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A meta-analysis of level I evidence comparing tenotomy vs tenodesis in the management of long head of biceps pathology

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Background: The ideal surgical treatment of long head of biceps pathology is unclear. This review evaluates Level I studies comparing tenotomy and tenodesis for the management of long head of biceps pathology.
Methods: Medline, EMBASE, and the Cochrane Library databases were searched from database inception though April 17, 2020. Clinical outcomes including Constant-Murley Shoulder Outcome Score, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form (ASES) shoulder score, pain on visual analog scale, postoperative strength, and Popeye deformity were evaluated. Dichotomous outcomes were pooled into relative risk ratios whereas continuous outcomes were pooled into weighted mean differences using random effects meta-analysis.
Results: A total of 5 studies (227 tenotomy and 227 tenodesis patients) met the final inclusion criteria. Postoperative improvement across all outcomes was observed regardless of surgical treatment. Pooled analysis demonstrated no statistically significant difference for Constant-Murley Shoulder Outcome Score, ASES, pain, or flexion strength. Tenodesis was superior to tenotomy in reducing the risk of Popeye deformity (relative risk ratio 3.07, confidence interval 1.87, 5.02; $P < .001$).
Conclusion: Tenotomy and tenodesis of the long head of the biceps results in comparable postoperative clinical and functional outcomes. Tenodesis is superior to tenotomy in preventing Popeye deformity postoperatively.
Level of Evidence: Level I; Meta-Analysis

Keywords: Shoulder; elbow; arthroscopy; meta-analysis; systematic review; surgery

Institutional review board approval was not required for this systematic review.

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The long head of the biceps tendon (LHBT) is a common source of shoulder pain and can be associated with a variety of concomitant shoulder pathologies.[7] Although conservative management such as rest, physiotherapy, analgesia, and corticosteroid injections may help at varying

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degrees with symptom control, surgical management with tenotomy or tenodesis of the LHBT is the definitive treatment when nonoperative therapies fail.[7]

Surgical treatment for LHBT pathology consists primarily of either tenotomy or tenodesis.[16] Traditionally, releasing the proximal LHBT via tenotomy has been associated with a higher postoperative cosmetic deformity known as Popeye deformity,[14,23,24] where a bulge in the upper arm forms because of retraction and shortening of the long head of the biceps muscle. In addition, proponents of tenodesis assert that it is protective against cramping pain.[2] Some studies also suggest that a loss of biceps muscle tension with tenotomy can lead to a decrease in elbow flexion and supination strength, although this is controversial in the literature.[19] Tenodesis, on the other hand, is technically more challenging, more costly, and results in some increase in operative time.[8] Certain fixation locations may also result in residual bicipital groove pain at the site of tenodesis.[4]

Previous systematic reviews have found tenotomy and tenodesis to be comparable with respect to postoperative function and alleviation of pain but were limited because of the inclusion of lower-quality evidence and nonrandomized studies.[9,22,26] We therefore sought to provide an up-to-date meta-analysis of randomized controlled trials comparing tenotomy to tenodesis in the management of LHBT pathology. With MacDonald et al's[20] new contribution to the topic, the aim was to synthesize the highest-level and up-to-date evidence available, which may generate novel differences or substantiate previous knowledge in order to guide clinical decision making for surgical treatment of LHBT lesions. The working hypothesis is that there is no difference in clinical outcomes postoperatively between the 2 treatment options.

Methods

This study was conducted according to the methodology described in the Cochrane Handbook for Systematic Reviews of Interventions[13] and is reported according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines.[13] The study was prospectively registered on the International Prospective Register of Systematic Reviews (PROSPERO).

Search and screening strategy

A comprehensive search of Ovid Medline, Ovid Embase, and the Cochrane Central Register of Controlled Trials (CENTRAL) was performed covering from January 1, 1946, to April 17, 2020. The search strategy can be found in Table I. The title, abstract, and full-text screening was performed by 2 reviewers (X.M.Z. and E.B.D.) independently and in duplicate using piloted screening forms. Disagreements during title and abstract screening moved onto the next stage for further in-depth review. Discrepancies between reviewers were discussed with the principal investigator (M.K.).

Inclusion and exclusion criteria

Included studies must be Level I evidence, minimum 12-month follow-up, arthroscopic studies comparing LHBT tenodesis and tenotomy, in the English language, and with human subjects. Studies that were in another language, nonhuman subjects, reviews, retrospective cohort studies, case reports, case series, commentaries, editorials, and conference abstracts were excluded. In studies that used the same population, the study with the larger patient pool was used.

Data extraction

A predefined form was used by each independent reviewer to extract data from the selected studies. This included title, authorship, number of patients for each study, mean age, and follow-up period. Outcomes extracted included pain, incidence of Popeye deformity, Constant-Murley Shoulder Outcome Score, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form (ASES) score, and strength in flexion and supination modalities for both pre- and postoperative periods.

Risk of bias assessment

Methodologic quality of the included studies were assessed in duplicate (by X.M.Z. and E.B.D.) using the Cochrane Risk of Bias Tool for randomized controlled trials (RCTs).[12]

Statistical analysis

Data analysis was performed using Cochrane Review Manager 5.4.[12] Dichotomous outcomes were reported as relative risk ratios (RRs) with 95% confidence intervals (CIs). Quantitative data (ie, Constant-Murley score and pain visual analog scale [VAS]) were measured as mean differences (MDs) with 95% CIs. $P < .05$ was considered to be statistically significant. Data from latest postoperative follow-up point was used from each study.

As the studies varied in reporting at unified periods, postoperative outcomes for each period was recorded and analyzed,

Table I Search criteria on MEDLINE and EMBASE (through OVID) and CENTRAL

OVID (Medline and Embase)	CENTRAL
1. Tenotomy	1. Tenotomy
2. Tenodesis	2. Tenodesis
3. Bicep	3. Bicep
4. Biceps	4. Biceps
5. Long head	5. Long head
6. Lesion	6. Lesion
7. 1 AND 2	7. 1 AND 2
8. 3 or 4 or 5 or 6	8. 3 or 4 or 5 or 6
9. 7 AND 8	9. 7 AND 8

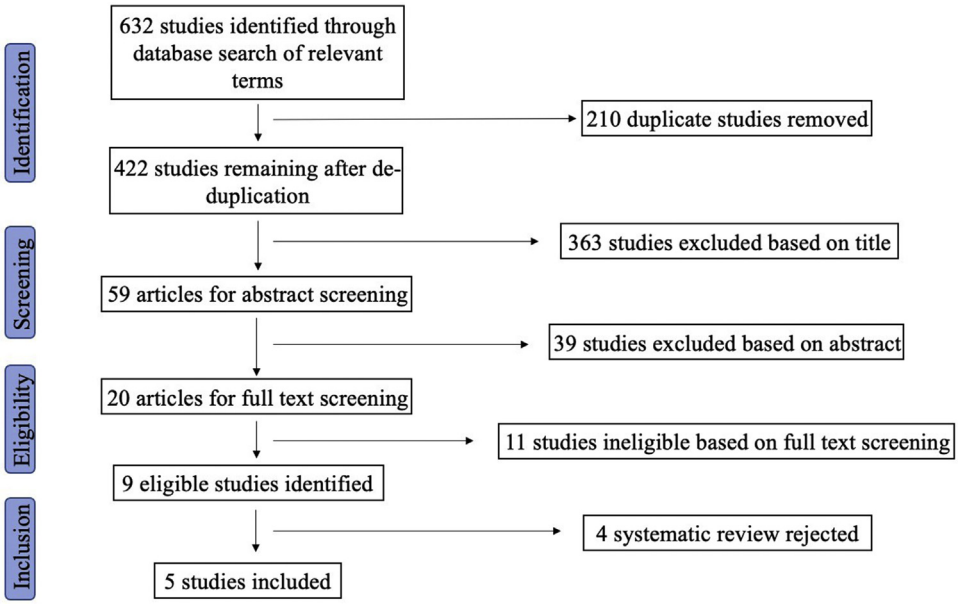

Figure 1 A summary of literature search and screening results according to PRISMA guidelines.

where applicable, at specified postoperative timelines (ie, 12 months).

Kappa score was used to assess agreement between the reviewers during the study screening. On the basis of the guidelines of Landis and Koch, a κ of 0 to 0.2 represents slight agreement, 0.21-0.40 fair agreement, 0.41-0.60 moderate agreement, and 0.61-0.80 substantial agreement.[18] A value greater than 0.80 is considered almost near perfect agreement.

Results

Study selection

Initial search of online databases yielded 632 titles from Ovid Medline and Ovid Embase, and 42 from CENTRAL. After deduplication, this yielded a total of 422 eligible studies that underwent screening. Using a predetermined inclusion criteria, after title, abstract, and full-text screening, a total of 5 eligible studies (227 tenotomy patients, 227 tenodesis patients) were used in this meta-analysis.[5,15,19,20,27] Literature search and screening results can be found in Figure 1. There were insufficient data comparing tenotomy and open tenodesis. Agreement on study inclusion between reviewers for title was near perfect (κ = 0.803, SE 0.040), for abstract was substantial (κ = 0.760, SE 0.092), and for full text was near perfect (κ = 0.900, SE 0.097) (see Fig. 1).

Assessment of risk of bias

Risk of bias assessment for included studies can be found in Figure 2. Castricini et al[5] reported 20% lost to follow-up without providing specification of blinding postoperative assessment. Hufeland et al's[15] outcomes were assessed by one of the authors and had a high relative degree of patient loss to follow-up. Lee et al[19] did not report standard deviations with postoperative pain or Constant-Murley scores and had a moderate degree of attrition bias. MacDonald et al[20] declared a conflict of interest with regard to funding. Study characteristics along with patient demographics can be found in Table II. Insufficient data on patient demographics such as body mass index, patient satisfaction, and arthroscopic approach was available for analysis.

Postoperative functional scores

Three of 5 studies reported Constant-Murley scores.[5,15,27] Lee et al[19] could not be used as no standard deviation of the Constant-Murley, ASES, or VAS pain scores were reported at the last follow-up. In these studies, 119 patients were treated with tenotomy and 107 patients were treated with tenodesis. No statistically significant difference existed between tenotomy and tenodesis with respect to Constant-Murley score (MD –3.16, CI –8.28, 1.95; $P = .23$). Significant heterogeneity was found between the groups ($I^2 = 87\%$, $P < .01$) (see Fig. 3).

Two studies reported ASES scores[15,20] comprising 63 patients treated with tenotomy and 57 patients treated with tenodesis. No significant difference was observed with respect to final ASES score (MD –6.17, CI –26.72, 14.39; $P = .56$). Significant heterogeneity was found between groups ($I^2 = 78\%$, $P < .05$) (see Fig. 4).

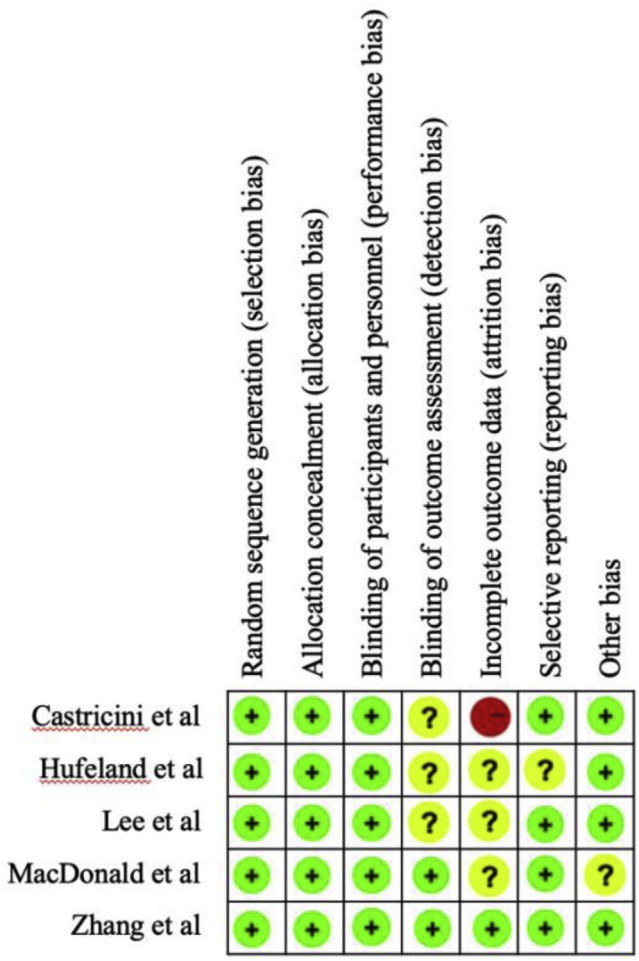

Figure 2 Risk of bias assessment for included studies.

Postoperative VAS pain

All studies reported postoperative pain as an outcome; however, only 3 studies could be used in the analysis.[5,20,27] Hufeland et al[15] used a 0-15 scale that was reverse in measurement (ie, 15 was no pain and 0 represented the highest degree of pain). With the scale reversed (ie, 15 → 0, 14 → 1, etcetera) and analyzed with data from the other studies, the results still indicated no significant difference in pain (SMD 0.05, CI –0.17, 0.26; $P = .68$). Because of the inconsistent reporting method compared with other studies and the relative insignificant effect on overall outcome, this study was not included in the analysis. Lee et al[19] reported no standard deviation. Across the 3 included studies, 160 patients were treated with tenotomy, and 146 patients were treated with tenodesis. No significant difference in postoperative pain was found between the 2 groups (MD –0.01, CI –0.39, 0.37; $P = .96$); no heterogeneity was found between the 2 groups either ($I^2 = 0\%$, $P = .54$) (see Fig. 5).

Popeye deformity

Postoperative Popeye deformity was assessed at latest follow-up across all 5 studies.[5,15,19,20,27] Of the 227 patients receiving tenotomy, 24.7% of patients (56 cases) developed Popeye deformity at latest follow-up. Of these 227 tenodesis patients, 17 cases (7.5%) developed Popeye deformity at latest follow-up. There was a statistically significant difference in favor of bicep tenodesis (RR 3.07, CI 1.87, 5.02; $P < .001$) compared with tenotomy. No heterogeneity was found between the 2 groups ($I^2 = 0\%$, $P > .99$) (see Fig. 6).

Postoperative flexion strength

Flexion strength was assessed in 3 studies.[5,15,20] There were 94 patients who received tenotomy and 81 who received tenodesis. There was no statistically significant difference found between tenotomy and tenodesis (MD -1.56 [CI -8.34 to 5.23], P = 0.65); no heterogeneity was found between the 2 groups ($I^2 = 90\%$, $P = .54$) (see Fig. 7).

Discussion

This study of the current highest available evidence finds that although both tenotomy and tenodesis are successful in alleviating pain and improving function, tenodesis carries a significantly lesser risk of patients developing Popeye deformity.

The Constant-Murley score has been the most widely used assessment of shoulder function since its inception.[6] Previous meta-analyses on the topic have had little agreement in postoperative function as measured by the Constant-Murley score, with evidence supporting both tenodesis,[22] tenotomy,[10] and no difference between the two.[11] All studies that reported the Constant-Murley score[5,15,27] found that both treatment modalities were effective in producing a significant improvement to function as defined by the minimal clinically important difference (MCID) of 10.4 for the Constant-Murley score.[17] This study, which provides the most up-to-date analysis using the highest-level evidence available, has not demonstrated superiority of either tenotomy or tenodesis in postoperative functional assessment via the Constant-Murley score. Similarly, no difference was found between tenotomy and tenodesis on the basis of the postoperative ASES score.

Assessment of postoperative pain as per the VAS resulted in a mean of 2.0 for tenotomy and 1.8 for tenodesis across the 4 studies[5,19,20,27] that reported it. Given the lack of consistent preoperative pain reporting in these studies, it cannot be concluded statistically that there was a significant improvement. However, given that the MCID for pain is 2.4,[25] and that the preoperative VAS scores reported ranged

Table II Study characteristics and patient demographics

Author (year)	Study type	Concomittant rotator cuff injury	Sample size		Average age, yr		Gender distribution, % male		Average follow-up, mo	
			Tenotomy	Tenodesis	Tenotomy	Tenodesis	Tenotomy	Tenodesis	Tenotomy	Tenodesis
Castricini et al 2018[5]	RCT	Yes	31	24	59.9	57.1	45.2	29.2	24	24
Hufeland et al 2019[15]	RCT	No	11	9	52.8	51.5	36.4	77.8	12	12
Lee et al 2016[19]	RCT	Yes	56	72	62.8	62.9	19.6	25.0	25.1	19.7
MacDonald et al 2020[20]	RCT	Yes	52	48	56.3	58.7	78.9	82	12	12
Zhang et al 2015[27]	RCT	Yes	77	74	61	61	46.8	47.3	25	25
Total	—		227	227	60.3	59.8			—	—

RCT, randomized controlled trial.

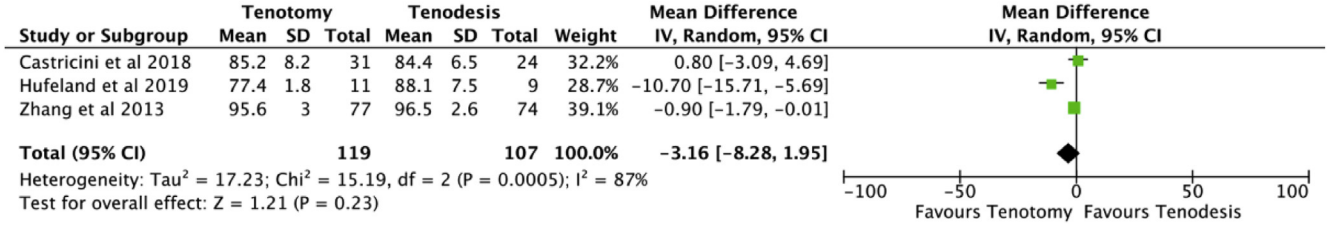

Figure 3 Constant-Murley scores.

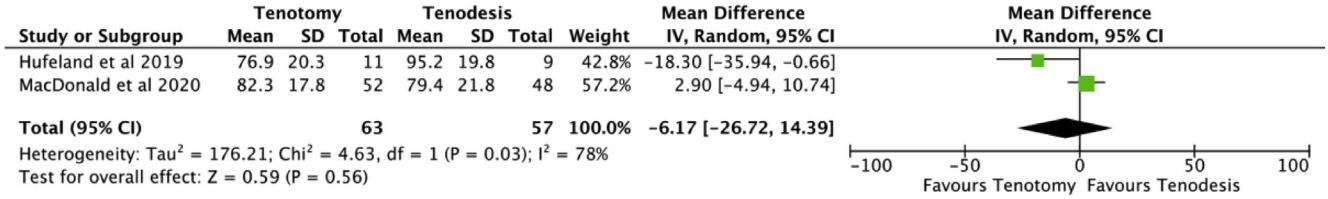

Figure 4 ASES scores. *ASES*, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form.

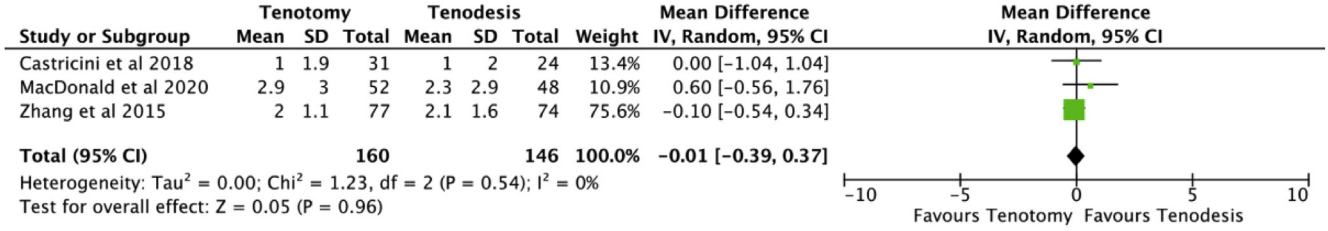

Figure 5 Postoperative pain on visual analog scale (VAS).

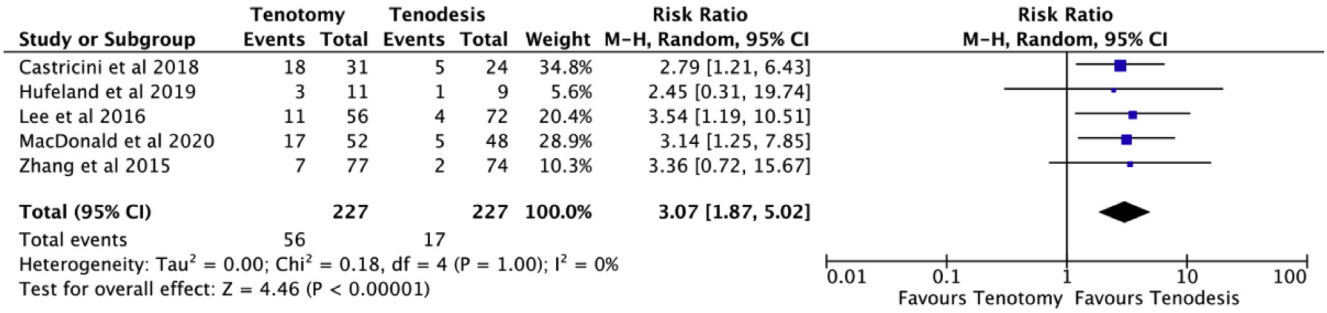

Figure 6 Postoperative Popeye deformity.

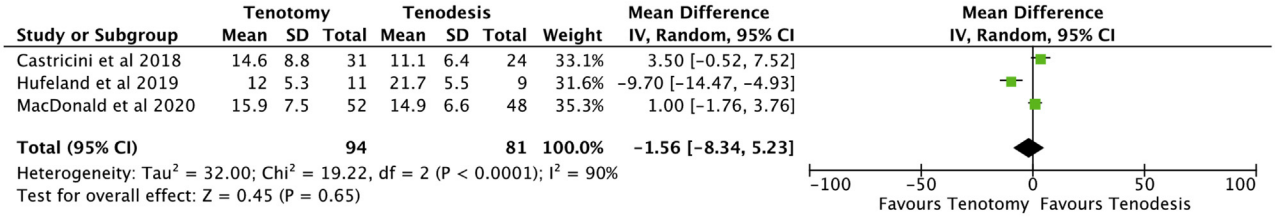

Figure 7 Postoperative flexion strength.

from 6.8-8.4 from the 2 studies that did report this value,[15,19] it is likely that both treatment methods are effective in alleviating pain, in accordance with previous findings.[26]

Similar to previous reviews and primary studies, this review has found that tenodesis is associated with a significantly lower relative risk of developing Popeye deformity postoperatively compared with tenotomy.[10,11,22] This study found that patients undergoing tenotomy were on average more than 3 times as likely to develop Popeye deformity when compared with their tenodesis counterparts. Despite the significantly increased risk, only a quarter of patients undergoing tenotomy developed the deformity. In addition, no heterogeneity was found between the 2 groups of patients across all 5 studies in the pooled assessment of Popeye deformity, lending to its validity. The implication of this difference may be helpful clinically in assessing whether patients may prefer one option to the other. Previous studies have found that body mass index can be a useful tool of assessment, as the deformity may be better masked in patients with a higher body mass index.[3] Other documented patient demographics that factor into cosmetic satisfaction are age[1,21] and gender,[21] with older patients and women giving more satisfactory reviews for tenotomy compared with their younger or male counterparts—a finding that may be attributable to a higher amount of muscle bulk in the latter group making the deformity more noticeable. Previous studies have indicated that patients in general find the results of either tenotomy or tenodesis favorable.[1] However, given the significantly higher chance of developing Popeye deformity with tenotomy, previously mentioned demographics, along with patient preference, can be crucial in determining the best course of surgical treatment.

Strengths and limitations

The advantage of this review is that studies of only Level I evidence were used, which provides the most salient and powerful set of data collection in the comparison of tenotomy and tenodesis of the LHBT. Compared with previous reviews,[9,22,26] the exclusive use of only RCTs limits the effects of confounding factors.

A notable weakness of this review is the heterogeneity in time points for the data reported in each included study. For instance, patients in Zhang et al's study[27] were followed up for 25 months, but the pain scores at latest follow-up were only stated for 4 weeks postoperatively. The impact of concomitant rotator cuff injuries is a potential confounding variable; however, given the nature of randomization, it should be balanced between groups. Two studies[5,19] did not report the presence of any concomitant rotator cuff pathologies. Hufeland et al[15] stated a total of 17 patients in their study with associated pathologies that underwent repair; however, the distribution of these patients across the 2 treatment arms was not specified. MacDonald et al[20] reported an even distribution of patients—37 of 57 in tenotomy and 34 of 57 in tenodesis—who received rotator cuff repair. Lastly, all patients in Zhang et al's study[27] received rotator cuff repairs.

Different time points made it difficult to pool all studies for all outcome variables. Another limitation is that given the restriction of including only Level I studies, few

studies—and by extension overall sample size—were eligible for data analysis, which means some of the conclusions can be underpowered. In addition, concomitant rotator cuff injuries were present in all but one study,[15] which likely makes an appreciable impact on postoperative functions. Postoperative cramping was not analyzed as only 2 studies formally reported the outcome using different methods.[20,27] Finally, not all studies reported the same postoperative outcomes. The only parameter reported by all studies included was Popeye deformity.

Conclusion

Both tenotomy and tenodesis result in comparable postoperative clinical and functional outcomes in patients with LHBT pathology. Tenodesis carries a significantly lower risk of developing a postoperative Popeye deformity.

Disclaimer

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