

Primary Biceps Tenodesis Is Superior to Revision Following Failed SLAP Repair



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Purpose: To compare satisfaction and return to play (RTP) rates between patients undergoing primary biceps tenodesis for a symptomatic SLAP tear and patients undergoing secondary biceps tenodesis following a failed SLAP repair. **Methods:** A retrospective review of patients who underwent subpectoral mini-open biceps tenodesis following failed SLAP repair between January 2011 and October 2019 was performed. Inclusion criteria included age older than 16 years, skeletal maturity, and a minimum follow-up of 12 months. Both athletes and nonathletes were included across all types of sport. Patients who had anterior or posterior instability or rotator cuff tears were excluded; in addition, those requiring concomitant procedures were excluded. Case–control matching was performed using age, sex, indication, follow-up, and type of sport, to generate a 3:1 control group for the primary biceps tenodesis cohort. Primary outcome measurements were collected via telephone in 2020 and included the American Shoulder and Elbow Surgeons score, visual analog scale score, Subjective Shoulder Value score, patient satisfaction, willingness to undergo surgery again, and revisions. RTP and timing of RTP were evaluated as secondary outcomes. A P value of $<.05$ was considered to be statistically significant. **Results:** The current study included 76 patients in total; 57 patients with primary biceps tenodesis, and 19 patients with secondary biceps tenodesis. The mean age was 39 years (19–48 years), 100% were male, and the mean follow-up was 54 months (16–99 months). Patient reported outcomes were obtained postoperatively via telephone survey. Overall, we found that primary biceps tenodesis patients reported greater American Shoulder and Elbow Surgeons scores (89.9 vs 76.4, $P = .0162$), lower visual analog scale scores (1.0 vs 3.1, $P = .0034$), and greater Subjective Shoulder Value scores (86.7 vs 64.7, $P = .0004$). Overall, there was no significant difference in the total rate of RTP (84% vs 75%, $P = .5025$), or timing of RTP (8.2 months vs 8.1 months, $P = .9529$) between patient groups. Patients reported playing tennis, swimming, golf, rock climbing, and basketball. No patients required a further shoulder surgery after undergoing biceps tenodesis. **Conclusions:** In this study, patients undergoing primary biceps tenodesis had significantly better functional outcomes compared with secondary biceps tenodesis following a failed SLAP repair. **Level of Evidence:** III, retrospective comparative study.

SLAP tears are a common shoulder pathology seen in up to a quarter of those undergoing shoulder arthroscopy.^{1,2} SLAP tears are often the result of traumatic events and overuse, as seen in athletes and manual workers. SLAP lesions involving the biceps–labral complex are the most common subtype of SLAP tear.² Arthroscopic repair of the SLAP lesion is an attractive option, particularly in athletes and in

younger patients, as it maintains the patients' anatomy. However, SLAP repair has been associated with sub-optimal patient satisfaction, a risk of postoperative stiffness, and high rates of failure, particularly in overhead athletes.^{3–5}

SLAP repair is a commonly used surgical intervention for symptomatic SLAP tears. There was a 464% increase in the number of SLAP repairs between 2002

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The authors report the following potential conflicts of interest or sources of funding: K.A.C. reports grants from Mitek, Samumed, and Stryker, outside the submitted work. E.J.S. reports grants from Arthrex, BetterPT, CartiHEAL, Fidia, Flexion Therapeutics, JRF, Organogenesis, Smith & Nephew, Subchondral Solutions, and Vericel, outside the submitted work. L.M.J. reports grants from Arthrex, Mitek, and Smith & Nephew, outside the submitted work. Full ICMJE author disclosure forms are available for this article online, as [supplementary material](#).

Received October 16, 2021; accepted August 18, 2022.

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<https://doi.org/10.1016/j.asmr.2022.08.006>

and 2010, underscoring the popularity of this arthroscopic procedure. Moreover, there has been an increase in the mean age of patients being treated with SLAP repair, despite studies demonstrating that patients older than 36 years of age experience greater rates of failure. More recently, Cvetanovich et al.⁶ observed a decline in arthroscopic SLAP repair for the treatment of SLAP tears. Boileau et al.⁷ was the first to describe biceps tenodesis as an alternative to repair of SLAP lesions. Since then, biceps tenodesis has been gaining popularity as a primary surgical option for symptomatic SLAP tears, particularly in patients older than the age of 35 years.^{6,8} In a meta-analysis, Hurley et al.³ found that biceps tenodesis resulted in greater patient satisfaction, return to play (RTP) in athletes, and lower revision rates compared with SLAP repair.

Nadeem et al.⁹ found in their systematic review on the management of failed SLAP repair that biceps tenodesis was the most commonly used procedure, performed in 112 of their 176 included patients. In addition, the authors found that biceps tenodesis resulted in better surgical outcomes than those treated with revision SLAP repair. Despite this, there is still a dearth of literature on how those undergoing biceps tenodesis as a revision procedure compare with those undergoing biceps tenodesis as a primary procedure in the management of superior labral pathology. The purpose of this study was to compare patient satisfaction and RTP rates between patients undergoing primary biceps tenodesis for a symptomatic SLAP tear and patients undergoing secondary biceps tenodesis following a failed SLAP repair. Our hypothesis was that patients undergoing primary biceps tenodesis would experience better functional outcomes, greater rates of RTP, and greater satisfaction scores when compared with patients who underwent secondary biceps tenodesis following a failed SLAP repair.

Methods

Patient Selection

After approval from our institutional review board, a retrospective review was carried out to identify all patients who had a failed SLAP repair and underwent revision biceps tenodesis between January 2011 and October 2019. We included all patients who underwent biceps tenodesis and were of age >16 years at the time of surgery, had a previous isolated SLAP repair that required revision, were skeletally mature, and had a minimum follow-up of 12 months. SLAP tears were diagnosed via magnetic resonance imaging. Patients who had anterior or posterior instability or rotator cuff tears were excluded; in addition, those requiring concomitant procedures were excluded. Indications for biceps tenodesis in both cohorts were recorded. Case-control matching was performed using age, sex,

indication, follow up, and type of sport, to generate a 3:1 control group for the primary BT cohort.

Data Collection and Clinical Outcomes

Data on patient characteristics and preoperative demographics were collected, with intraoperative and postoperative complications recorded. Evaluation of postoperative patient-reported outcomes was carried out following postoperative telephone survey in 2020, including visual analog scale (VAS) score, Subjective Shoulder Value (SSV) score, American Shoulder and Elbow Surgeons (ASES) score, satisfaction, and whether they would undergo the same surgery again. In addition, the rate and timing of RTP and VAS during Sport were evaluated as secondary outcomes, with subgroup analysis among athletes. Athletes were defined as those participating in sport preoperatively. RTP was defined as the athletes' returning to their sport at their previous level of competition. Finally, complications and revision surgeries were recorded.

Statistical Analysis

All statistical analysis was performed using GraphPad Prism 8.3 (GraphPad, La Jolla, CA). For all continuous and categorical variables, descriptive statistics were calculated. Continuous variables were reported as weighted mean and estimated standard deviation, whereas categorical variables were reported as frequencies with percentages. Categorical variables were analysed using the Fisher exact or χ^2 test. The independent or paired *t*-test for normally distributed variables, or the nonparametric Mann-Whitney *U* test or Wilcoxon signed-rank test was performed to compare continuous variables. A value of $P < .05$ was considered to be statistically significant.

Surgical Technique (With Video Illustration)

Biceps Tenodesis

A standard mini-open subpectoral biceps tenodesis was performed as has been previously described.¹⁰ Patients underwent an interscalene nerve block and were positioned in the lateral decubitus or beach-chair position per the surgeon's preference (6 surgeons total). Standard posterior and anterosuperior arthroscopic portals were created, and a diagnostic arthroscopy was performed. After confirming the SLAP tear with biceps-labral complex involvement (types II-IV), a biceps tenotomy was performed. In the case of lateral decubitus positioning, the arm was removed from traction and inserted into an impervious sleeve to maintain sterility. The shoulder was then abducted and externally rotated, and an axillary-based incision along the inferior border of the pectoralis major muscle was used. Blunt dissection was performed down to the clavipectoral fascia, which was incised sharply. The long

Table 1. Patient Demographics

	Primary BT	Secondary BT	<i>P</i> Value
N	57	19	—
Age, y	39 ± 8.1	40 ± 8.6	.647
Sex (male %)	57 (100%)	19 (100%)	>.99
Athletes	31 (54%)	12 (63%)	.504
Follow-up, mo	52.8 ± 21.6	56.4 ± 22.8	.536

BT, biceps tenodesis.

head of the biceps tendon was then identified and retrieved out of the incision. A looped high-strength suture was then passed in a retrograde fashion through the tendon starting just distal to the musculotendinous junction and locked proximally. A cortical button construct was used for fixation in all cases.

Rehabilitation Protocol

The postoperative rehabilitation protocol generally consisted of a short period of shoulder immobilization in a sling (minimum 2-week period), followed by a progressive shoulder range-of-motion and strengthening protocol. Progressive biceps strengthening was permitted at 8 weeks postoperatively. A sport-specific training program was initiated once full range-of-motion and strength was achieved, and patients were permitted to RTP after 6 months, once they met all rehabilitation criteria.

Results

Patient Demographics

Overall, 23 patients were identified who had undergone secondary biceps tenodesis following a failed SLAP repair, with 19 (82.6%) available for follow-up. In total, 57 patients with primary biceps tenodesis were identified via case–control matching. There were no significant differences in demographic variables between the groups. The average time to revision biceps tenodesis after primary SLAP repair was 19 months (range 15–26 months). There were no significant differences in mean follow-up time between primary and secondary biceps tenodesis groups (52.8 ± 21.6 vs 56.4 ± 22.8 months; *P* = .536). Sporting activities included tennis, swimming, golf, rock climbing, and basketball. Indications for biceps tenodesis in both primary and revision cohorts were pain and/or stiffness. A comparison of patient demographics between primary biceps tenodesis and secondary groups is further illustrated in [Table 1](#).

Functional Outcomes

There was a statistically significant difference between those that underwent primary biceps tenodesis and secondary biceps tenodesis in terms of the ASES score, in favor of patients treated with a primary biceps tenodesis (89.9 vs 76.4, *P* = .01). Primary biceps

tenodesis patients were also found to have significantly lower VAS scores (1.0 vs 3.1, *P* = .003) and greater SSV scores (86.7 vs 64.7, *P* ≤ .001). There was no statistically significant difference between groups in terms of satisfaction, (84.8% vs 74.1%, *P* = .17), or whether they would undergo surgery again (77% vs 63%, *P* = .23). A comparison of patient-reported outcomes between the groups is shown in [Table 2](#).

Return to Play

Overall, there was no significant difference in the total rate of RTP (84% vs 75%, *P* = .502), timing of RTP (8.2 months vs 8.1 months, *P* = .95), or VAS during sports (1.7 vs 3.3, 06). A comparison of RTP outcomes between the groups is shown in [Table 3](#).

Complications and Revisions

There were no complications in either group, and no patients required additional surgery.

Discussion

The most important finding from this study is that patients undergoing primary biceps tenodesis for SLAP tears had significantly better functional outcomes compared with patients undergoing revision biceps tenodesis following a failed SLAP repair, consistent with our hypothesis. Both patients who underwent primary and revision biceps tenodesis reported high satisfaction as well as a high rate of willingness to undergo the same procedure again if required. No patients undergoing primary or revision biceps tenodesis required further shoulder surgery. With regard to functional outcomes, primary biceps tenodesis should be strongly considered over a primary SLAP repair, particularly in those at high-risk for failure following SLAP repair.

SLAP lesions are a common shoulder pathology, associated with significant levels of pain and disability. Lesions involving the biceps–labral complex account for the majority of SLAP tears indicated for surgical intervention, with SLAP repair serving as the current gold standard for treatment of SLAP lesions. Erickson et al.¹¹ found that 93% of Major League Baseball team orthopaedic surgeons would treat a SLAP tear with a SLAP repair, and that none would perform a primary biceps tenodesis. As such, biceps tenodesis has been

Table 2. Functional Outcomes

	Primary BT	Secondary BT	<i>P</i> Value
ASES	89.9 ± 19.2	76.4 ± 24.8	.016
VAS	1 ± 2.5	3.2 ± 3.4	.003
SSV	86.7 ± 16.6	64.7 ± 34.8	<.001
Satisfaction	84.8 ± 27.9	74.1 ± 31.7	.166
Would undergo surgery again	44 (77%)	12 (63%)	.228

ASES, American Shoulder and Elbow Surgeons Score; BT, biceps tenodesis; SSV, subjective shoulder value; VAS, visual analog scale.

Table 3. Return to Play

	Primary BT	Secondary BT	<i>P</i> Value
Return to play	26 (84%)	9 (75%)	.502
Return to play time	8.2 ± 4.2	8.1 ± 4	.952
VAS during sport	1.7 + 2.9	3.3 ± 3.6	.064

BT, biceps tenodesis; VAS, visual analog scale.

largely reserved as a salvage procedure following failed primary SLAP repair in younger patients, particularly as revision SLAP repairs have demonstrated poor results in the literature. Park and Glousman¹² evaluated 12 patients between the ages of 19 and 67 years (mean age 32.6 years) who underwent revision SLAP repair and found that the mean satisfaction score was 6.4 of 10 and that only 42.2% of patients were able to return to sport at their previous level, with none of the baseball players capable of returning. In contrast, McCormick et al.¹³ evaluated 46 patients (mean age 39.2 ± 6.1 years) following a biceps tenodesis as a revision procedure for failed SLAP repair and found that at a mean follow-up of 3.6 years, there were improvements across all measurements of functional outcomes including ASES score and satisfaction. It was also reported that compared to primary SLAP repair, revision of a failed SLAP repair with biceps tenodesis demonstrated no difference in rates of return to military duty in active-duty service members.

SLAP repair is compelling as a primary surgical option for its anatomic-preserving nature, in contrast with biceps tenodesis. Recent studies, however, have increasingly demonstrated high rates of complications and poor outcomes associated with primary SLAP repair. Provencher et al.¹⁴ reviewed 179 patients who underwent SLAP repair and found that 28% required a revision procedure, with patient age >36 years associated with a greater risk of treatment failure. Boileau et al.⁷ demonstrated that 60% of patients who underwent primary SLAP repair experienced persistent pain, and only 20% were able to RTP to sports at their pre-surgical level of competition. Conversely, 87% of the primary biceps tenodesis cohort was able to return to their pre-surgical level of competition, and 93% were satisfied with their procedure. In addition, Katz et al.⁴ reported that 55% of patients were unable to return to their presurgical level of athletic activity following SLAP repair, and 37% of patients were not satisfied with the outcome of their procedure. Furthermore, Hurley et al.³ reported in their meta-analysis that biceps tenodesis resulted in greater rates of patient satisfaction and return to sport in the studies published in the literature, with slightly lower rates of revision surgery. Therefore, biceps tenodesis has slowly been gaining popularity as a procedure for the primary treatment of SLAP tears.¹⁵

Nadeem et al.⁹ found in their systematic review on the management of failed SLAP repair that biceps tenodesis was the most commonly used procedure and resulted in better surgical outcomes than those treated with revision SLAP repair. However, there is still a dearth of literature with low patient numbers and no studies comparing those managed with a primary and secondary biceps tenodesis. The data in the current study demonstrate that primary biceps tenodesis is associated with better functional outcomes and less pain relative to a biceps tenodesis as a revision procedure following a failed SLAP repair. This finding echoes previous literature, which has shown revision procedures being commonly associated with poorer outcomes than primary procedures in orthopaedics.^{16,17} Primary biceps tenodesis also was associated with greater rates of RTP and less pain experienced during sport as measured in our subset of athletes, although not statistically significant. Therefore, in those who may be at high risk for failure following a SLAP repair, including those older than the age of 40 years, individuals with obesity, smokers, and those with biceps tendinitis or tearing of the long head of the biceps, a primary biceps tenodesis should be strongly considered as those who require revisions ultimately have less successful outcomes when compared with patients who underwent biceps tenodesis as the index procedure.⁹ Revision SLAP repair may be still considered in particular circumstances, such as with younger, active patients with no biceps pathology as well as in those concerned about potential cosmetic deformity, but further study is still required on this topic. In addition, while the evidence is compelling to do a primary biceps tenodesis, there is still potential problems with biceps tenodesis, including pain in the bicipital groove. However, this may be minimized with a subpectoral tenodesis, as this has been shown to have a lower rate of bicipital groove pain compared with bicipital groove or intra-cuff tenodesis.^{18,19}

Limitations

This study is not without limitations. This was a retrospective analysis and was thus subject to biases and confounders. In addition, all the revision procedures at the institution were performed on male patients, and the sample size of secondary biceps tenodesis included only 19 patients. We were not able to obtain baseline or pre-operative patient reported outcomes, as the phone survey was conducted years following the procedure. The patient-reported outcomes were only collected at a single follow-up time point, and the preoperative physical examination data were missing. As such, we were unable to calculate measures of clinical relevance. Finally, we did not examine patients in person at the time of the last follow-up due to current limitations in bringing patients back during the current pandemic.

Conclusions

In this study, patients undergoing primary biceps tenodesis had significantly better functional outcomes compared with secondary biceps tenodesis following a failed SLAP repair.

References

1. Kim TK, Queale WS, Cosgarea AJ, McFarland EG. Clinical features of the different types of SLAP lesions: An analysis of one hundred and thirty-nine cases. *J Bone Joint Surg Am* 2003;85:66-71.
2. Snyder SJ, Karzel RP, Del Pizzo W, Ferkel RD, Friedman MJ. SLAP lesions of the shoulder. *Arthroscopy* 1990;6:274-279.
3. Hurley ET, Fat DL, Duigenan CM, Miller JC, Mullett H, Moran CJ. Biceps tenodesis versus labral repair for superior labrum anterior-to-posterior tears: A systematic review and meta-analysis. *J Shoulder Elbow Surg* 2018;27:1913-1919.
4. Katz LM, Hsu S, Miller SL, et al. Poor outcomes after SLAP repair: Descriptive analysis and prognosis. *Arthroscopy* 2009;25:849-855.
5. Sayde WM, Cohen SB, Ciccotti MG, Dodson CC. Return to play after type II superior labral anterior-posterior lesion repairs in athletes: A systematic review. *Clin Orthop Rel Res* 2012;470:1595-1600.
6. Cvetanovich GL, Gowd AK, Frantz TL, Erickson BJ, Romeo AA. Superior labral anterior posterior repair and biceps tenodesis surgery: Trends of the American Board of Orthopaedic Surgery Database. *Am J Sports Med* 2020;48:1583-1589.
7. Boileau P, Parratte S, Chuinard C, Roussanne Y, Shia D, Bicknell R. Arthroscopic treatment of isolated type II SLAP lesions: Biceps tenodesis as an alternative to reinsertion. *Am J Sports Med* 2009;37:929-936.
8. Erickson BJ, Jain A, Abrams GD, et al. SLAP lesions: Trends in treatment. *Arthroscopy* 2016;32:976-981.
9. Nadeem IM, Vancolen S, Horner NS, Leroux T, Alolabi B, Khan M. Management of failed SLAP repair: A systematic review. *HSS J* 2020;16:261-271.
10. Baron SL, Shamah S, McGee AW, Alaia MJ, Feldman AJ, Jazrawi LM. Clinical outcomes of open subpectoral biceps tenodesis with cortical button fixation. *Bull Hosp Jt Dis (2013)* 2019;77:238-243.
11. Erickson BJ, Harris JD, Fillingham YA, et al. Treatment of ulnar collateral ligament injuries and superior labral tears by Major League Baseball team physicians. *Arthroscopy* 2016;32:1271-1276.
12. Park S, Glousman RE. Outcomes of revision arthroscopic type II superior labral anterior posterior repairs. *Am J Sports Med* 2011;39:1290-1294.
13. McCormick F, Nwachukwu BU, Solomon D, et al. The efficacy of biceps tenodesis in the treatment of failed superior labral anterior posterior repairs. *Am J Sports Med* 2014;42:820-825.
14. Provencher MT, McCormick F, Dewing C, McIntire S, Solomon D. A prospective analysis of 179 type 2 superior labrum anterior and posterior repairs: Outcomes and factors associated with success and failure. *Am J Sports Med* 2013;41:880-886.
15. Hurley ET, Pauzenberger L, Mullett H. Editorial Commentary: Which to fix—the biceps or the labrum? The shoulder SLAP tear is still controversial. *Arthroscopy* 2019;35:1939-1940.
16. Shamsudin A, Lam PH, Peters K, Rubenis I, Hackett L, Murrell GA. Revision versus primary arthroscopic rotator cuff repair: A 2-year analysis of outcomes in 360 patients. *Am J Sports Med* 2015;43:557-564.
17. Yan X, Yang XG, Feng JT, Liu B, Hu YC. Does revision anterior cruciate ligament (ACL) reconstruction provide similar clinical outcomes to primary ACL reconstruction? A systematic review and meta-analysis. *Orthop Surg* 2020;12:1534-1546.
18. Anil U, Hurley ET, Kingery MT, Pauzenberger L, Mullett H, Strauss EJ. Surgical treatment for long head of the biceps tendinopathy: A network meta-analysis. *J Shoulder Elbow Surg* 2020;29:1289-1295.
19. Hurley DJ, Hurley ET, Pauzenberger L, Lim Fat D, Mullett H. Open compared with arthroscopic biceps tenodesis: A systematic review. *JBJS Rev* 2019;7:e4.