLAP repair, tenodesis, and combined tenodesis and labral repair groups. Post hoc Tukey's testing was employed as applicable. Categorical data were compared using Chi-square tests. A Pearson's correlation test was performed to determine whether number of anchors correlated with VAS, SST, or ASES scores within the SLAP repair and combined tenodesis and labral repair groups. As no previously published data exist regarding outcomes following combined tenodesis and labral repair, no a priori power analysis was possible, and thus, all possible patients were recruited. A post hoc subgroup analysis was performed to compare VAS, SST, and ASES scores in patients without a Worker's Compensation claim as this pre-operative factor has been linked to less successful outcomes [21].

Results

One hundred and sixty-eight patients met inclusion criteria. One patient was excluded due to incomplete medical records, five patients were excluded because they were revisions of prior SLAP repairs, and two were excluded for concomitant rotator cuff repair. Of the 160 patients who were eligible for the study, 44 % of the tenodesis group, 45 % of the SLAP repair group, and 51 % of the combined tenodesis and labral repair group were lost to follow-up for an overall 46 % loss to follow-up rate with no significant differences between groups (n.s.). There were several demographic differences between groups (Table 1). There were no significant differences in pre-operative SST, pre-operative ASES (Fig. 1), pre-operative VAS scores (Fig. 2), or pre-operative range of motion between groups. Distribution of SLAP types did significantly differ between groups. Among the tenodesis patients, 92 % of patients had an interference screw utilized for biceps tendon fixation, while a suture anchor was used in one patient and sutures tied over bone bridge in a "docking" technique was used in one patient. Among the combined tenodesis and labral repair patients, 78 % (16/18) of patients had an interference screw utilized for biceps tendon fixation, while a suture anchor was used in two patients (n.s.). Among the tenodesis group, 83 % had pre-operative tenderness to palpation at the bicipital groove, 17 % had signs of tendonitis in the groove on MRI as demonstrated by increased signal update within the bicipital sheath, and 74 % had intra-operative evidence of tenosynovitis extending into the groove. Among the combined tenodesis and labral repair group, 79 % had pre-operative tenderness to palpation at the bicipital groove, 21 % had signs of tendonitis in the groove on MRI as demonstrated by increased signal uptake within the bicipital sheath, and 64 % had intra-operative evidence of tenosynovitis extending into the groove. All patients within the both groups had one or more of these findings as an indication for the biceps tenodesis.

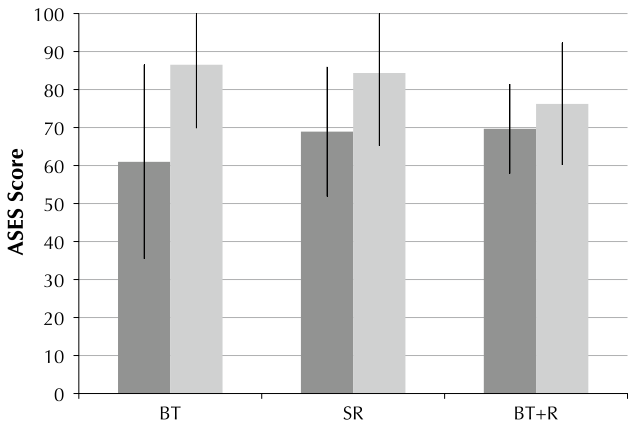

Fig. 1 Pre-operative and post-operative American Shoulder and Elbow Surgeons scores for the biceps tenodesis, superior labral repair, and combined tenodesis and labral repair groups. Data are reported as means with *error bars* representing one standard deviation. While there were no significant differences in pre-operative scores between groups (n.s.) post-operatively, the combined tenodesis and labral repair group had significantly worse ASES scores than the tenodesis and SLAP repair groups ($p = 0.015$)

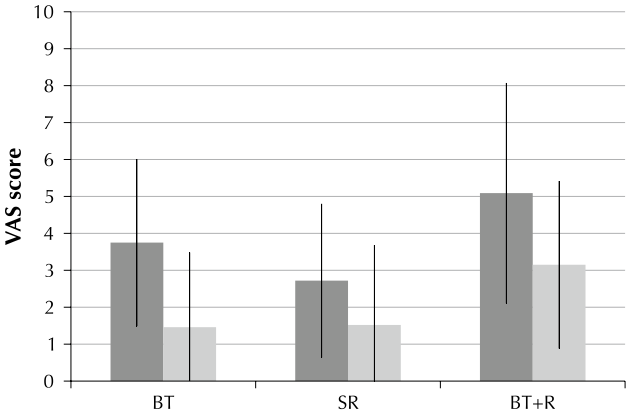

Fig. 2 Pre-operative and post-operative visual analogue pain scale (VAS) scores for the biceps tenodesis, superior labral repair, and combined tenodesis and labral repair groups. Data are reported as means with *error bars* representing one standard deviation. While there were no significant differences in pre-operative scores between groups (n.s.) post-operatively, the combined tenodesis and labral repair group had significantly worse VAS scores than the tenodesis and SLAP repair groups ($p = 0.019$)

Post-operatively, there were no significant differences in rates of return to pre-operative level of play, return to work, revision surgery, or post-operative SST (Table 2). Patient status-post tenodesis had significantly higher flexion than either the combined tenodesis and labral repair or SLAP repair cohorts. ASES scores significantly differed between groups ($p = 0.015$), with patients undergoing combined tenodesis and labral repair having lower ASES scores than those undergoing tenodesis or SLAP repair. VAS scores differed significantly between groups ($p = 0.019$), with patients undergoing combined tenodesis and labral repair having higher VAS scores than those undergoing tenodesis or SLAP repair. There were no significant differences between tenodesis and SLAP repair subgroups in SST, VAS, or ASES scores. Number of anchors did not correlate with any post-operative outcome measures (n.s.). A subgroup analysis of just those patients without Worker's Compensation status demonstrated significantly worse outcomes for combined tenodesis and labral repair than tenodesis or SLAP repair with significantly lower ASES scores (Table 3, $p = 0.045$) and higher VAS scores ($p = 0.016$). One patient (4 %) in the tenodesis group underwent reoperation with a subsequent arthroscopic lysis of adhesions and manipulation

Table 2 Post-operative data

Variable	Biceps tenodesis	SLAP repair	Combined tenodesis and labral repair	*p* value
Length of follow-up (years)	2.3 ± 0.9 (1.0–4.0)	4.1 ± 1.9 (1.0–4.9)	2.9 ± 1.4 (1.3–9.4)	<0.001
Return to pre-injury level of play	75 %	64 %	64 %	n.s.
Return to full duty at work	75 %	88 %	60 %	n.s.
Per cent requiring re-operation	4 %	18 %	22 %	n.s.
Simple shoulder test (SST)	9.4 ± 3.6	10.2 ± 2.8	8.7 ± 3.6	n.s.
ASES score	87 ± 17	84 ± 19	76 ± 16	n.s.
Visual analogue pain scale (VAS)	1.5 ± 2.0	1.5 ± 2.2	3.2 ± 2.3	0.019
Change in SST	3.8 ± 3.5	1.1 ± 3.5	−0.4 ± 5.9	n.s.
Change in ASES	26 ± 27	11 ± 21	2 ± 22	n.s.
Change in VAS	−2.7 ± 2.1	−0.8 ± 2.5	−1.5 ± 1.8	n.s.
Active forward elevation	180 ± 0	170 ± 16	165 ± 16	0.038
External rotation in adduction	80 ± 13	70 ± 12	65 ± 15	n.s.
Internal rotation in abduction	73 ± 32	71 ± 19	68 ± 20	n.s.
Abduction	168 ± 25	165 ± 27	160 ± 27	n.s.

All continuous data are reported as mean ± standard deviation (range in selected cases)

ASES American Shoulder and Elbow Surgeons

under anaesthesia. Four patients (22 %) in the combined tenodesis and labral repair group underwent reoperation including one arthroscopic repair of a humeral avulsion of the antero-inferior glenohumeral ligament, one arthroscopic revision labral repair, and two arthroscopic intra-articular debridements. Eight patients (18 %) in the SLAP repair group underwent reoperation including one intra-articular debridement, two biceps tenodeses, one biceps tenotomy, three revision SLAP repairs, and one rotator cuff repair of supraspinatus and subscapularis.

Discussion

The most important finding of the present study was that high-demand patients (i.e. athletes) who underwent combined tenodesis and labral repair for the indication of the presence of (1) a symptomatic SLAP lesion, (2) a risk of glenohumeral instability, and (3) pre-operative bicipital tendonitis symptoms trended towards lower ASES scores had significantly worse active forward flexion and had significantly higher pain scores. However, this group did not differ in rates of return to play or return to work when compared to patients who underwent either SLAP repair or tenodesis alone. In the subgroup of patients without a Worker's Compensation claim, both ASES and VAS scores were significantly lower among the combined tenodesis and labral repair cohort when compared to SLAP repair or tenodesis alone. The authors' pre-operative indications for these procedures differed, and these groups differed in demographics and levels of demand.

Whether these findings are pathology or treatment mediated remains unclear. Several theories exist to potentially explain these results. The native laxity within the superior labrum may be poorly restored by SLAP repair. Alternatively, the labral repair may fail to heal, creating pain. Alternatively, high-demand patients with both bicipital tendonitis and labral or glenohumeral instability in association with a SLAP tear may have worse outcomes regardless of whether labral repair is performed concomitant with tenodesis.

Previous studies are in conflict as to whether SLAP repair or tenodesis provides superior outcomes in the treatment of SLAP tears. While a prospective comparative trial demonstrated significantly higher rates of return to play and superior outcomes with tenodesis in a European patient population with an average age close to 40 years old [4], two recent retrospective trials show no differences between tenodesis and SLAP repair [7, 9]. Although the purpose of this study was not specifically to address differences in outcome between tenodesis and SLAP repair, no difference was found between tenodesis and SLAP repair in return to play, return to work, pain, or functional outcomes.

Strengths of the study include a comparative design, a relatively large patient cohort, the use of validated objective outcome measures. However, this study has several important limitations. As with all retrospective case series, loss of follow-up can create a distorted image of the results. Given that rates of loss to follow-up were identical across patient groups, we do not expect that this differentially affects one group over another. Many of these patients are young and mobile, and thus,

Table 3 Data for the subgroup of patients without Worker's Compensation

Variable	Biceps tenodesis	SLAP repair	Combined tenodesis and labral repair	*p* value
Pre-operative				
N	15	43	29	
Per cent male	53 %	67 %	67 %	n.s.
Per cent dominant extremity	100 %	56 %	67 %	0.023
Manual labourers	40 %	44 %	44 %	n.s.
Per cent athletes	40 %	76 %	88 %	0.004
Per cent overhead athlete	83 %	73 %	75 %	n.s.
Age (years)	44 ± 16	35 ± 13	33 ± 12	n.s.
Length of follow-up (years)	2.5 ± 1.0	4.1 ± 1.9	2.2 ± 1.3	0.001
Simple shoulder test	7.3 ± 3.8	9.4 ± 1.7	8.5 ± 3.9	n.s.
ASES score	63 ± 25	72 ± 11	73 ± 13	n.s.
Visual analogue pain scale	3.6 ± 2.1	2.5 ± 1.8	5.4 ± 3.0	0.018
Active forward elevation	140 ± 38	158 ± 28	159 ± 28	n.s.
External rotation in adduction	65 ± 20	68 ± 17	81 ± 7	n.s.
Internal rotation in abduction	70 ± 14	57 ± 15	72 ± 15	n.s.
Abduction	163 ± 15	150 ± 0	158 ± 30	n.s.
Post-operative				
Return to pre-injury level of play	75 %	67 %	64 %	n.s.
Per cent requiring re-operation	0 %	19 %	22 %	n.s.
Simple shoulder test	10.0 ± 2.9	10.4 ± 2.6	9.0 ± 3.7	n.s.
ASES score	87 ± 18	86 ± 17	72 ± 17	0.045
Visual analogue pain scale	1.1 ± 1.8	1.3 ± 1.8	4.1 ± 2.7	0.016
Active forward elevation	180 ± 0	172 ± 10	169 ± 11	n.s.
External rotation in adduction	84 ± 10	70 ± 12	74 ± 14	n.s.
Internal rotation in abduction	85 ± 25	71 ± 19	69 ± 21	n.s.
Abduction	180 ± 0	167 ± 25	167 ± 16	n.s.

All continuous data are reported as mean ± standard deviation

Per cent overhead athletes are presented as a proportion of total number of athletes

ASES American Shoulder and Elbow Surgeons

achieving high levels of follow-up can be very difficult. This issue plagues much of the literature on this subject, although it may not be universally acknowledged. A larger sample size and longer follow-up could alter our results. However, given the large differences between groups at early follow-up, we felt these results warranted publication so that other surgeons will employ caution when considering combined tenodesis and labral repair. In addition, given that this is a cohort study and not a randomized clinical trial, selection bias certainly exists between cohorts, as reflected by pre-operative differences between cohorts, differences in age, differences in SLAP types, variations in indications, variations in the use of knotted vs. knotless anchors, and variations in post-operative protocols. This bias also exists in prior comparative trials and much of the literature on this subject—for instance in the most frequently cited comparative trial by Boileau et al. [4]. Significant baseline differences exist between groups. Each treatment option was selected based on individual interpretation of pathology, likely creating significant differences between groups given that multiple surgeons were included, which increases externally generalizability while decreasing internal consistency. The sensitivity and specificity of tenderness to palpation at the bicipital groove as a marker for bicipital tendonitis remain unknown. Similarly, no validation was performed of the surgeons' intra-operative assessment of the SLAP classification, which may be subject to significant intra- and inter-surgeon variability. Our conclusions are thus limited to our ability to describe outcomes within each of the three different SLAP treatment methodologies with these surgical indications. For definitive recommendations, a randomized clinical trial would be necessary and to achieve adequate study power, a multi-centre effort may be required.

Conclusion

High-demand patients with biceps tendonitis in the setting of a SLAP lesion with labral instability who undergo combined tenodesis and labral repair have significantly worse outcomes than patients who undergo either isolated labral repair for type II SLAP tears or isolated biceps tenodesis for a SLAP tear and biceps tendonitis.

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