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REVIEW ARTICLE

Biceps tenodesis versus labral repair for superior labrum anterior-to-posterior tears: a systematic review and meta-analysis



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Background: This study systematically reviewed the comparative studies in the literature to ascertain whether biceps tenodesis or labral repair results in superior clinical outcomes in the treatment of superior labrum anterior-to-posterior (SLAP) tears.

Methods: A systematic search of articles in PubMed, EMBASE and The Cochrane Library databases was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. Cohort studies of biceps tenodesis compared with labral repair of SLAP tears were included. Statistical analysis was performed using Review Manager software (The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark). A *P* value of <.05 was considered to be statistically significant.

Results: Included were 5 studies with 234 patients. Biceps tenodesis resulted in improved rates of patient satisfaction (95.6% vs. 76.2%, *P* = .01) and rate of return to sport (81.3% vs. 64.3%, *P* = .02), compared with SLAP repair. Although the difference in reoperation rates was not statistically significant, there was a trend toward higher reoperation rates in patients treated with SLAP repair (14.2% vs 6.5%, *P* = .09). In addition, there was no difference in complication rates or functional outcomes.

Conclusion: Our study found that biceps tenodesis resulted in higher rates of patient satisfaction and return to sport in the studies published in the literature and that biceps tenodesis and SLAP repair resulted in similar functional outcome scores.

Level of evidence: Level III; Systematic Review/Meta-Analysis

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Keywords: Biceps; repair; meta-analysis; tenodesis; superior labral anterior-posterior; systematic review

This study was a meta-analysis of the literature and did not require Institutional Review Board approval.

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Superior labrum anterior-to-posterior (SLAP) tears were first described by Andrews et al² in 1985 and have been reported to be present in up to 26% of shoulder arthroscopies.¹⁷ Although the exact cause of SLAP tears is unknown, they are often related to traumatic events and sports activity,

particularly overhead sports such as baseball.²⁹ Type II SLAP tears, which are characterized by superior labral fraying with a detached biceps anchor, are the most common subtype, based on the classification by Snyder et al.²⁷ Surgical treatment options include SLAP repair, biceps tenodesis, biceps tenotomy, and débridement.

Arthroscopic SLAP repair is the most commonly performed procedure for SLAP tears.^{10,22} A recent survey of Major League Baseball (MLB) physicians found that 93% would repair a symptomatic SLAP tear when they have decided on surgical management.⁹ However, results remain disappointing.^{11,24,26} A recent systematic review by Sayde et al²⁴ found that only 63% of overhead athletes and 73% of all athletes return to sport after SLAP repair. Other studies have found the rate of return to sport is 20% to 86% in athletes treated with SLAP repair.^{3,7}

Biceps tenodesis has been gaining popularity as a primary surgical option for SLAP tears, rising from less than 2% of procedures in 2002 to close to 20% in 2011. A recent biomechanical study that looked at the alteration of throwing motions compared with controls after biceps tenodesis vs. SLAP repair showed that biceps tenodesis results in less altered throwing motions.⁶ Biceps tenodesis can be performed via an open or arthroscopic approach, and both are commonly used to treat SLAP tears.^{1,22}

As a result of the various treatment options available for SLAP tears, the optimal management remains controversial. This study systematically reviewed the comparative studies in the literature to ascertain whether biceps tenodesis or labral repair results in superior clinical outcomes in the treatment of SLAP tears. Our hypothesis was that biceps tenodesis would result in superior patient-reported outcomes, higher rates of return to sport, and a lower reoperation rate.

Materials and methods

Search strategy and study selection

Two independent reviewers (E.T.H. and C.M.D.) performed a literature search following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines and reviewed the search results, with a senior author (C.J.M.) arbitrating in the event of a disagreement.¹⁹ The following search terms were used in PubMed, EMBASE and The Cochrane Library databases from their inception to April 17, 2017: (tenodesis *and* repair) *and* (SLAP *or* superior labral anterior-posterior). The title and abstract were reviewed for all of the studies identified by the search strategy, and then the full texts were reviewed. The references of all included studies and all of the literature reviews found were subsequently screened for additional articles meeting the inclusion criteria.

Eligibility criteria

The inclusion criteria were (1) comparative studies comparing biceps tenodesis with SLAP repair in SLAP tears, (2) minimum 1-year follow-up, (3) published in a peer reviewed journal, (4) published

in English or full translation freely available, and (5) full text of studies available. The exclusion criteria were (1) associated rotator cuff tear, (2) case series, (3) review studies, (4) cadaveric studies, (5) biomechanical studies, or (6) abstract only.

Data extraction

All relevant information was collected by 2 independent reviewers using a predetermined data sheet on Excel software (Microsoft, Redmond, WA, USA). When required information was not available in the text, the authors were contacted via email. The level of evidence (LOE) was assessed using the criteria from the Oxford Centre for Evidence-Based Medicine. The methodological quality of the evidence (MQOE) was assessed using the Newcastle-Ottawa scale, a 9-point scale where studies with 7 to 9 points are identified as very good, 5 to 6 points as good, 4 points as satisfactory, and 0 to 3 as unsatisfactory.²⁸

Outcomes analyzed and statistics

Outcomes analyzed were patient satisfaction, return to sport, reoperations, functional outcomes, and complications. All statistical analysis was performed using Review Manager 5.3 software (The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark). When 3 or more studies reported an outcome, the results were meta-analyzed, otherwise they were descriptively analyzed. Heterogeneity between studies was quantified using the I^2 statistic.¹⁴ We chose an I^2 value of <25% to represent low heterogeneity and an I^2 value of >75% to indicate high heterogeneity. Fixed-effects models were used. When range was given instead of a standard deviation, the methods by Hozo et al¹⁵ were used to calculate the standard deviation. Results are expressed as risk ratio (RR) for dichotomous outcomes and mean difference for continuous outcomes, with a 95% confidence interval (CI). A P value of <.05 was considered to be statistically significant.

Results

Literature search

The initial literature search resulted in 114 studies. Once duplicates were removed, 71 studies were assessed for eligibility, and full texts were reviewed. This review included 5 clinical trials with 234 patients (Fig. 1).

Study characteristics and patient demographics

The 5 studies included (LOE I, 1; LOE II, 1; LOE III, 3) reported 107 patients treated with biceps tenodesis and 127 treated with SLAP repair.^{3,5,7,8,25} The mean age of patients treated with biceps tenodesis and SLAP repair was 45.4 and 38.8 years, respectively, with a significant difference between the cohorts ($P < .001$). Gender distribution did not differ significantly, with men making up 66.7% of patients treated with biceps tenodesis and 70.1% of patients treated with SLAP repair ($P = .27$). Most of the included patients had type II SLAP lesions, but the group treated with biceps

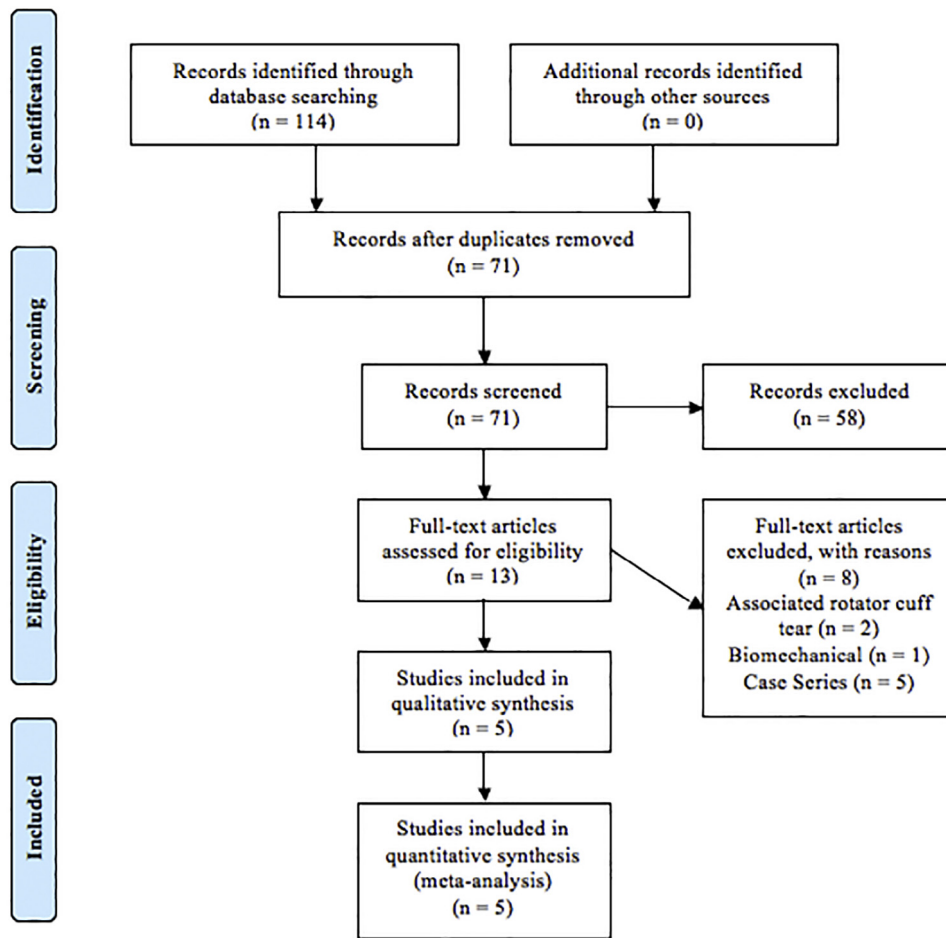


Figure 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses study selection flow diagram.

Table I Study characteristics and patient demographics

Author	LOE	MQOE	Tenodesis				SLAP repair				Follow-up (mo)
			No.	SLAP type	Age (yr)	M/F	No.	SLAP type	Age (yr)	M/F	
Boileau et al, ³ 2009	III	7	15	II	52 ± 9.0	6/9	10	II	37 ± 9.5	10/0	34 (24-69)
Chalmers et al, ⁵ 2015	III	7	23	I, II, III, IV	45 ± 3.0	14/9	45	II	35 ± 13.0	31/14	42 (12-59)
Denard et al, ⁷ 2014	III	7	15	II	52 ± 8.0	12/2	22	II	45 ± 5.5	14/6	54 (>24)
Ek et al, ⁸ 2013	III	7	15	II	47 ± 7.3	14/1	10	II	31 ± 5.5	10/0	33 (25-52)
Schroder et al, ²⁵ 2017	I	9	39	II	40 ± 11.5	24/15	40	II	42 ± 8.8	25/15	24

LOE, level of evidence; MQOE, methodological quality of evidence; SLAP, superior labrum anterior-to-posterior repair; M, male; F, female. Continuous data is presented as the mean ± standard deviation.

tenodesis in 1 study also included patients with type I, III, and IV lesions.

The SLAP repair was performed arthroscopically in all of the studies. The biceps tenodesis was performed with an open approach in 3 studies and arthroscopically in 2 studies. The mean follow-up time was 45 months overall, and all patients were monitored for a minimum of 1 year. The study characteristics and patient demographics are reported in Table I.

Clinical outcomes

Patient satisfaction

Patient satisfaction was reported in 3 studies, with 45 patients treated with biceps tenodesis and 42 with SLAP repair.^{3,7,8} Satisfaction with the results was reported by 95.6% of patients treated with biceps tenodesis and by 76.2% of patients treated with SLAP repair. There was a statistically

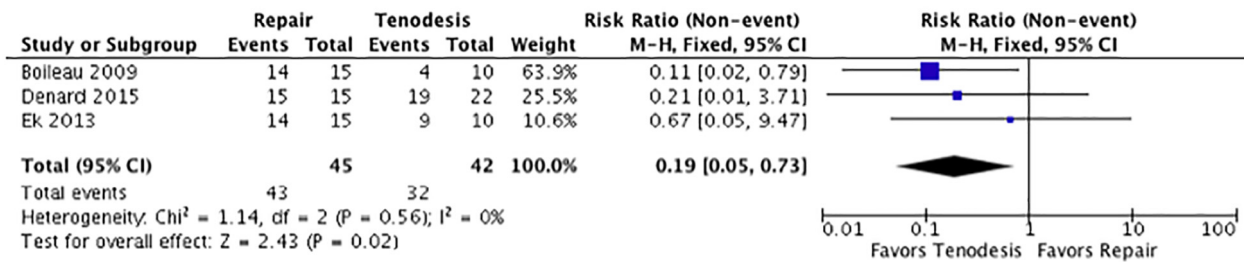


Figure 2 Patient satisfaction. The *horizontal lines* represent the 95% confidence interval (CI).The *solid squares* indicate the mean difference and are proportional to the weights used in the meta-analysis. The *diamond* indicates the weighted mean difference, and the *lateral tips* of the diamond indicate the associated 95% CI. *M-H*, Mantel-Haenszel test.

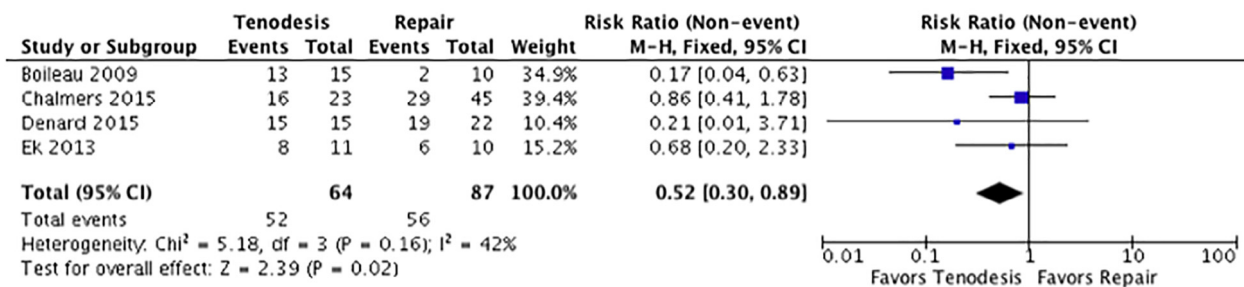


Figure 3 Return to sport. The *horizontal lines* represent the 95% confidence interval (CI).The *solid squares* indicate the mean difference and are proportional to the weights used in the meta-analysis. The *diamond* indicates the weighted mean difference, and the *lateral tips* of the diamond indicate the associated 95% CI. *M-H*, Mantel-Haenszel test.

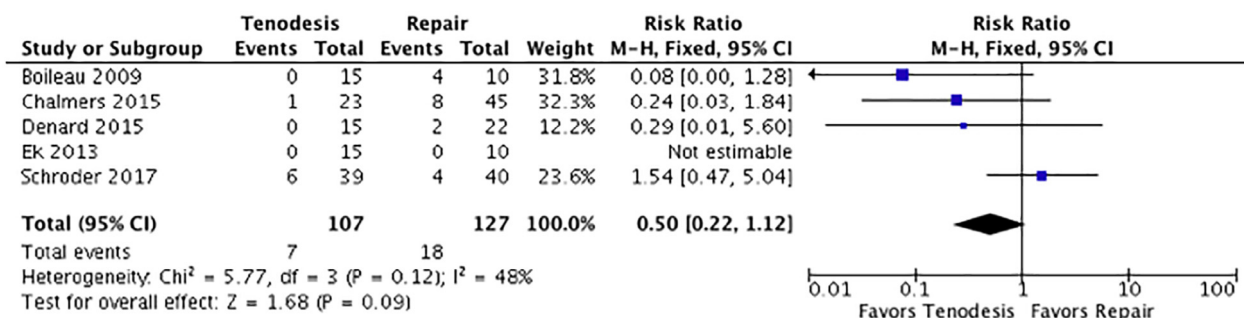


Figure 4 Reoperations. The *horizontal lines* represent the 95% confidence interval (CI).The *solid squares* indicate the mean difference and are proportional to the weights used in the meta-analysis. The *diamond* indicates the weighted mean difference, and the *lateral tips* of the diamond indicate the associated 95% CI. *M-H*, Mantel-Haenszel test.

significant difference in favor of biceps tenodesis (RR, 0.18; 95% CI, 0.05-0.73; $I^2 = 0\%$, $P = .02$). The forest plot of patient satisfaction is presented in Fig. 2.

Return to sport

Return to sport was reported in 4 studies, with 64 patients treated with biceps tenodesis and 87 with SLAP repair.^{3,5,7,8} Of these, 81.3% of patients treated with biceps tenodesis and 64.3% of patients treated with SLAP repair returned to sport. There was a statistically significant difference in favor of biceps tenodesis (RR, 0.52; 95% CI, 0.30-0.89; $I^2 = 42\%$, $P = .02$). The forest plot of return to sport is presented in Fig. 3.

Reoperation

Reoperations were reported in 5 studies, with 107 patients treated with biceps tenodesis and 127 patients treated with SLAP repair.^{3,5,7,8,25} With biceps tenodesis, reoperations were reported in 6.5% of patients compared with 14.2% of patients treated with SLAP repair. The difference between the treatments was not statistically significant (RR, 0.50; 95% CI, 0.22-1.12; $I^2 = 48\%$, $P = .22$). The forest plot of reoperations is presented in Fig. 4.

Stiffness

Stiffness postoperatively was reported in 3 studies with 69 patients treated with biceps tenodesis and 72 patients treated

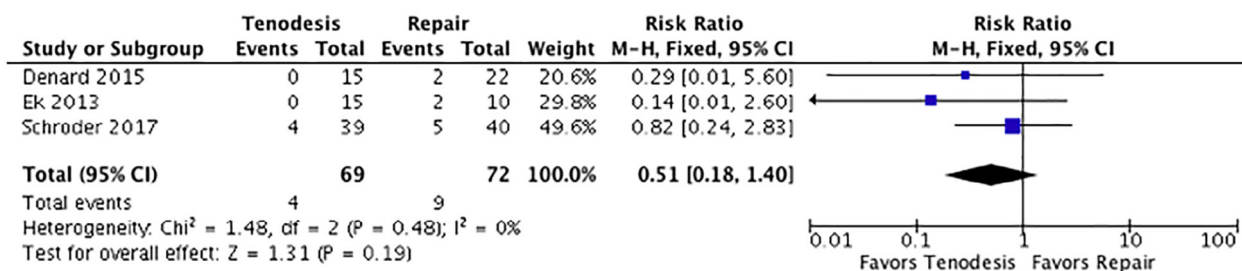


Figure 5 Stiffness. The horizontal lines represent the 95% confidence interval (CI). The solid squares indicate the mean difference and are proportional to the weights used in the meta-analysis. The diamond indicates the weighted mean difference, and the lateral tips of the diamond indicate the associated 95% CI. M-H, Mantel-Haenszel test.

Author	ASES	Constant	Rowe	SSV	VAS
Boileau et al, ³ 2009		89 ± 4.7 vs. 83 ± 5.2			
Chalmers et al, ⁵ 2015	87 ± 17 vs. 84 ± 19				1.5 ± 2.0 vs. 1.5 ± 2.2
Denard et al, ⁷ 2014	89.9 vs. 87.4			88.7 vs. 91.2	1.2 vs. 1.5
Ek et al, ⁸ 2013	93.3 ± 11.0 vs. 93.5 ± 8			85.4 ± 12.2 vs. 84 ± 14.9	0.8 ± 1.4 vs. 0.8 ± 1.3
Schroder et al, ²⁵ 2017			86.8 ± 2.3 vs. 85.8 ± 2.3		

ASES, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment score; SSV, subjective shoulder value; VAS, visual analog scale. Continuous data is presented as the mean ± standard deviation.
* Results presented as biceps tenodesis vs. superior labrum anterior-to-posterior repair.

with SLAP repair.^{7,8,25} Stiffness was reported in 5.8% of patients treated with biceps tenodesis compared with 12.5% of patients treated with SLAP repair. The difference between the treatments was not statistically significant (RR, 0.51; 95% CI, 0.18-1.40; I² = 0%, P = .19). The forest plot of stiffness is presented in Fig. 5.

Functional outcomes

A meta-analysis of the functional outcomes was not possible due to a variety of reported outcome measures used by each study and under-reporting in some of the studies. Overall, no study found a statistically significant difference between biceps tenodesis and SLAP repair in any functional outcome scores. Boileau et al³ found the activity subscore of the Constant score was significantly better in patients treated with biceps tenodesis. The most commonly reported outcome score was the American Shoulder and Elbow Surgeons (ASES) Standardized Shoulder Assessment score in 3 studies, with an average score of 89.6 for biceps tenodesis and 86.2 for SLAP repair. No study found any significant difference in the ASES score. The visual analog scale (VAS) score was reported in 3 studies, with an average score of 1.2 for biceps tenodesis and 1.4 for SLAP repair. No study found any significant difference in the VAS score. The functional outcomes are summarized in Table II.

Discussion

The principal findings from our literature analysis show that in patients in their 30s and 40s, biceps tenodesis resulted in higher rates of patient satisfaction and return to sport. Although biceps tenodesis and SLAP repair resulted in similar functional outcome scores, a meta-analysis of this was not possible due to variable reporting outcomes. As a result of discouraging results, there has been a recent trend away from SLAP repair, with the percentage of patients treated with SLAP repair decreasing from 69.3% in 2002 to 44.8% in 2011.²² The percentage of patients treated with biceps tenodesis has risen substantially during this time, from less than 2% in 2002 to close to 20% in 2011.²²

Boileau et al³ reported the largest difference in rates of return to sport between biceps tenodesis and SLAP repair in a cohort of patients playing contact or overhead sports. Of those undergoing biceps tenodesis, 87% returned to their preinjury level of play compared with only 20% of those undergoing SLAP repair. No other study found a statistically significant difference in the rate of return to sport between the 2 procedures, but in each study, there was a slightly higher rate among those treated with biceps tenodesis. Multiple studies evaluating the rate of return after biceps tenodesis for SLAP lesions have found excellent results.^{13,23} The findings from this study indicate that

biceps tenodesis may be superior to SLAP repair in recreational athletes in their 30s.

There are also some additional concerns with performing biceps tenodesis in overhead athletes. SLAP lesions commonly affect overhead athletes, with a high prevalence in baseball players and the potential to limit athletes' careers. A recent survey of MLB physicians found that 93% would repair a SLAP tear when they have decided on operative management.⁹ Chalmers et al⁶ found that after SLAP repair, baseball pitchers demonstrated altered trunk biomechanics compared with players who underwent biceps tenodesis. However, Chalmers et al⁶ found that although there was an 80% rate of return to play among MLB position players after biceps tenodesis, the rate of return among MLB pitchers was only 17%.⁴ This is far below the reported rates of 63% in those undergoing SLAP repair.²⁴ Although pitching mechanics may not be altered among patients treated with a biceps tenodesis, the power, and control of the pitching may be affected. The biceps is the chief elbow supinator and secondary elbow flexor, and thus, performing biceps tenodesis as a primary procedure may be inadvisable. Caution should therefore be exercised when considering biceps tenodesis for a SLAP lesion in an overhead athlete, but it may be a viable secondary procedure for a failed repair.²⁰

The most commonly used outcome measures were the ASES and VAS scores. Although a quantitative comparison of these outcomes was not possible, no study identified a statistically significant difference between the cohorts.^{5,7,8} All included studies showed significant changes in functional outcome scores for both biceps tenodesis and SLAP repair from baseline to follow-up. Despite the improved outcomes after these procedures, Schroder et al²⁵ found no difference in functional outcome scores between biceps tenodesis, repair, and sham surgery in a randomized controlled trial. However, this randomized control trial reported a significantly higher rate of reoperation in the cohort treated with sham surgery (35%) and a significantly lower rate of patients felt they had been treated surgically.

Denard et al⁷ found that there was a greater delay in restoration to full range of motion in forward flexion and external rotation in the SLAP repair group than in the biceps tenodesis group, but this result was not statistically significant. This may be a result of the residual pain or stiffness that can be experienced postoperatively after a SLAP repair.

Although ASES and VAS scores were used to assess function in most of the studies in this review, Franceschi et al¹² and Neuman et al²¹ concluded that the Kerlan-Jobe Orthopaedic Clinic score is more accurate in determining the functional outcome, especially in overhead athletes after SLAP repair. This suggests that the functional outcomes may not be optimal to detect a difference. In particular, the Rowe score may be inappropriate as a functional outcome measure for SLAP tears because none of the included studies showed postoperative instability was a problem.

The rate of reoperation was lower among those undergoing biceps tenodesis, but this was not statistically significant.

No study reported the reason for revision among those undergoing biceps tenodesis, but residual pain was the most common reason for revision among the repaired lesions.³ Among patients undergoing patients undergoing biceps tenodesis, only 1 reported patient had a positive Popeye sign, despite high rates being reported in the literature.⁸ Stiffness was a complication in both groups, with several studies reporting postoperative stiffness with biceps tenodesis and SLAP repair, and stiffness was a significant cause of revision surgery.^{7,8,25} No complications with regards to mechanical symptoms or instability were reported in either group.

Further study is still needed to identify who may be best treated with biceps tenodesis or SLAP repair. We found a higher rate of return among those treated with biceps tenodesis, but there was a mixture of athletic demands among the patients studied. In addition, 2 studies have found that SLAP repair may not have any advantage over tenotomy alone in patients with concomitant rotator cuff tears.^{12,16} To our knowledge, no study has compared biceps tenodesis with SLAP repair in the setting of a SLAP lesion combined with a rotator cuff tear, but studies have shown that biceps tenodesis and biceps tenotomy have similar functional outcomes in isolated rotator cuff tears.¹⁸

There are several limitations and inherent bias in our study. First, the limitations inherent in the included studies are present in this study because this a systematic review. There was moderate heterogeneity in satisfaction and return to sport, which may be a result of the mixtures of overhead athletes, contact athletes, and manual laborers, limiting the applicability of our conclusions. Also, the numbers were low, which prevented our ability to compare functional outcomes and may have underpowered the outcome measures.

Although most of the included studies focused exclusively on type II SLAP tears, in 1 study, there were several patients included in the biceps tenodesis group who had type I, III, and IV SLAP tears as well, which may contribute to the heterogeneity. However, due to the limited numbers of patients with other SLAP types, we felt it was necessary to include this study.⁵ The retrospective nature and low level of the included studies also is a limiting factor in our conclusions.

Conclusion

Our study found that biceps tenodesis resulted in higher rates of patient satisfaction and return to sport in the studies published in the literature, whereas biceps tenodesis and SLAP repair resulted in similar functional outcome scores.

Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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