

Lower Reoperation and Higher Return-to-Sport Rates After Biceps Tenodesis Versus SLAP Repair in Young Patients: A Systematic Review



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Purpose: To evaluate patient-reported outcomes, return to sport, and adverse events after SLAP repair versus biceps tenodesis (BT) in a young patient population undergoing treatment of SLAP tears. **Methods:** We performed a systematic review and meta-analysis of the PubMed (MEDLINE), Scopus, CENTRAL (Cochrane Central Register of Controlled Trials), and Web of Science databases for comparative studies discussing outcomes after SLAP repair and BT in patients younger than 40 years with at least 1 year of follow-up. **Results:** Four studies were included, comprising a total of 274 patients who underwent treatment of SLAP tears with SLAP repair (169 patients) or BT (105 patients). Most patients were male patients (79.8%) and athletes (74.5%). Preoperative and postoperative pain visual analog scale scores decreased similarly in both groups (range, 6.6-6.7 preoperatively to 0.8-2.6 postoperatively in SLAP repair group vs 5.6-7.3 preoperatively to 0.7-1.9 postoperatively in BT group). Similar and substantial American Shoulder and Elbow Surgeons Standardized Shoulder Assessment score increases were observed after both procedures (range, 40.6-45.8 preoperatively to 75.4-92.0 postoperatively in SLAP repair vs 41.9-55.0 preoperatively to 85.7-91.2 postoperatively in BT group). Patient satisfaction rates were similar but showed slightly higher ranges after BT (8.5-8.8 vs 8.0-8.2). Rates of return to sport were higher after BT (63%-85% vs 50%-76%), with higher odds of returning to sport after BT reported by all studies. Surgical complications were rare after SLAP repair and BT. Rates of reoperation were substantially higher after SLAP repair (3%-15% vs 0%-6%), with 3 of 4 studies reporting no reoperations after BT. BT comprised 78% to 100% of reoperation procedures after SLAP repair. **Conclusions:** Postoperative pain, function, and patient satisfaction were similar after SLAP repair and BT in patients younger than 40 years. There are higher rates of reoperation and lower rates of return to sport after SLAP repair than after BT. **Level of Evidence:** Level III, systematic review of Level III studies.

SLAP tears were described by Andrews et al.¹ in 1985 and classified by Snyder et al.² in 1990. Of the sub-classifications, type II SLAP tears are the most frequently reported subtype and account for 55% of all SLAP injuries.³ SLAP tears comprise fewer than 10% of labral tears,⁴ yet there is controversy surrounding the operative management of SLAP tears in younger patients.

The incidence of arthroscopic SLAP repair increased dramatically in the early 2000s, with up to 4 times as

many repair procedures performed in 2010 compared with 2002 in patients of all ages.⁵ Over one-third of patients undergoing SLAP repair are reported to meet failure criteria, and concerns regarding return to sport, especially for overhead athletes, complications, and reoperation rates leave substantial room for improvement in SLAP tear treatment algorithms.^{6,7} Subsequently, surgical alternatives to SLAP repair, notably debridement and biceps tenodesis, have grown

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increasingly popular. Although acceptable for type I SLAP tears, arthroscopic debridement imbues poor outcomes for type II SLAP tears, rendering biceps tenodesis as the primary alternative.⁶

Older age is a notable risk factor for failed labral repair and need for revision.⁷ In 2009, Boileau et al.⁸ introduced biceps tenodesis as a viable alternative to SLAP repair in a patient cohort with an average age older than 35 years. Denard et al.⁹ further postulated that patients older than 35 years treated with biceps tenodesis rather than SLAP repair have more predictable outcomes, a shorter recovery period, higher satisfaction, and a greater rate of return to sport. In a series of patients younger than 25 years who underwent biceps tenodesis for SLAP tears, including a substantial portion of college athletes, Griffin et al.¹⁰ described high rates of return to sport and low revision rates. Recent evidence has similarly reaffirmed that biceps tenodesis may also be a viable alternative in younger patients because of the combination of comparable outcomes when primarily treating SLAP tears and the role of biceps tenodesis as a revision treatment for failed SLAP repair.^{11,12} Biceps tenodesis is commonly advocated as the treatment of choice for older patients and non-overhead athletes, and the incidence of biceps tenodesis for SLAP tears notably surpassed the incidence of SLAP repair starting in 2017.^{6,13-15}

The purpose of this study was to evaluate patient-reported outcomes, return to sport, and adverse events after SLAP repair versus biceps tenodesis in a young patient population undergoing treatment of SLAP tears. We hypothesized that SLAP repair and biceps tenodesis would have comparable outcomes for younger patients with SLAP tears without significant differences between the groups.

Methods

Eligibility

A systematic review was performed and reported according to Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines. The screening criteria required studies to report any outcomes after both SLAP repair and biceps tenodesis. Studies eligible for inclusion reported at least Level III evidence and compared labral repair versus biceps tenodesis for the treatment of type II SLAP lesions in patients younger than 40 years. Studies that included type III and IV SLAP lesions were considered eligible for inclusion only if over 85% of patients presented with type II SLAP lesions. Given the lack of randomized controlled trials comparing labral repair and biceps tenodesis in this age population, nonrandomized studies were included in our analysis. Studies were excluded if patients underwent revision SLAP repair, concomitant rotator cuff repair, or shoulder procedures

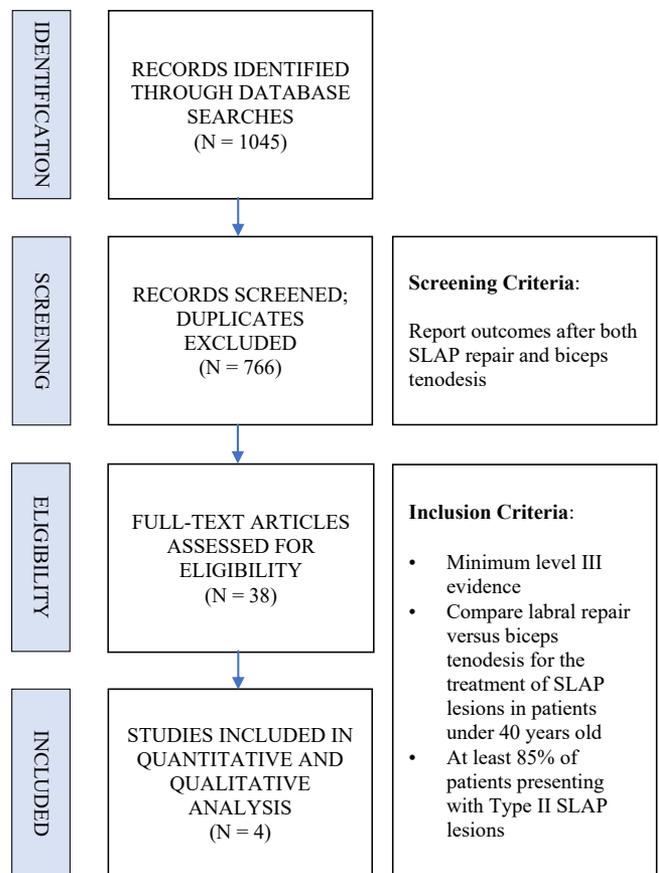


Fig 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) flow diagram.

other than SLAP capsulolabral repair, with the exception of subacromial decompression, distal clavicle excision, subacromial bursectomy, and debridement. Case reports, editorials, review articles, technical reports, and articles not in English were excluded.

Search

A search of the PubMed (MEDLINE), Scopus, CENTRAL (Cochrane Central Register of Controlled Trials), and Web of Sciences databases was conducted on March 17, 2022, with the following search terms: ((superior labrum anterior-posterior) OR (SLAP) OR (superior labrum anterior posterior)) AND ((biceps tenodesis*) OR (labral repair) OR (SLAP repair) OR (labrum repair)). No filters or limits were used. Two authors (A.B.S. and J.P.S.) screened, reviewed, and selected studies eligible for inclusion (Fig 1). Disputes between authors were reviewed by a third author (N.P.) to determine appropriate management.

Data

Data extraction was performed twice to decrease the likelihood of error. The following data were collected: total patients, sex distribution, number of patients who identified as athletes, concomitant procedures, pain

Table 1. Characteristics of Included Studies

Authors	Year	Study Design/Level of Evidence	Types of SLAP Tears (n)	Patients, n	SLAP Repair, n	Biceps Tenodesis, n	Biceps Tenodesis Technique	Concomitant Procedures	MINORS Score
Dunne et al. ¹⁸	2021	Retrospective comparative study/III	II (52)	52	33	20	All-arthroscopic suprapectoral technique	SLAP repair: subacromial bursectomy (4), debridement of partial rotator cuff tear (4), repair of posterior capsular rent (1), and debridement of Bennett lesion (1) Biceps tenodesis: subacromial bursectomy (4), debridement of partial rotator cuff tear (1), decompression of paralabral cyst (1), manipulation under anesthesia (1), and PRP injection (1)	21 of 24
Hurley et al. ¹¹	2022	Retrospective comparative study/III	II (95), III (7), and IV (5)	107	78	29	Open subpectoral technique	NR	21 of 24
Parnes et al. ¹²	2021	Retrospective comparative study/III	II (48)	48	25	23	Arthroscopic-assisted subpectoral technique	SLAP repair: subacromial decompression (25) and distal clavicle excision (4) Biceps tenodesis: subacromial decompression (23) and distal clavicle excision (4)	22 of 24
Van Nielen et al. ¹⁹	2017	Retrospective comparative study/III	II (66)	66	33	33	Open subpectoral technique	NR	20 of 24

MINORS, Methodological Index for Non-randomized Studies; NR, not reported; PRP, platelet-rich plasma.

Table 2. Demographic Characteristics

Authors	SLAP Repair				Biceps Tenodesis				
	Patients, n	Male Patients	Mean Age (SD), yr	Overhead Athletes, n	Patients, n	Male Patients	Mean Age (SD), yr	Overhead Athletes, n	Mean Follow-up (SD), mo
Dunne et al. ¹⁸ (2021)	33	78.7% (26)	30.4 (7.4)	32	20	65.0% (13)	26.9 (5.9)	19	32.3 (10.3)
Hurley et al. ¹¹ (2022)	78	79.5% (62)	24.3 (4.0)	55	38	79.3% (23)	26.0 (4)	20	53.4 (26.0)
Parnes et al. ¹² (2021)	25	96.0% (24)	27.8 (4.3)	13	NR	78.3% (18)	28.0 (4)	16	79.8 (22.2)
Van Nielen et al. ¹⁹ (2017)	33	NR	25.7 (NR)	NR	NR	NR	26.4 (NR)	NR	42.0 (NR)
Total	169	112 of 136	27.1 (2.7)	100 of 136	58 of 111	54 of 72	26.8 (0.9)	55 of 72	51.9 (20.5)

NR, not reported; SD, standard deviation.

visual analog scale (pVAS) scores, American Shoulder and Elbow Surgeons (ASES) Standardized Shoulder Assessment scores, patient satisfaction, return-to-sport rate, complication rate, and reoperation rate. Patient satisfaction ratings were converted to scores out of 10 and were recorded. Return to sport was pooled as a combination of “return to sport at previous level” and “return to play” given that the studies reporting return to play reported satisfactory SLAP–Return to Sport Index (SLAP-RSI) analyses.¹⁵ Patients with adverse events were divided into 2 categories: those with surgical complications that did not require revision versus those requiring reoperation.

Statistics

Comparative data included ranges of means and odds ratios with 95% confidence intervals (CIs). Calculation of summary estimates and weighted means was not performed given that included studies were non-randomized and heterogeneous. Review Manager software (RevMan, version 5; Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark)¹⁶ was used for analysis and forest plot generation. Methodological Index for Non-randomized Studies (MINORS) criteria were used to assess study bias.¹⁷

Results

In total, 842 studies were identified, 720 studies were screened after removal of duplicates, 36 full-text articles were assessed for eligibility, and 4 studies were included in our quantitative and qualitative analyses (Fig 1). A total of 274 patients were eligible for inclusion, 169 of whom underwent SLAP repair and 105 of whom underwent biceps tenodesis. Characteristics of included studies, biceps tenodesis techniques, and concomitant procedures are presented in Table 1. Most patients were male patients (range, 78.7%-96.0% for SLAP repair and 65.0%-79.3% for biceps tenodesis; 166 of 208 patients) and athletes (range, 52.0%-97.0% for SLAP repair and 69.0%-95.0% for biceps tenodesis; 155 of 208 patients) (Table 2). Mean patient ages ranged from 24.3 to 30.4 years for SLAP repair and from 26.0 to 28.0 years for biceps tenodesis. Although we required a follow-up period of at least 1 year for studies to be eligible for inclusion, the weighted average time to follow-up was considerably longer and noted to be 63.9 months for patients undergoing SLAP repair and 51.9 months for patients undergoing biceps tenodesis. Follow-up times were typically longer after SLAP repair compared with biceps tenodesis (range, 61.0-86.6 months after SLAP repair vs 32.3-79.8 months after biceps tenodesis).

Patient-Reported Outcomes

Pain. Mean preoperative pVAS scores were reported for 101 patients,^{12,18} and postoperative pVAS scores

Table 3. Patient-Reported Outcomes

Authors	Patients, n	Mean Pain VAS Score (SD)		Mean ASES Score (SD)		Mean Satisfaction Score (SD)
		Preoperative	Postoperative	Preoperative	Postoperative	
SLAP repair						
Dunne et al. ¹⁸ (2021)	33	6.6 (2.2)	1.6 (2.0)	46 (20)	86 (17)	8.0 (2.3)
Hurley et al. ¹¹ (2022)	78	NR	0.8 (1.9)	NR	92 (21)	8.2 (2.2)
Parnes et al. ¹² (2021)	25	6.7 (2.0)	2.6 (2.5)	41 (10)	75 (17)	NR
Van Nielen et al. ¹⁹ (2017)	33	NR	NR	NR	NR	NR
Biceps tenodesis						
Dunne et al.	20	5.6 (2.3)	1.9 (1.9)	55 (19)	86 (13)	8.5 (1.7)
Hurley et al.	29	NR	0.7 (1.6)	NR	91 (14)	8.8 (2.5)
Parnes et al.	23	7.3 (1.8)	1.3 (1.9)	42 (10.2)	86 (16)	NR
Van Nielen et al.	33	NR	NR	NR	NR	NR

ASES, American Shoulder and Elbow Surgeons; NR, not reported; SD, standard deviation; VAS, visual analog scale.

were reported for 208 patients.^{11,12,18} Average preoperative to postoperative pVAS scores decreased after both SLAP repair and biceps tenodesis, with similar ranges in values for both procedures. For SLAP repair, mean preoperative pVAS scores ranged from 6.6 (standard deviation [SD], 2.2) to 6.7 (SD, 2.0)^{12,18} and decreased to 0.8 (SD, 1.9) to 2.6 (SD, 2.5) postoperatively.^{11,12,18} For biceps tenodesis, mean preoperative pVAS scores ranged from 5.6 (SD, 2.2) to 7.3 (SD, 1.8)^{12,18} and decreased to 0.7 (SD, 1.6) to 1.9 (SD, 1.9) postoperatively^{11,12,18} (Table 3).

Function. Preoperative ASES scores were reported for 101 patients,^{12,18} and postoperative ASES scores were reported for 208 patients.^{11,12,18} Preoperative to postoperative ASES scores nearly doubled after both SLAP repair and biceps tenodesis and remained similar between the 2 procedures. Mean ASES scores increased from ranges of 40.6 (SD, 10.1) to 45.8 (SD, 19.8) preoperatively^{12,18} to 75.4 (SD, 16.8) to 92 (SD, 20.6) postoperatively^{11,12,18} in patients with SLAP repair and from 41.9 (SD, 10.2) to 55.0 (SD, 19.1) preoperatively^{12,18} to 85.7 (SD, 15.7) to 91.2 (SD, 13.7) postoperatively^{11,12,18} in patients with biceps tenodesis (Table 3).

Satisfaction. Patient satisfaction scores were reported for 160 patients.^{11,18} For both SLAP repair and biceps tenodesis, average patient satisfaction scores ranged in the top 20% of the 10-point scoring system. On

average, patients with biceps tenodesis reported slightly higher satisfaction rates (range of mean scores, 8.5 [SD, 1.7] to 8.8 [SD, 2.5] for biceps tenodesis vs 8.0 [SD, 2.3] to 8.2 [SD, 2.2] for SLAP repair)^{11,18} (Table 3).

Return to Sport. Rates of return to sport were reported for a total of 208 patients.^{11,12,18} Rates of return to sport ranged from 50% to 76% after SLAP repair versus 63% to 85% after biceps tenodesis.^{11,12,18} The individual odds of returning to sport ranged from 0.47 (95% CI, 0.14-1.55) to 0.58 (95% CI, 0.18-1.86), with all studies reporting greater rates of return to sport after biceps tenodesis (Fig 2).

Adverse Events

Surgical complications were rare among the 208 patients enrolled in studies that reported complications (Table 4).^{12,16,20} Rates of complications were similar between groups, ranging from 0% to 4% after SLAP repair and from 0% to 5% after biceps tenodesis.^{11,12,18} Reoperations were reported in an overall cohort of 274 patients.^{11,12,18,19} Reoperation rates were higher than complication rates, ranging from 3% to 15% after SLAP repair versus from 0% to 6% after biceps tenodesis.^{11,12,18,19} Patients undergoing SLAP repair had substantially increased rates of reoperation, with 3 of 4 studies reporting no reoperations after biceps tenodesis whereas all studies reported at least 1 reoperation after SLAP repair (Fig 3). Biceps tenodesis comprised 78% of

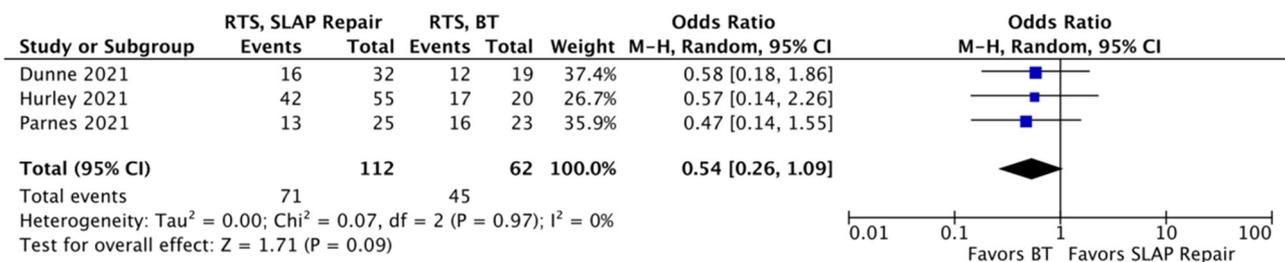


Fig 2. Forest plot for return to sport (RTS). (BT, biceps tenodesis; CI, confidence interval; M-H, Mantel-Haenszel.)

Table 4. Adverse Events

	SLAP Repair		Biceps Tenodesis	
	n	%	n	%
Complications				
Dunne et al. ¹⁸ (2021)	1	3.0	1	5.0
Hurley et al. ¹¹ (2022)	0	0	0	0
Parnes et al. ¹² (2021)	1	4.0	0	0
Van Nielen et al. ¹⁹ (2017)	NR	—	NR	—
Reoperations				
Dunne et al.	1	3.0	0	0
Hurley et al.	9	11.5	0	0
Parnes et al.	4	16.0	0	0
Van Nielen et al.	5	15.0	2	6.0
NR, not reported.				
				Description
				Postoperative superficial infection successfully treated with antibiotics
				Superficial paresthesia of anterior shoulder partially relieved with gabapentin
				Failure of treatment; elected for nonoperative management
				Capsular release (n = 1)
				Biceps tenodesis (n = 7), revision SLAP repair (n = 1), and arthroscopic debridement (n = 1)
				Biceps tenodesis (n = 4)

reoperation procedures after SLAP repair (7 of 9) in the patient population of Hurley et al.¹¹ and 100% of reoperation procedures after SLAP repair (4 of 4) in that of Parnes et al.¹²

Discussion

In a comparison of SLAP repair and biceps tenodesis in patients younger than 40 years, biceps tenodesis shows substantially lower reoperation rates and potentially higher return-to-sport rates. Postoperative pain, function, and patient satisfaction are similar after the 2 procedures. Given the recency of studies included in our systematic review, these findings highlight a need to reassess the role of biceps tenodesis as a primary treatment for SLAP tears in patients younger than 40 years.

Originally introduced as a surgical means by which to manage biceps tendon pathology, biceps tenodesis is now supported as the preferred surgical treatment for type II SLAP tears in older patients.^{6,9,21-23} Proponents of this procedure cite higher patient-reported outcome scores, satisfaction rates, and rates of return to sport and/or activity, as well as lower revision rates, after tenodesis compared with primary repair.^{8,9,22} Investigating these outcomes in younger patients, however, is not as straightforward because much of the published data is skewed by current clinical practice trends, in which older patients are preferentially treated with biceps tenodesis and younger patients are treated with SLAP repair.^{8,24-26} With this in mind, there is clearly budding interest in the topic: Three studies in our analysis were published in 2021 or 2022, a clear demonstration of reinvigorated interest in the subject.^{11,12,18}

In our study, both SLAP repair and biceps tenodesis showed substantial clinical improvement as evidenced by increases in patient-reported outcome measures. Although the variability among nonrandomized studies precluded pooled comparison, ranges of mean scores were notably similar between the 2 interventions at final follow-up. A comparison of sham surgery, SLAP repair, and biceps tenodesis in an equally age-distributed patient population similarly reinforced the lack of outcome superiority between the 2 procedures, and baseline functional status was the only significant covariate with patient-reported outcome scores.²⁷

Without obvious differences in patient-reported outcomes, measures such as return to sport and adverse events emerge as important markers of comparison. Our findings indicate that rates of return to sport are considerably higher after biceps tenodesis. Similarly, multiple studies have reported a consistently higher incidence of return to sport at the preinjury level after biceps tenodesis versus SLAP repair irrespective of age and athletic engagement, although there is evidence that suggests a nearly 3-month longer time line for

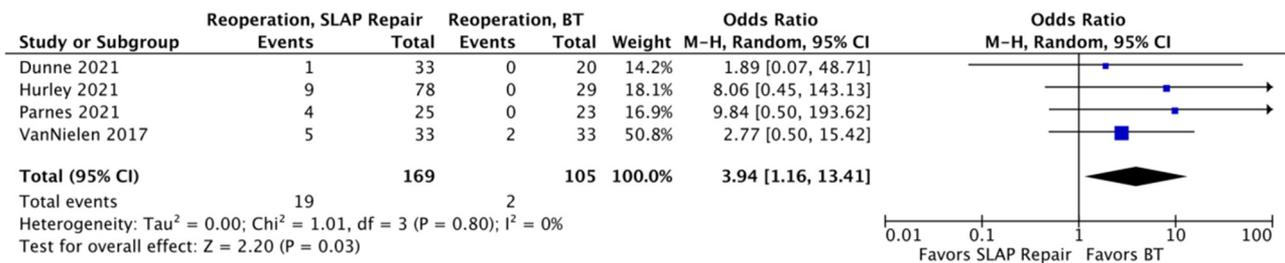


Fig 3. Forest plot for reoperation. (BT, biceps tenodesis; CI, confidence interval; M-H, Mantel-Haenszel.)

returning to sport for older patients.^{20,28-30} Additionally, SLAP tears are not exclusive to the overhead athlete: Tactical athletes in the active-duty military population are also at increased risk of SLAP tears.³¹ In this typically younger population, there is evidence that biceps tenodesis provides superior outcomes, higher return-to-duty rates, and lower rates of medical discharge.^{7,12,32} It is interesting to note that a systematic review by Shin et al.³³ showed no significant differences between the 2 procedures; however, these data were not limited to younger patients and rather concluded noninferiority of biceps tenodesis. In this context, our results suggest that patient age alone may not be as intransigent of a factor as previously thought in choosing between biceps tenodesis and SLAP repair, especially when considering outcomes that are important to a younger, active, and working cohort, such as return to activity and risk of reoperation.

Age is a major risk factor for failed SLAP treatment.^{7,34-37} In our analysis of a young patient population, rates of reoperation ranged from 3% to 16% for SLAP repair and from 0% to 6% for biceps tenodesis, culminating in a nearly 4 times higher likelihood of reoperation after SLAP repair, consistent with the published literature.^{8,15,20} Furthermore, most patients in our study with specified revision procedures after SLAP repair underwent biceps tenodesis (78%-100%), also consistent with the published literature.³⁸⁻⁴¹ Along with the higher rates of failure after SLAP repair come compounded challenges of management: Failure of conservative management occurs in 71% of patients, and disappointing results after operative treatment are reported by 32% of patients.³⁵

Limitations

Our study is not without limitations. The small number of nonrandomized, heterogeneous studies eligible for inclusion reflects the recent interest in pursuing biceps tenodesis as an alternative to SLAP repair and absence of these data in the existing literature. By the nature of a systematic review, data collection is limited to what studies report and there were extremely few studies that reported patient age, outcomes according to treatment, and type of SLAP lesion. Age categories were also not standard across

studies, with Dunne et al.¹⁸ including patients younger than 40 years, Parnes et al.¹² including those younger than 35 years, and both Hurley et al.¹¹ and Van Nielen et al.¹⁹ including those younger than 30 years. Follow-up time was also considerably longer after SLAP repair. Moreover, biceps tenodesis techniques varied per study. Our measure of the return-to-sport variable included both return to sport at the previous level and return to sport in general given that the study reporting on the return to sport in general described a satisfactory psychological level of return to sport.

Conclusions

Postoperative pain, function, and patient satisfaction were similar after SLAP repair and biceps tenodesis in patients younger than 40 years. There are higher rates of reoperation and lower rates of return to sport after SLAP repair than after biceps tenodesis.

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