RESEARCH ARTICLE

Patient Reported Outcomes of Long Head Biceps Tenodesis after Spontaneous Rupture

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Abstract

Background: The aim of this study was to evaluate the factors influencing patient reported outcome measures (PROM) of biceps tenodesis after the rupture of proximal long head of the biceps tendon.

Methods: Retrospective chart review was conducted to identify patients with complete proximal rupture of the long head of the biceps that underwent biceps tenodesis between 2002-2017. This yielded 42 patients, of which 23 (55%) completed the PROMIS Pain Interference, PROMIS Upper Extremity, Quick DASH, and a custom biceps tear questionnaire, at a median of 8.5 years (IQR:5.2-12) post-operatively. The median age of the respondents was 57 years (IQR: 43-61). The majority of patients (n=12, 52%) underwent tenodesis using suture anchor fixation, while the remaining underwent tenodesis with interference screw technique (n=6, 26%), key hole technique (n=1, 4.3%), or tunnel technique (n=1, 4.3%). A bivariate analysis was performed to evaluate factors influencing the PROMs.

Results: Six patients (27%) reported persistent biceps cramping at a median of 8.2 years post-operatively, negatively impacting PROMs, and this was associated with older age. Six patients (27%) had post-operative complications, including infection, pain, stiffness, and re-rupture, of which four patients (17%) underwent reoperation. Patients with activity/sports-induced injury or those that underwent tenodesis using a suture anchor technique demonstrated better PROMs.

Conclusion: Post-operative biceps cramping persists in almost one-third of patients and significantly impacts PROMs. Patient activity level and the use of suture anchor technique for tenodesis were independent predictors of improved biceps tenodesis outcome scores.

Level of evidence: IV

Keywords: Long head biceps tendon, Patient reported outcomes, Tenodesis

Introduction

The proximal tendon of the long head of the biceps (LHB) runs from the glenoid labrum through the bicipital groove to the muscle belly of the biceps tendon. Various functions have been proposed for the LHB tendon, but they continue to be debated (1-4). The majority of biceps brachii injuries consist of ruptures of the proximal tendon of the long head and often present in patients at 40s and 50s (5). Usually, a proximal LHB tendon tear is characterized by a characteristic "Popeye" deformity due to distal retraction of the muscle (2-4).

Most patients undergo conservative treatment after a proximal biceps rupture (6, 7). If surgery is elected, it usually consists of a biceps tenodesis. Biceps tenotomy followed by immediate tenodesis is commonly performed in patients undergoing shoulder surgery for other problems (8-10); however, there is a paucity of data regarding biceps surgery after prior rupture. Surgery is complicated by proximal tendon atrophy and reciprocal

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changes of the bicep muscle belly which make tenodesis less predictable. The aim of this study was to evaluate the factors influencing patient reported outcomes of biceps tenodesis after proximal long head of the biceps tendon rupture.

Materials and Methods

This retrospective study was conducted at a single institutional system after institutional review board approval. To identify patients, we used Current Procedural Technology (CPT) codes ("29828", "23430") and International Classification of Diseases (ICD), Ninth and Tenth Revision procedure codes that coded for biceps tenodesis ("0LQ10ZZ", "0LQ20ZZ", "83.61", "83.63", "83.88"). These results were cross-matched with ICD-9 and ICD-10 diagnoses codes ("727.62", "M66.821", "M66.822", "M66.829", "S46.119A") that coded for proximal long head of the biceps tendon ruptures to identify patients who underwent a biceps tenodesis for a rupture of the proximal biceps long head tendon (n=1306). All adult patients with complete proximal biceps tendon rupture prior to surgery and underwent a biceps tendon tenodesis from January 2002 to December 2017 were included. Patients were treated at one of five urban academic hospitals in the Northeastern United States. To identify patients with a potential proximal biceps tendon tear, a data processing program (STATA 14.0, StataCorp, Texas, USA) was used to text-search the clinic notes for the following string: "proximal bicep". A subsequent chart review was performed to verify treatment with a proximal biceps tenodesis, and 625 were excluded for either having no bicep tear, did not undergo a tenodesis, had a rupture of a different tendon or not having an operative note (n=681). Additionally, 639 patients who had a partial tear of the long head of the biceps tendon were excluded. A total of 42 patients had a biceps tenodesis for a full rupture of the proximal long head of the biceps tendon.

All living patients (n=42) were contacted by mail and then by telephone to complete questionnaires. Twenty-three patients (55%) agreed to complete the questionnaires, eight (19%) declined to participate, and 11 (26%) could not be contacted. Three patients had already been deceased at the time this study was conducted. Patient demographics, injury characteristics/symptoms, and operative information were extracted by manual medical chart review. Post-operative complications were also recorded, including infections, pain, stiffness, re-rupture, and physician reported decreased range of motion. Reoperation was defined as any unplanned surgery of the ipsilateral shoulder of the initial biceps tenodesis. The mechanisms of injury were grouped as spontaneous, traumatic, sports induced, and unknown. The type of surgery was divided into open and arthroscopic, and the technique of tenodesis was categorized as suture anchor, interference screw, keyhole, or tunnel. Follow-up was defined as the time from surgery to the time of completion of the questionnaires.

Study population

The included 23 patients had a median age of 57 years (IQR: 43-61) and a median follow-up of 8.5 years (IQR: 5.2-12) [Table 1]. Twenty-one patients (91%) were male, and 18 (78%) were manual laborers. The most common mechanism of injury was sports induced (n=11, 48%). The median time from injury to surgery was 1.5 months (IQR: 0.8-3) and 15 (65%) patients had conservative treatment including pain medication and physical therapy prior to surgery. Seventeen patients had some other associated shoulder pathology (including a partial rotator cuff tear, labral tear, glenohumeral synovitis, subacromial bursitis, acromioclavicular arthrosis or a combination of these), and six patients had no other shoulder pathology.

Indications for proceeding with biceps tenodesis included pain (n=15), limited range of motion (n=6), and cosmetic reasons (n=2). The location of the rupture was not reported in 8 patients and for the other 15 patients, majority of tear was located near the bicipital groove (n=10). Other areas included muscle tendon junction (n=3) and glenoid-humeral region (n=2).

The majority of patients (n=12, 52%) had a tenodesis with suture anchor fixation (Bio-sutureTak, Mitek Lupine, Panalok, Fastenator, Bioraptor, Osteoraptor, and SwiveLock), other techniques included interference screw technique (n=6, 26%), key hole technique (n=1, 4.3%), tunnel technique (n=1, 4.3%), and other (n=3, 13%) [Table 2]. Only one patient had an arthroscopic tenodesis. Surgeries were performed by 17 orthopedic surgeons, of which three performed more than one procedure. Six patients were referred to our institution for treatment.

Patient reported outcomes

The patient reported outcome questionnaires were the PROMIS Upper Extremity (UE) v2.0 CAT, PROMIS Pain Interference v1.1 CAT, Quick Disabilities of the

Table 1. Patient Demographics

Variable	# of patients
Total patients	23
Median age in years (IQR)	57 (43-61)
Gender, n(%)	
Male	21 (91)
Female	2 (8.8)
Race, n(%)	
Caucasian	18 (82)
Black	2 (8.7)
Asian	1 (4.3)
Other	2 (8.7)
Tobacco use, n(%)	1 (4.3)
Diabetes, n(%)	3 (13.0)
Occupation, n(%)	
Manual labor	10 (44)
Non-manual labor	13 (57)

Table 2. Injury and treatment characteristics

Variable	# of patients
Median time to surgery in months (IQR)	1.5 (0.82-3.0)
Median time to follow up in years (IQR)	8.5 (5.2-12)
Underwent conservative treatment, n(%)	15 (65)
Popeye sign, n(%)	18 (78)
Pre-operative bicep cramping, n(%)	12(52)
Mechanism of injury, n(%)	
Spontaneous	5 (22)
Traumatic	5 (22)
Activity induced/sports	11 (48)
Unknown	2 (8.7)
Surgery type, n(%)	
Open	22 (95)
Arthroscopic	1 (4.3)
Technique of tenodesis, n(%)	
Anchor	12 (52)
Interference screw	6 (26)
Key hole	1 (4.3)
Tunnel	1 (4.3)
Other	3 (13)
Intra-operative rotator cuff repairs, n(%)	9 (39)

Arm, Shoulder and Hand (DASH) score, and a custom biceps tear questionnaire [Appendix 1]. The PROMIS UE assesses patients' self-reported upper extremity function with a higher score representing a better function. The PROMIS pain interference evaluates the self-reported limitation of social, physical, and mental activities due to pain, where a higher score represents more limitations. Both PROMIS UE and pain interference have a mean score of 50 based on the general population in the United States of America, with a standard deviation of 10. The Quick DASH survey yields a composite score of 0-100, with a higher score indicating greater disability of the upper extremity (11). The custom biceps tear questionnaire was designed by the authors and aimed to evaluate proximal biceps tear symptoms, specifically directed at post-surgical cramping, how often it occurs, how long it lasts, and any alleviating/aggravating factors.

Study data were collected and managed using REDCap (Research Electronic Data Capture) tool hosted at our institution (12). REDCap is a secure, web-based application designed to support data capture for research studies, providing: 1) an intuitive interface for validated data entry; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for importing data from external sources.

Statistical Analysis

A bivariate analysis was performed to evaluate the factors influencing the patient-reported outcomes after biceps tenodesis for a full long head proximal biceps rupture. We only included age, time to surgery, occupation, mechanism of injury, tenodesis technique, whether an intra-operative rotator cuff repair was performed, and pre-operative cramping in analysis because other explanatory variables had small comparison groups. Another bivariate analysis was performed to evaluate which of the factors above influence post-operative cramping. The Spearman's rank correlation coefficient was used to evaluate the influence of nonparametric continuous explanatory variables on nonparametric continuous response variables; the Mann-Whitney U test was used to evaluate the influence of dichotomous explanatory variables on nonparametric continuous response variables. To evaluate the factors associated with post-operative biceps cramping we used the Fisher's exact test for dichotomous and categorical variables and the Mann-Whitney U test for age (non-parametric). A Fisher's exact test was performed to evaluate whether the technique of tenodesis and mechanism of injury were correlated. Statistical significance was defined as $P<0.05$ for all tests. Data were analyzed using STATA 14.0 (StataCorp, Texas, USA).

Results

The median PROMIS UE score was 50.4 (IQR: 39.4-54.5); the median PROMIS pain interference score was 28.7 (IQR: 28.7-46.6), and the median QuickDASH score was 9.1 (IQR: 2.3-18.2) [Table 3]. A proximal biceps tendon rupture due to sports injury was associated with a higher PROMIS upper extremity score compared to other mechanisms of injury (55, IQR: 45-61 vs 44, IQR: 34-51: $P=0.03$). Furthermore, a suture anchor technique for the biceps tenodesis was also associated with a higher PROMIS upper extremity score compared to the other listed surgical techniques (55, IQR: 48-58 vs 48, IQR: 39-50: $P=0.05$). There was no covariation between the mechanisms of injury and surgical technique (rho=0.05, $P= 0.59$). The median time from injury to surgery was 1.5 months (IQR: 0.8-3).

Post-operatively, six (27%) patients reported biceps cramping; the presence of this symptom was associated with inferior patient reported outcomes in all three questionnaires [Tables 3; 4]. Older age was associated with post-operative cramping ($P=0.03$) [Table 5]. For the six patients who reported cramping, the median (IQR) time to surgery was 1.4 (0.92-2.7) months and similar to the rest of the study cohort (1.65 (0.85-3.3), $P=0.72$). Other shoulder pathologies in these patients included partial RC (n=5) and labral tears (n=2) and one patient with no other pathology. The location of the tear was near the bicipital groove (n=2), near the glenoid-humeral junction (n=2), distal to the pectoralis major border (n=1) or not reported (n=1). The repair techniques included anchor (n=2), interference screw (n=2), tunnel (n=1), and undefined in one patient.

Six patients (27%) had post-operative complications including infection, pain, stiffness, and re-rupture, of

Table 3. Patient-reported outcomes

	PROMIS UE	PROMIS Pain	QuickDash
	Median (IQR)	Median (IQR)	Median (IQR)
All patients (n=23[a])	50.4 (39.4-54.5)	28.7 (28.7-46.6)	9.1 (2.3-18.2)
Age spearman correlation coef.	-0.29	0.09	0.3
P-value[b]	0.18	0.68	0.17
Time to surgery spearman correlation coef.	0.027	-0.02	0.05
P-value[b]	0.90	0.30	0.83
Occupation			
Manual labor (n=10[a])	51 (34-56)	39 (39-59)	9.1 (2.3-18)
Non-manual labor (n=13)	49 (44-55)	39 (39-46)	9.1 (2.3-18)
P-value[c]	0.95	0.54	0.59
Mechanism of injury			
Sports induced (n=11)	55 (45-61)	39 (39-54)	4.5 (0-18)
Other (n=12[a])	44 (34-51)	39 (39-46)	11 (4.5-32)
P-value[c]	0.03	0.96	0.18
Reoperation			
Yes (n=4)	38 (26-50)	51 (39-64)	30 (3.4-69)
No (n=19[a])	51 (44-56)	39 (39-46)	9.1 (2.3-18)
P-value[c]	0.10	0.18	0.26
Tenodesis technique			
Anchor (n=12)	55 (48-58)	39 (39-39)	2.3 (0-14)
Other (n=11[a])	48 (39-50)	43 (39-54)	11 (9.1-18)
P-value[c]	0.05	0.23	0.07
Rotator Cuff Repair			
Yes (n=9)	49 (38-51)	39 (39-47)	9.1 (2.3-21)
No (n=14[a])	52 (45-54)	39 (39-46)	4.5 (2.3-11)
P-value[c]	0.37	0.97	0.38
Other Shoulder Pathology			
Yes (n=17[a])	49 (38-55)	39 (39-50)	9.1 (2.3-19)
No (n=6)	52 (48-55)	39 (39-39)	8.0 (2.3-11)
P-value[c]	0.40	0.42	0.74
Pre-operative cramping			
Yes (n=12[a])	50 (41-55)	39 (39-46)	4.5 (0-18)
No (n=11)	50 (39-56)	39 (39-56)	11 (2.3-18)
P-value[c]	0.71	0.5	0.37
Post-operative Cramping			
Yes (n=6)	36 (27-49)	50 (39-64)	26 (4.5-57)
No (n=16)	54 (48-56)	39 (39-39)	6.8 (1.1-11)
P-value[c]	0.01	0.03	0.03

[a] These groups had one fewer patient in the PROMIS Pain survey and QuickDash survey, as one patient did not complete these two
[b] Spearman's Rank Correlation Coefficient
[c] Mann-Whitney U Test

Table 4. Post-operative outcomes

Variable	# of patients
Bicep cramping, n(%)	6 (27)
Post-operative complications, n(%)	6 (27)
Infection, n(%)	1 (4.3)
Reoperation, n(%)	4 (17)

which four patients (17%) underwent a revision tenodesis [Table 4]. Three patients underwent reoperation due to a re-rupture of the biceps tendon and one for infection. For three of the patients, the surgeon was the same, and the patient who had a different surgeon had an anchor technique tenodesis for the reoperation rather than the screw technique which was used originally. All four revision patients reported biceps cramping at long-term follow up. Four of the patients who reported biceps cramping are included in the group of patients affected by post-operative complications. Of the two post-op complications patients who did not report biceps cramping, one reported complaints of appearance/cosmetics, and the other reported limited range of motion in the shoulder. These four had a median PROMIS UE score of 38, median PROMIS Pain score of 51, and median QuickDASH of 30.

Discussion

We evaluated patient reported outcomes in 23 patients who underwent a proximal biceps tenodesis after a proximal long head biceps tendon rupture at a median follow-up of 8.5 years. A biceps tendon rupture due to a sports injury and the use of a suture anchor technique resulted in better patient reported outcomes. Four patients required a revision tenodesis, and their median PROM's indicated a lower functional outcome than the median scores of the 23 total patients who answered the survey. Additionally, post-operative cramping was present in 6 of the 23 (27%) patients and was associated with older age. The presence of post-operative cramping had a significant impact on the patient reported outcomes and was still present at a median of 8.2 years following surgery.

This study needs to be interpreted with respect to its strengths and limitations. First, as only 23 out of the 42 patients completed the questionnaires, there may be a selection bias in that patients who chose to participate may have had better or worse outcomes. However, the contacted versus non-contacted patient characteristics appeared to be similar. Second, the results of this study may not be generalizable because patients were treated at academic hospitals. However, they were treated by 17 different surgeons and only six were referred for treatment. Third, we were not able to adjust for confounding factors through multivariable analysis because of the small study cohort. Fourth, considering the retrospective nature of the study, there is no data on preoperative PROMs, making it difficult to objectively understand their functional status after conservative measures prior to tenodesis. Lastly, there was limited

Table 5. Factors affecting post-operative cramping

Variable	*P-value*
Occupation[a]	0.63
Mechanism of injury[a]	0.21
Tenodesis Technique[a]	0.23
Rotator cuff repair[a]	0.14
Time to surgery[b]	0.72
Age[b]	0.03

[a] Mann-Whitney U Test
[b] Spearman's Rank Correlation Coefficient

information of their postoperative rehabilitation and how this may impact post-operative functionality.

Conservative measures are the primary management for complete biceps ruptures. Following non-operative treatment, forearm flexion and supination loss of strength is 8-21%, but that the loss of strength post-tenodesis is only 0-10% (13). Persistent pain has been reported to be similar between conservative and operative treatments (13). Another study prospectively compared surgical to nonsurgical treatments for biceps rupture with a follow up of 2-22 years and found that reduced loss of strength of the elbow and a higher return to work rate (14). If symptoms persist after conservative therapy, subacromial pathologies or associated RC tears are usually the indication for surgery followed by aesthetic reasons, especially in the younger/athletic population (13, 15, 16). Zhang *et al.* found that if patients were to undergo operative management, a tenotomy (rather than a tenodesis) might be more suitable for patients older than 55 given its shorter surgical time and results of faster pain relief (17).

The median Quick DASH score of 9.1 (IQR: 2.3- 18.2) suggests limited post-operative functional disability, as the average non-clinical population has a quick DASH of 12.7(18). McMahon *et al.* had similar postoperative Quick DASH scores of 7.3 and 11.2 in their cohorts after a biceps tenodesis on patients with isolated biceps tendon ruptures (19). Zhang *et al.* reported a lower rate of cramping pain (5/76 or 6.7%) in their tenodesis cohort compared to the 6/23 (27%) of our cohort (17).

This study showed an association of higher patient reported outcomes after using a suture anchor fixation in comparison to other techniques (including interference screw, keyhole, and the tunnel methods). There were few non-suture anchor techniques used and the techniques were relatively heterogeneous limiting our conclusions regarding this finding. In patients with biceps pathology (but not spontaneous rupture), Millett *et al.* found similar outcomes (visual analogue scale, ASES (American shoulder and elbow surgeons) score, modified constant score, pain at the tenodesis site, complications) between the suture anchor and interference screw techniques (20). However, they did suggest that screws have a smoother bone-tendon interface, reducing the tendon inflammation compared to suture anchors. We found

that biceps tenodesis using a suture anchor technique had better Quick DASH scores. Biomechanically, the interference screw and suture anchor fixation have superior results in cyclic loading tests compared to other tenodesis techniques (21). Interference screws provide greater initial fixation strength and a stronger construct compared to the suture anchor technique (22, 23). It is important to note that this association of better outcomes with suture anchor may just be a small sample effect and the finding may not be present in a larger cohort. We believe that this is likely the case with this association.

Patients with a tendon tear due to a sports injury seemed to do better after biceps tenodesis compared to other causes. This may be because of a selection bias towards earlier surgical treatment in these patients. The majority of patients with an LHB tendon rupture usually underwent non-operative treatment; however, athletic patients may have a lower threshold to pursue surgical treatment, because of concerns of cosmetic deformity ("Popeye" deformity) and possibly better outcomes in strength, range of motion, and complication rate (14, 19, 24-28). Tangari *et al*. analyzed a case series of five high-demand wrestlers who underwent a biceps tenodesis shortly after a LHB tendon rupture, and noted no complications and no difference in outcomes scores or forearm flexion strength between the affected shoulder and contralateral side (29). Other studies showed similar results in professional athletes including body builders and softball players, post-tenodesis (30, 31). Another reason may also be that athletic patients have improved rehabilitation after injury, due to improved physical conditioning (32, 33).

Patient reported biceps cramping was correlated with inferior scores in all three patient reported outcome surveys. This highlights how this sequela impacts function and pain. Meeks *et al*. studied the rates of cramping for their group of 104 patients who underwent biceps tenotomy and found 20% had cramping or spasms in their biceps, typically occurring once weekly with two patients having severe cramping pain (34). Other studies compared the rates of cramping between tenodesis and tenotomy patients and have found either similar rates between the two groups or a lower incidence of cramping in the tenodesis group (8-10). In this study, it should be highlighted that patients reported complaints of cramping at a median of 8.2 years (IQR 5.0-13.2) following surgery. Moreover, we found that older age was associated with persistent biceps cramping. This should be taken in consideration when counseling patients on their expected outcomes after biceps tenodesis. This may be due to the fact that older patients have a greater chance of dehydration, electrolyte disturbances, or taking medication that have been reported to cause muscle cramping (such as diuretics, nifedipine, beta agonists, steroids, and statins) (35, 36). Tahal *et al*. analyzed 28 biceps tenodesis patients specifically under 45 years old and found none with biceps cramping at the time of follow up (average 3.1 years) (37). However, Voss *et al*. showed differing results as they found that there was no difference in complication rate between biceps tenodesis patients older than 65 and younger than 65 (38).

In conclusion, biceps tenodesis for proximal long head biceps tendon ruptures leads to modest outcomes. Cramping may persist long term in one third of patients, and older patients are at higher risk for this complication.

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Appendix 1.

Biceps Tear Questionnaire

1. After your surgical treatment for your biceps tear have you undergone additional treatment?
If yes,
What?
When? (mm/dd/yyyy)

2. In the last 3 months, have you experienced muscle cramps (involuntary painful muscle contractions occurring at rest, not associated with exercise) in your biceps?
Yes_____
No_____

3. How often have you experienced these?
Every day_____
If daily, how many cramps per day?_____
Every week_____
If weekly, how many cramps per week?_____
Every month_____
If monthly, how many cramps per month?_____

4. Which time of day might you have these cramps?
Day_____
Night_____
Both day and night_____

5. How long do your cramps last?
Few seconds_____
Minutes_____
Hours_____

6. Are they aggravated by any of the following?
Exertion_____
Post Exertion_____
Cold_____
Rest_____
Sleep_____
Standing_____

7. What do you do to get relief from your muscle cramps?
Nothing. I leave it alone until they get better on their own_____
Medication _____
If yes, what medication?
Other_____
If other, please describe below what you do:
_____

8. Are you satisfied with your biceps tendon surgery?
Very Satisfied____
Satisfied____
Neutral____
Dissatisfied____
Very Dissatisfied____