Early Versus Delayed Active Range of Motion After Open Subpectoral Biceps Tenodesis

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Background: Little is known regarding the effect of early active elbow range of motion (ROM) protocols on failure rates and outcomes after open subpectoral biceps tenodesis.

Hypothesis: We hypothesized that patients managed using an early active ROM protocol after open subpectoral biceps tenodesis would demonstrate similar failure rates and functional outcomes compared to patients managed using a traditional delayed active ROM protocol.

Study Design: Cohort study; Level of evidence, 3.

Methods: We evaluated 63 patients who underwent open subpectoral biceps tenodesis with unicortical suture button fixation. Based on surgeon preference, 22 patients were managed using an early active motion protocol consisting of no restrictions on elbow flexion or forearm supination, while 41 patients were managed using a delayed motion protocol postoperatively. Primary outcome measures included failure of biceps tenodesis and American Shoulder and Elbow Surgeons (ASES) and Single Assessment Numeric Evaluation (SANE) scores. Secondary outcomes included shoulder and elbow ROM at 6 months postoperatively.

Results: The mean follow-up for the 63 patients was 24.2 months postoperatively. One patient (2.4%) in the delayed active motion cohort and no patients in the early active motion cohort experienced failure. Final outcome scores as well as 6-month shoulder and elbow ROM indicated excellent functional outcomes, with no significant difference between motion cohorts. The median post-operative ASES scores were 97.99 in the early active motion cohort (mean ± standard deviation [SD], 95.49 ± 7.68) and 95.42 in the delayed motion cohort (mean ± SD, 90.93 ± 16.08), while median postoperative SANE scores were 96 in the early motion cohort (mean ± SD, 94.23 ± 6.68) and 95 in the delayed motion cohort (mean ± SD, 88.39 ± 17.98). Subgroup analysis demonstrated no significant difference in outcome scores based on the performance of concomitant rotator cuff repair or hand dominance.

Conclusion: Early active ROM after open subpectoral biceps tenodesis with unicortical suture button fixation resulted in low failure rates and excellent clinical outcomes, comparable to the results of patients managed using delayed active ROM protocols. This suggests that patients undergoing open subpectoral biceps tenodesis may be managed using either early or delayed active motion protocols without compromising functional outcome.

Keywords: biceps tenodesis; suture button; subpectoral; range of motion; biceps tendinitis

Pathology of the long head of the biceps (LHB) tendon and superior labrum complex is a common source of anterior shoulder pain and may derive from inflammation, tearing, or instability. Such processes can occur in isolation or in combination, often in association with rotator cuff pathology. Patients evaluated with symptoms related to the LHB–superior labral complex often undergo a trial of nonoperative management. For patients in whom nonoperative therapy fails, there exist several surgical options for treatment.

Biceps tenodesis is a well-established treatment for patients evaluated with pain secondary to LHB-superior labral complex pathology. Indications for tenodesis include biceps tendinosis and instability, superior labrum anterior-posterior (SLAP) lesions, and failed SLAP repair.[6,13] Biceps tenodesis involves detachment of the LHB tendon from the supraglenoid tubercle with fixation more distally along the proximal humerus, and it may be performed via an open, mini-open, or arthroscopic approach.[6,19] Numerous studies have demonstrated the clinical efficacy of biceps tenodesis, and the number of procedures performed annually in the United States has increased accordingly.[2,9,20] This trend is also likely attributable to studies that report improvements in supination strength, abduction strength, and cramping in patients undergoing tenodesis compared with biceps

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tenotomy,[1,14,21] as well as multiple studies demonstrating wide variability in outcomes after SLAP repair.[3,4]

Numerous techniques have been described for biceps tenodesis, with variations in approach (arthroscopic vs open) and fixation method (interference screws, transosseous tunnels, suture anchors, and cortical buttons). While previous data have suggested a greater strength of repair with interference screw fixation,[8,16] more recent literature has demonstrated no difference in biomechanical outcomes between interference screw and unicortical button constructs.[5,7]

Regardless of fixation technique, current rehabilitation after biceps tenodesis is guided by the belief that the tenodesed tendon should be protected in the early postoperative phase.[12,18] Many physicians limit early active elbow range of motion (ROM) and forearm supination after biceps tenodesis. To our knowledge, there is a paucity of studies examining whether early active motion after biceps tenodesis leads to an increased complication rate. A recent study by Liechti et al[12] reported excellent outcomes and low failure rates in patients undergoing biceps tenodesis with no postoperative ROM limitations. However, no study has directly compared outcomes between patients with and those without postoperative restrictions.

The purpose of this study was to compare the effects of early active elbow ROM versus delayed active ROM on patient-reported outcomes and failure rates in patients undergoing open subpectoral biceps tenodesis. Our hypothesis was that patients undergoing biceps tenodesis with no ROM restrictions would demonstrate similar outcomes to those patients in the traditional delayed active motion cohort.

METHODS

Patient Selection

Patients were identified via retrospective chart review and were subsequently contacted via telephone and email for collection of outcome data. All patients who underwent open subpectoral biceps tenodesis by 1 of 4 fellowship-trained surgeons (including E.S.C. and B.J.B.) between January 2016 and June 2019 were included in the study. Indications for tenodesis included proximal biceps tendon tear, biceps tendinosis, tendinitis or tenosynovitis, and SLAP tear. Despite the comparable outcomes demonstrated between biceps tenodesis and tenotomy, the authors prefer tenodesis because of the lower reported incidence of cosmetic deformity and increased forearm supination strength.[1,14,21] Of the 156 qualifying patients, 54 were excluded as they were aged <18 years, did not speak English, or declined to participate in the survey. Patients were not excluded on the basis of concomitant procedures requiring postoperative immobilization, including rotator cuff repair. Overall, 102 patients consented to fill out the online survey, and 63 completed all postoperative survey sections.

Surgical Technique

All biceps tenodeses were performed with the patient in the beach-chair position via a subpectoral approach utilizing an onlay, unicortical button technique. A diagnostic arthroscopy was first performed on all patients. The proximal LHB tendon was subsequently released arthroscopically. After completion of the tenotomy and any concomitant arthroscopic procedures, an incision was made at the axilla near the inferior border of the pectoralis major tendon. The pectoralis major tendon was then retracted laterally, and the LHB was dissected out and whipstitched approximately 2 cm from the musculotendinous junction. The sutures were then fed into a cortical button (Arthrex). A 3.2-mm unicortical hole was drilled near the base of the bicipital groove, approximately 1 cm superior to the inferior margin of the pectoralis tendon. The cortical button was then introduced into the intramedullary canal, and the sutures were pulled to bring the button flush along the anterior humeral cortex. The sutures were then tensioned to lay the biceps tendon against the humerus. The suture was passed through the tendon again using a free needle and subsequently tied down, completing the tenodesis.

Postoperative Management

Postoperative rehabilitation was performed at the discretion of the treating surgeon: 2 of 4 surgeons prescribed an early active protocol, while 2 employed a delayed active motion protocol. Patients in the early active motion cohort wore a sling for comfort postoperatively and were permitted to perform immediate active elbow flexion and forearm supination without limitations on ROM. Further restrictions on shoulder ROM and sling use were dictated by concomitant rotator cuff repair. All patients undergoing rotator cuff repair were managed using the same postoperative protocol (see Supplemental Material). Patients undergoing isolated biceps

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tenodesis had no restrictions on shoulder, elbow, or forearm motion; were allowed to wean from the sling as tolerated; and were permitted to perform activities of daily living with a 5-pound (2.25-kg) weight limit for the first 4 weeks. A progressive strengthening program was initiated at 4 weeks postoperatively, and patients were permitted to perform unrestricted activities at 12 weeks. Physical therapy was initiated within 1 to 2 weeks after surgery and was tailored to each patient based on concomitant procedures performed.

Patients in the delayed active motion cohort also wore a sling immediately after surgery. Sling immobilization was continued for 4 weeks in the setting of isolated biceps tenodesis and for 6 weeks in the setting of concomitant rotator cuff repair (see Supplemental Material). Gentle passive elbow ROM only was permitted postoperatively. After 4 weeks, patients progressed to active-assisted ROM and progressive weightbearing through the elbow. Return to full, unrestricted activity was typically permitted 12 weeks postoperatively.

Patient Assessment

Characteristic and historical data were retrieved via retrospective chart review. Data collected included patient characteristics (age, sex, body mass index, and hand dominance) as well as injury laterality, concomitant procedures performed, and any postoperative complications. Failure was defined as the documentation of a Popeye deformity on clinical examination or requirement for revision surgery. ROM at 6 months postoperatively, including forward elevation of the shoulder and flexion-extension arc of the elbow, was also recorded. After obtaining consent, we sent online surveys to patients at a minimum of 6 months postoperatively for collection of patient-reported outcome measures (PROMs). Documented PROMs included the American Shoulder and Elbow Surgeons (ASES) and Single Assessment Numeric Evaluation (SANE) scores. Preoperative outcome scores were not collected for this study.

Statistical Methods

An a priori power analysis was performed based on a primary outcome of a difference of at least 16.8 in ASES score between groups, equivalent to the substantial clinical benefit (SCB) as identified by Puzzitiello et al.[17] Assuming a standard deviation (SD) of 18.4[17] and a withdrawal rate of 10%, 22 patients in each group would be required to observe a difference in mean ASES score equivalent to the SCB with 80% power at $\alpha = .05$, while including 41 patients in the control group would achieve 90% power.

Categorical data are presented as counts with or without percentages and were compared using the Fisher exact or chi-square test as appropriate. Continuous data were assessed for normality using the Shapiro-Wilk test. Normally distributed data are presented as mean ± SD and were compared using the Student t test. Nonparametric data were presented as median (interquartile range [IQR]) and compared using the Mann-Whitney U or Kruskal-Wallis test as appropriate, with the post hoc Dunn test used for multiple comparisons when a significant difference was identified via Kruskal-Wallis analysis. The Hodges-Lehmann estimator of location was also computed for rank-based comparisons of nonparametric continuous data between 2 groups. The association of age with undergoing rotator cuff repair in this sample was assessed using univariate logistic regression. All analyses were conducted using R Version 3.6.3 (The R Foundation for Statistical Computing). The criterion for statistical significance was $P < .05$.

Multivariable linear regression was conducted to further clarify the influence of patient factors and surgical variables on ASES and SANE scores, including concomitant rotator cuff repair and surgery on the dominant extremity. An initial model with second-order interactions between early active elbow motion, concomitant rotator cuff repair, and surgery on the dominant extremity was evaluated and compared using a simplified model with first-order terms only via a type 2 analysis of variance test, overall R^2, and corrected Akaike information criterion (AICc). The results of the multivariable analyses were interpreted utilizing a Bonferroni-adjusted level of significance defined as $P < .005$ for 10 comparisons.

RESULTS

A total of 63 patients (mean ± SD age, 52.52 ± 10.26 years; range, 30-74 years) were included in the analysis, including 36 men (mean ± SD age, 49.83 ± 9.85 years; range, 30-69 years) and 27 women (mean ± SD age, 56.11 ± 9.86 years; range, 36-74 years). There were 22 patients in the early active motion cohort, and 41 patients in the delayed motion control cohort. The mean follow-up time was 24.2 months (range, 6-55 months). The majority of patients underwent concomitant rotator cuff repair. This was the case overall, as well as in both early and delayed motion cohorts separately. Patient baseline characteristics, including comparisons between groups, are summarized and presented in Table 1.

Patient-Reported Outcomes

The median postoperative ASES scores were 97.99 in the early active motion cohort (mean ± SD, 95.49 ± 7.68; range, 64.77-100) and 95.42 in the delayed motion cohort (mean ± SD, 90.93 ± 16.08; range, 10.55-100). There was no significant difference in ASES between cohorts ($P = .281$) (Table 2). The median postoperative SANE scores were 96 in the early motion cohort (mean ± SD, 94.23 ± 6.68; range, 73-100) and 95 in the delayed motion cohort (mean ± SD, 88.39 ± 17.98; range, 10-100). There was no significant difference in SANE between cohorts ($P = .173$) (Table 2).

Effects of Rotator Cuff Repair

Overall, a total of 40 patients (63.49%) underwent concomitant rotator cuff repair, including 14 (63.64%) in the early active motion cohort and 26 (63.41%) in the delayed active motion cohort. For patients undergoing concomitant rotator cuff tear, the median (IQR) postoperative ASES and

SANE scores were 97.98 (93.46-99.88) and 95.5 (89.75-99), respectively, compared with 95.05 (88.92-98.82) and 94 (85.5-97), respectively, for patients who underwent isolated biceps tenodesis. There was no significant difference in postoperative ASES (Hodges-Lehmann estimate, 0.87; 95% confidence interval [CI], –0.82 to 3.83; P = .285) or SANE (Hodges-Lehmann estimate, 2.00 [95% CI, –1.00 to 6.00]; P = .180) based on undergoing concomitant rotator cuff repair. The effects of concomitant rotator cuff repair were also considered within the 2 study cohorts (Table 3). No significant differences in postoperative ASES (P = .399) or SANE (P = .296) were observed.

TABLE 1
Baseline Patient Characteristics[a]

	Overall (N = 63)	Early Active Motion (n = 22)	Delayed Active Motion (n = 41)	P
Age	52.52 ± 10.26	54.64 ± 10.91	51.39 ± 9.85	.251[b]
Sex				>.999[c]
Male	36 (57.14)	13 (59.09)	23 (56.1)	
Female	27 (42.86)	9 (40.91)	18 (43.9)	
Body mass index	28.24 ± 4.53	28.18 ± 4.41	28.27 ± 4.65	.941[b]
Dominant side affected?				>.999[b]
Yes	38 (60.32)	13 (59.09)	25 (60.98)	
No	25 (39.68)	9 (40.91)	16 (39.02)	
Concomitant rotator cuff repair?				>.999[b]
Yes	40 (63.49)	14 (63.64)	26 (63.41)	
No	23 (36.51)	8 (36.36)	15 (36.59)	

[a]Data are presented as mean ± SD or n (%).
[b]Student *t* test.
[c]Fisher exact test.

Effects of Operative Extremity Being the Dominant Extremity

Thirty-eight patients (60.32%) had surgery on their dominant upper extremity, including 13 (59.09%) in the early active motion cohort and 25 (60.98%) in the delayed active motion cohort. The median (IQR) postoperative ASES scores were 98.29 (94.4225-99.9875) among patients who had surgery on their dominant upper extremity and 95.416 (90.15-99.25) among patients who had surgery on their nondominant upper extremity. Having surgery on the dominant side was not associated with a significant difference in postoperative ASES score (Hodges-Lehmann estimate, 1.03; 95% CI, –0.60 to 4.00; P = .212). By contrast, postoperative SANE scores were significantly higher among patients who had surgery on the dominant extremity (median [IQR], 96 [90-98.75] for dominant vs 89 [85-96] for nondominant; Hodges-Lehmann estimate, 4.00; 95% CI, 0.00008-9.00; P = .029).

A subgroup analysis was conducted to examine the effects of operating on the dominant extremity, similar to the procedure carried out for concomitant rotator cuff repair (Table 4). Postoperative ASES did not differ significantly between early and delayed active motion cohorts depending on whether the operative extremity was the dominant versus nondominant side (P = .417); however, using the Kruskal-Wallis test, we did identify significant differences in postoperative SANE scores among these subgroups. Post hoc pairwise analysis using the Dunn test revealed that postoperative SANE scores were significantly lower among patients in the delayed motion cohort who had

TABLE 2
Patient-Reported Outcomes of Biceps Tenodesis Using Early and Delayed Active Motion Protocols[a]

Outcome Measure	Early Active Motion	Delayed Active Motion	P[b]	Hodges-Lehmann Estimate (95% CI)
ASES	97.99 (95.27 to 99.85)	95.42 (91.05 to 99.40)	.281	0.76 (–0.65 to 4.24)
SANE	96.00 (94.25 to 98.75)	95.00 (86.00 to 97.00)	.173	2.00 (–1.00 to 7.00)

[a]Patient-reported outcomes are presented as median (interquartile range). ASES, American Shoulder and Elbow Surgeons; SANE, Single Assessment Numeric Evaluation.
[b]Mann-Whitney *U* test.

TABLE 3
Subgroup Analysis of Patient-Reported Outcomes Based on Concomitant Rotator Cuff Repair[a]

	Early Active Motion		Delayed Active Motion		
Outcome Measure	With RCR	Without RCR	With RCR	Without RCR	P[b]
ASES	98.42 (96.38-99.96)	96.93 (92.84-98.33)	97.16 (91.82-99.36)	94.95 (88.92-99.58)	.399
SANE	96.5 (95-98.75)	95.5 (92-97.5)	95 (88.5-98.5)	88 (85-97)	.296

[a]Patient-reported outcomes are presented as median (interquartile range). ASES, American Shoulder and Elbow Surgeons; RCR, rotator cuff repair; SANE, Single Assessment Numeric Evaluation.
[b]Kruskal-Wallis test.

TABLE 4
Subgroup Analysis of Patient-Reported Outcomes Based on Hand Dominance[a]

Outcome Measure	Early Active Motion		Delayed Active Motion		P^b
	Operative, Dominant	Operative, Nondominant	Operative, Dominant	Operative, Nondominant	
ASES	98.33 (96.21-100)	97.65 (94.65-99.85)	98.28 (93.5-99.95)	94.14 (89.1675-98.95)	.417
SANE	97 (95-98)	96 (89-99)	96 (90-99)	87.5 (84.5-95)	.049

[a]Patient-reported outcomes are presented as median (interquartile range). ASES, American Shoulder and Elbow Surgeons; SANE, Single Assessment Numeric Evaluation.
[b]Kruskal-Wallis test.

TABLE 5
Multivariable Linear Regression for SANE Score[a]

	Estimate	SE (95% CI)	P^b
Early active motion	12.742	9.367 (–6.054 to 31.539)	.180
Male sex	–0.091	4.253 (–8.624 to 8.443)	.983
Age	–0.004	0.249 (–0.503 to 0.496)	.988
Body mass index	0.031	0.442 (–0.575 to 1.199)	.483
Surgery on dominant extremity	13.488	7.927 (–2.419 to 29.394)	.095
Rotator cuff repair	2.396	7.885 (–13.427 to 18.220)	.762
Early active motion and rotator cuff repair[c]	–2.069	12.867 (–27.889 to 23.751)	.873
Early active motion and surgery on dominant extremity[c]	–12.878	13.314 (–39.595 to 13.838)	.338
Rotator cuff repair and surgery on dominant extremity[c]	–1.304	10.312 (–21.995 to 19.388)	.900
Early active motion, rotator cuff repair, and surgery on dominant extremity[c]	5.558	17.358 (–29.273 to 40.389)	.750

[a]The estimate is the regression coefficient. SANE, Single Assessment Numeric Evaluation.
[b]Bonferroni-corrected level of significance: $P < .005$.
[c]Second-order interaction.

TABLE 6
Multivariable Linear Regression for ASES Score[a]

	Estimate	SE (95% CI)	P^b
Early active motion	0.510	8.896 (–17.342 to 18.362)	.954
Male sex	2.176	4.039 (–5.929 to 10.281)	.592
Age	–0.064	0.236 (–0.539 to 0.410)	.787
Body mass index	–0.376	0.420 (–1.218 to 0.466)	.410
Surgery on dominant extremity	6.641	7.529 (–8.466 to 21.749)	.382
Rotator cuff repair	3.016	7.489 (–12.012 to 18.044)	.689
Early active motion and rotator cuff repair[c]	4.332	12.220 (–20.190 to 28.854)	.724
Early active motion and surgery on dominant extremity[c]	–2.735	12.645 (–28.108 to 22.639)	.830
Rotator cuff repair and surgery on dominant extremity[c]	–9.692	9.793 (–29.344 to 9.959)	.327
Early active motion, rotator cuff repair, and surgery on dominant extremity[c]	6.967	16.485 (–26.113 to 40.047)	.674

[a]The estimate is the regression coefficient. ASES, American Shoulder and Elbow Surgeons.
[b]Bonferroni-corrected level of significance: $P < .005$.
[c]Second-order interaction.

surgery on their nondominant extremity compared with patients in both delayed ($P = .016$) and early ($P = .014$) motion cohorts who had surgery on their dominant side. There was no significant difference in postoperative SANE score between patients in the delayed and early motion cohorts who had surgery on the dominant ($P = .662$) or nondominant ($P = .091$) side or between patients in the early motion cohort who had surgery on the dominant side versus on the nondominant side ($P = .623$).

Multivariable Analysis

Multivariable analysis demonstrated no difference in SANE or ASES score based on patient factors including sex, age, hand dominance, and body mass index or based on surgical factors including rotator cuff repair and postoperative protocol. Specifically, multivariable analysis for SANE score including interaction terms ($R^2 = 0.1664$; $P = .4257$; AICc = 539.6) was not significantly different from a simplified first-order effects-only model ($R^2 = 0.1444$; $P = .1716$; AICc = 529.7) ($P = .8469$) (Table 5). Multivariable analysis for ASES score including interaction terms ($R^2 = 0.09078$; $P = .8688$; AICc = 533.1) was not significantly different from a simplified first-order effects-only model ($R^2 = 0.0524$, $P = .7937$; AICc = 524.1) ($P = .7007$) (Table 6).

Range of Motion

The mean (± SD) forward elevation of the shoulder in the early active cohort at 6 months postoperatively was 168.14° ± 12.64° compared with 168.66° ± 15.38° in the delayed active motion cohort (P = .8930). The mean (± SD) flexion-extension arc of the elbow in the early active cohort at 6 months postoperatively was 131.14° ± 4.25° compared with 129.15° ± 3.81° in the delayed active motion cohort (P = .0666).

Complications

One patient (2.44%) in the delayed motion cohort experienced a failure of tenodesis with rupture of the proximal biceps tendon 3 weeks postoperatively when he reached out to prevent a 5-gallon (19-L) water cooler from falling on his dog. He elected not to undergo revision surgery and returned to martial arts at 5 weeks postoperatively. No patient in the early active motion cohort had experienced biceps tendon rupture or undergone revision surgery at the time of final follow-up. Patients were also monitored for other postoperative complications including stiffness, neurological injury, and surgical site infection. None of these complications were reported during the study period.

DISCUSSION

The present study found no increased risk of failure in an early active motion cohort after open subpectoral biceps tenodesis compared with a delayed active motion control cohort. Furthermore, both groups demonstrated similar clinical outcomes, as quantified via the SANE and ASES scores. Finally, we found no significant difference in postoperative shoulder and elbow ROM between early and delayed active motion cohorts. To our knowledge, this is the first study to directly compare outcomes of 2 different postoperative protocols after biceps tenodesis, as well as the first to specifically investigate early versus delayed active elbow ROM. Our finding that early active ROM after biceps tenodesis does not result in increased failure rates or superior ROM suggests that patients undergoing open subpectoral biceps tenodesis may be managed using either early or delayed active motion protocols postoperatively, at the discretion of the treating surgeon.

Our failure rates of 2.4% (delayed active motion) and 0% (early active motion) are consistent with those previously reported in the literature.[9-12] In addition to low failure rates, we also demonstrated excellent functional outcomes in both early active and delayed motion cohorts, with no significant difference between the 2. The outcomes reported in our study are similar to those previously reported in patients undergoing both open and arthroscopic biceps tenodesis for various indications, as well as patients managed using early active versus delayed ROM.

Gottschalk et al[10] reported on 26 patients with type II and IV SLAP lesions who underwent subpectoral biceps tenodesis with interference screw fixation. All patients were immobilized for 3 weeks postoperatively with only passive ROM of the elbow permitted during this time. The authors noted a 3.4% failure rate in their cohort of patients, similar to the failure rate of 2.4% noted in our delayed ROM cohort. At an average follow-up of 40 months, the authors reported a mean ASES score of 87.5, similar to our median postoperative ASES scores of 95.4 and 98.0 in the delayed and early active motion cohorts, respectively.

Gupta et al[11] described a similar cohort of 28 patients with SLAP tears and biceps tendonitis treated using open subpectoral biceps tenodesis with interference screw fixation. Patients were initially restricted to passive elbow ROM but were permitted rapid progression to active-assisted and subsequently active ROM. The authors reported no failures as well as significant improvement in clinical outcome scores, with mean postoperative ASES and SANE scores of 89 and 88, respectively. These findings are consistent with our reported ASES scores as well as median postoperative SANE scores of 96.0 and 95.0, respectively, in our early active and delayed motion cohorts.

In addition to studies of patients managed nonoperatively using passive ROM protocols, our findings are consistent with those of cohorts managed more aggressively. Gombera et al[9] presented a comparison of outcomes after arthroscopic suprapectoral versus open subpectoral biceps tenodesis with interference screw fixation. While patients in each cohort were initially restricted to passive elbow ROM, active ROM was permitted in all patients at 2 to 3 days postoperatively. The authors reported no failures of tenodesis in either cohort of 23 patients, similar to our early active subgroup and to the results of Gupta et al.[11] The authors further demonstrated mean postoperative ASES scores of 92.3 and 88.9, respectively, in patients undergoing open and arthroscopic tenodesis, similar to our findings.[9]

Liechti et al[12] reported on 98 patients who underwent isolated open subpectoral biceps tenodesis with dual cortical button and interference screw fixation. In contrast to prior studies, the authors allowed immediate active motion of the extremity, with no postoperative strength or ROM restrictions. The authors reported a failure rate of 2.2%, as well as a mean postoperative ASES score of 89.4, similar to the finding of 98.0 in our early active subgroup. Based on their results, the authors concluded that a dual-fixation construct may obviate the need for postoperative limitations after biceps tenodesis. Our results support these findings and suggest that a single-construct fixation with a unicortical suture button is sufficient to minimize failure in both early active and delayed motion protocols.

Although the aforementioned studies demonstrated similar failure rates and PROMs in patients undergoing early and delayed active motion protocols, no study recorded postoperative ROM. While some studies have reported shoulder ROM after biceps tenodesis,[1] elbow ROM is uncommonly reported. Our finding that early active motion after biceps tenodesis does not result in improved postoperative elbow ROM may lead some surgeons to continue use of a delayed active motion protocol postoperatively, given the lack of apparent benefit of early postoperative motion.

In addition to demonstrating no significant difference in outcomes between early active and delayed motion protocols, we found no significant difference in functional outcomes between these groups based on the performance of concomitant rotator cuff repair. Subgroup analysis of PROMs in patients undergoing rotator cuff repair demonstrated similarly excellent outcomes between the early active and delayed motion protocols, with median ASES scores of 98.4 and 97.2, respectively. This was also true of patients undergoing isolated subpectoral biceps tenodesis in the absence of rotator cuff repair, with median ASES scores of 96.9 and 95.0. While no study has evaluated the outcomes of biceps tenodesis in the context of postoperative motion protocol and concomitant rotator cuff repair, our results are consistent with reported outcomes after combined biceps tenodesis and rotator cuff repair. In a prospective randomized study comparing interference screw versus suture anchor fixation in patients undergoing arthroscopic biceps tenodesis with concomitant rotator cuff repair, Park et al[15] reported a mean postoperative ASES score of 93.2. All patients in this study were allowed immediate active elbow flexion and supination postoperatively. Notably, the authors reported failure rates of 21% and 5.8%, respectively, in the interference screw and suture anchor cohorts. Despite the higher failure rates observed in this study, the excellent functional outcomes reported in this population managed using immediate active ROM are consistent with our findings.

Our study has several strengths. This is the first study, to our knowledge, that directly compares the outcomes of 2 different rehabilitation protocols after biceps tenodesis. Our study further stratified patients based on concomitant rotator cuff repair and hand dominance, offering insight into the effect of these patient-specific factors on functional outcomes. Additionally, each patient in our cohort underwent subpectoral biceps tenodesis by 1 of 4 fellowship-trained surgeons using the same technique and implant. This lends consistency to our methodology and contributes to the validity of our results, although it does limit the generalizability of our findings.

Our study has several limitations. One-third of eligible patients undergoing tenodesis declined to participate in our follow-up survey. It is possible that patients experiencing worse outcomes were less likely to consent, therefore biasing our results in favor of higher PROMs. The high PROMs reported in this study may also indicate a ceiling effect, limiting our ability to differentiate between groups. We were also unable to ascertain preoperative outcome scores in either cohort and were therefore unable to determine the net clinical improvement offered by each rehabilitation protocol. Furthermore, although our mean follow-up period was 24 months, we did include patients with only 6 months of follow-up. It is possible that some clinical benefit or decline would have occurred further from surgery, and therefore would have been missed in our survey. However, Puzzitiello et al[17] noted a lack of significant changes in PROMs at 6 months and 1 year postoperatively in their analysis of the minimal clinically important difference and SCB for patient-reported outcomes after biceps tenodesis. We thus believe that our decision to include 6-month follow-up patient outcome scores is reasonable.

A further limitation is our heterogeneous study population, given the inclusion of a subset of patients undergoing concomitant rotator cuff repair. We attempted to address this limitation by performing a subgroup analysis comparing patients with and those without rotator cuff repair and demonstrated no difference in outcomes between the 2 groups. Finally, our study is limited by its lack of randomization, small sample size, and single surgical technique. Our results should be applied cautiously to patients treated arthroscopically or via alternative methods of fixation. As postoperative protocol was dictated by surgeon preference rather than randomization, it is possible that outcomes were influenced by surgical skills or technical ability. Furthermore, although the observed failure rates appeared similar between cohorts, it is possible that because of a small sample size and low incidence of rerupture, our study was underpowered to detect a significant difference in failure rates between the 2 cohorts. Larger, randomized studies are necessary to determine the optimal rehabilitation protocol after open and arthroscopic biceps tenodesis.

CONCLUSION

Early active elbow ROM after open subpectoral biceps tenodesis with unicortical suture button fixation resulted in low failure rates and excellent clinical outcomes. This study demonstrated no significant difference in failure rates, PROMs, or postoperative shoulder and elbow ROM between early and delayed active elbow motion protocols. This suggests that patients undergoing open subpectoral biceps tenodesis may be managed using either early or delayed active motion protocols postoperatively, at the discretion of the treating surgeon, without compromising functional outcome.

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