Clinical Outcomes After Revision Distal Biceps Tendon Surgery

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Background: Little is known about the clinical indications of performing a revision distal biceps tendon repair/reconstruction, and there is even less data available on the clinical outcomes of patients after revision surgery.

Purpose: To determine the clinical outcomes of patients undergoing revision distal biceps tendon repair/reconstruction and evaluate the causes of primary repair failure.

Study Design: Case series; Level of evidence, 4.

Methods: We performed a retrospective review of patients undergoing ipsilateral primary and revision distal biceps tendon repair/reconstruction at a single institution. Between 2011 and 2016, a total of 277 patients underwent distal biceps tendon repair, with 8 patients requiring revision surgery. Patient characteristics, surgical technique, and patient-reported outcome scores (shortened version of Disabilities of Arm, Shoulder and Hand [QuickDASH], 12-Item Short Form Health Survey [SF-12], visual analog scale [VAS] for pain, and Mayo Elbow Performance Score [MEPS]), were assessed. Complications as well as indications for reoperation after primary and revision surgery were examined.

Results: The overall revision rate was 2.9%. The number of single- and double-incision techniques utilized were similar among the primary repairs (50% single-incision, 50% double-incision) and revision repairs/reconstructions (62.5% single-incision, 37.5% double-incision). Reasons for reoperation included continued pain and weakness (n = 7), limited range of motion (n = 2), and acute traumatic re-rupture (n = 1). The median duration between primary and revision surgery was 9.5 months (interquartile range [IQR], 5.8-12.8 months). Intraoperatively, the most common finding during revision was a partially ruptured, fibrotic distal tendon with extensive adhesions. At a median of 33.7 months after revision surgery (IQR, 21.7-40.7 months), the median QuickDASH was 12.5 (IQR, 1.7-23.3), MEPS was 92.5 (IQR, 80.0-100), SF-12 mental component measure was 53.4 (IQR, 47.6-58.2), SF-12 physical component measure was 52.1 (IQR, 36.9-55.4), and VAS for elbow pain was 1.0 (IQR, 0-2.0). Revision surgery had a complication rate of 37.5% (3 of 8 patients), consisting of persistent pain and weakness (2 patients; 25%) and numbness over the dorsal radial sensory nerve (1 patient; 12.5%). Two patients required reoperation (25% reoperation rate).

Conclusion: The overall revision distal biceps repair/reconstruction rate was approximately 3%. While patients undergoing revision distal biceps repair demonstrated improved outcomes after revision surgery, these outcomes remained inferior to previously reported outcomes of patients undergoing only primary distal biceps repair.

Keywords: distal biceps; revision; clinical outcomes; patient-reported outcomes

The biceps brachii muscle is composed of a long and short head that originate from the supraglenoid tubercle and coracoid process, respectively, and merge to form the distal biceps tendon, which inserts at the radial tuberosity. It primarily functions to supinate and flex the forearm. Ruptures of the distal insertion of the biceps brachii tendon most often occur in men during the fourth or fifth decades of life, frequently involving the dominant arm. The most common mechanism of injury is a heavy load causing an unexpected, eccentric contraction on a flexed and supinated elbow.[1,10,13,15] For the vast majority of patients, surgical repair is recommended, as nonoperative treatment often leads to significantly decreased flexion and supination strength and endurance.[1,13]

Both single- and double-incision techniques can be used for distal biceps repair. The single-incision approach is typically performed with a longitudinal incision extending distally from the antecubital fossa, whereas the double-incision approach is typically completed via a transverse incision along the antecubital crease and a subsequent longitudinal incision along the dorsal aspect of the proximal forearm. There is no established superiority of one technique over the other.[10,19]

While the majority of patients who undergo distal biceps repair surgery have satisfactory long-term outcomes and

The Orthopaedic Journal of Sports Medicine, 9(1), 2325967120981752
DOI: 10.1177/2325967120981752

functional recovery, complications can occur in up to 25% of cases, with a reported re-rupture rate ranging from 1.6% to 4%.[3,5,10,11,19] While the overall complication rates are similar for the single- and double-incision techniques, the specific complications associated with each technique differ. Historically, the single-incision approach is associated with increased nerve injury, most commonly the lateral antebrachial cutaneous (LABC) nerve and radial sensory nerve, while the double-incision is associated with an increased rate of proximal radioulnar synostosis, heterotopic ossification, and stiffness with supination/pronation.[6,8,10,19] Notably, while the overall complication rate is relatively high, the incidence of complications leading to revision surgery is comparatively low.[3,5] Thus, there are few data available with regard to the clinical outcomes after revision surgery.

The purpose of this study was to report the clinical outcomes of patients undergoing revision distal biceps repair and identify causes of primary repair failure in this subset of patients. The authors hypothesized that patients undergoing revision distal biceps repair will demonstrate improvements in function and pain levels compared with pre-revision (after primary repair) surgery; however, outcomes will be inferior to historical controls undergoing primary repair.

METHODS

This study was designed as a retrospective review of consecutive patients at a single institution. After institutional review board approval was obtained, we conducted an initial search of the institution database using Current Procedural Technology code 24342 to identify all patients who underwent distal biceps or distal triceps repair between 2011 and 2016. Two investigators (G.G., E.D.B.) then reviewed individual operative reports of patients to identify distal biceps repair/reconstruction procedures and determine whether the procedure was a primary or a revision repair. Only patients who had undergone both primary and revision repair on the ipsilateral elbow were included for analysis. Patients who experienced an infection or a neurovascular complication after a primary distal biceps repair as well as patients younger than 18 years of age were excluded. The methodology used to identify patients who underwent revision distal biceps surgery is described in Figure 1.

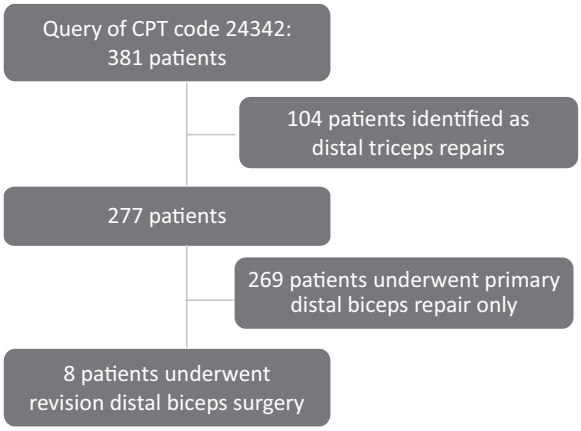

Figure 1. Flowchart of patient inclusion methodology. CPT, Current Procedural Terminology.

Once patients who had undergone revision distal biceps repair/reconstruction were identified, data including age, sex, body mass index (BMI), comorbidities, smoking status, laterality, arm dominance, mechanism of original injury, reason for failure, surgical technique (single- vs double-incision), fixation method and type of implant used, use of graft, pathology findings at revision, time between original injury and primary surgery, and time between primary surgery and revision surgery were collected. All 8 patients who underwent revision distal biceps repair/reconstruction were then contacted by phone to complete functional outcome questionnaires to determine postoperative outcomes after revision surgery. Patient-reported outcomes (PROs) collected included the shortened version of Disabilities of Arm, Shoulder and Hand (QuickDASH) score, Mayo Elbow Performance Score (MEPS), 12-Item Short Form Health Survey (SF-12) score, and visual analog scale (VAS). All 8 patients who were contacted completed all revision postoperative PRO questionnaires, resulting in 100% follow-up. Our institution's PRO database was then queried to determine patients' preoperative outcome scores before and postoperative outcome scores after primary surgery. Primary preoperative PROs were available for only patient 2; we deemed this insufficient and

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Final revision submitted August 14, 2020; accepted August 26, 2020.
One or more of the authors has declared the following potential conflict of interest or source of funding: M.S.C. has received faculty/speaker fees from Synthes, consulting fees from Acumed, and royalties from Acumed and Integra LifeSciences. J.J.F. has received education payments from Arthrex. N.N.V. has received research support from Arthrex, Arthrosurface, Athletico, ConMed Linvatec, DJO, Miomed, Mitek, and Ossur; consulting fees from Minivasive, Smith & Nephew, Medacta, Orthospace, and Arthrex; nonconsulting fees from Arthrex; royalties from Smith & Nephew and Vindico Medical–Orthopedics Hyperguide; and stock/stock options from Cymedica, Minivasive, and Omeros. A.A.R. has received research support from Aesculap/B.Braun, Arthrex, Histogenics, Medipost, NuTech, OrthoSpace, Smith & Nephew, and Zimmer; consulting fees and speaking fees from Arthrex; and royalties from Arthrex, Saunders/Mosby-Elsevier, and SLACK. R.M.F. has received grant support from Arthrex, educational payments from Arthrex/Medwest and Smith & Nephew, and royalties from Elsevier. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.
Ethical approval for this study was obtained from Rush University Medical Center.

therefore did not present these data. Primary postoperative PROs were available for 6 patients (75%) and included only QuickDASH and SF-12 scores. The latest outcomes documented after primary surgery but before revision surgery were considered primary postoperative outcomes for this study. QuickDASH, MEPS, and VAS were selected to measure clinical patient outcomes in this study due to their utilization in previous studies[14,15] examining patient outcomes after distal biceps repair and their broad acceptance in the field. Data on complications and indications for reoperation after primary and revision surgery were analyzed.

Statistical Analysis

Because of the low incidence of distal biceps revisions, patient numbers were expected to be low. Therefore, statistical analyses were limited to mainly nonparametric central measures, reported as medians with interquartile ranges (IQRs), and descriptive outcomes of cases. QuickDASH scores after primary surgery and QuickDASH, MEPS, and VAS after revision surgery were compared with outcomes scores previously reported by Redmond et al,[15] and *P* values were calculated using a 2-tailed Mann-Whitney *U* test. This comparison group was utilized as it is the only study, to the authors' knowledge, that reported all 4 outcome scores after distal biceps repair, similar to the outcomes reported in this study after revision surgery.

RESULTS

Characteristics

Of the 277 distal biceps repairs performed from 2011 to 2016 at our institution, 8 patients were identified as revision distal biceps repairs, for an overall revision rate of 2.9%. When analyzed by surgical technique, single- and double-incision repairs were determined to have a revision rate of 2.4% (4/166) and 3.6% (4/111), respectively. All of the patients who underwent a revision were male (100%), with a median age at the time of the primary repair of 47.5 years (IQR, 33.8-46.0 years) and median age at the time of their revision of 39.0 years (IQR, 34.5-46.5 years). The patients had a median BMI of 30.1 kg/m^2 (IQR, 27.2-34.4 kg/m^2). Three patients (37.5%) had either a history of smoking tobacco or currently smoked, and 3 patients (37.5%) had medical comorbidities at the time of surgery, including hypertension, hyperlipidemia, and/or hypothyroidism. Five of the 8 cases (62.5%) were classified as workers' compensation cases, and 7 of the 8 (87.5%) were right-hand dominant, with the dominant arm involved in 5 cases (62.5%). The median time between injury and primary repair was 3.0 months (IQR, 0.0-6.3 months), while the median time between primary and revision surgery was 9.5 months (IQR, 5.8-12.8 months).

Primary Repairs

Among the 8 primary repairs, the single-incision technique was used in 4 patients (50%), and the double-incision technique was used in 4 patients (50%). Of the primary single-incision repair patients, 3 of the 4 patients underwent fixation with an interference screw and cortical button, while 1 patient (patient 4) underwent fixation with only an interference screw. Of the 4 double-incision repair patients, all 4 underwent fixation using a standard transosseous suture repair technique. No patient required a graft during the primary surgery.

TABLE 1
Characteristics of Patients Who Underwent a Distal Biceps Revision Repair Summary of Laterality of Injury, Dominant Arm Involvement, Repair Technique Incidence, and Duration Between Repairs[a]

Laterality of injury	Right = 6 Left = 2
Injury in dominant arm	62.5% (5/8 patients)
Primary technique	Single-incision = 4 Double-incision = 4
Revision technique	Single-incision = 5 Double-incision = 3
Time between injury and primary surgery, median (IQR)	3.0 (0.0-6.3) months
Postoperative time to revision surgery, median (IQR)	9.5 (5.8-12.8) months

[a]IQR, interquartile range.

Revision Repairs/Reconstructions

Among the 8 revision repairs/reconstructions, the single-incision technique was utilized in 62.5% (n = 5), and the double-incision technique was utilized in 37.5% (n = 3). Patient 3 was the only patient who was converted to a different surgical technique during revision surgery, going from the double- to single-incision technique (Table 1). Of the 5 patients undergoing revision surgery with a single-incision technique, 2 had fixation with a cortical button, 2 with cortical button and semitendinosus allograft, and 1 (patient 3) was fixated with an interference screw with cortical button. Of the 3 patients undergoing revision surgery using a double-incision technique, 2 were re-repaired using only a suture-based transosseous technique, while 1 patient underwent suture-based transosseous repair with additional semitendinosus allograft augmentation (patient 2). The specific surgical technique for each patient is detailed in Table 2.

Primary Postoperative Complications/Reasons for Revision

Seven of the 8 (87.5%) patients underwent revision distal biceps tendon repair/reconstruction due to demonstrated continued pain and weakness in elbow flexion and supination after their primary repair, often elicited while doing resistance training during physical therapy. Of the 7 patients who reported pain and weakness in elbow flexion, 6 patients reported specific concern in their ability to return to their high-demand occupation (eg, police officer, firefighter, heavy machinery operator) and 1 patient reported difficulty returning to a weight-lifting hobby as reason to pursue revision

TABLE 2
Operative Techniques and Findings

Patient	Surgical Technique (Primary)	Surgical Technique (Revision)	Intraoperative Findings at Revision	Complications	Reoperation
1	Double-incision, transosseous sutures	Double-incision, transosseous sutures	Partial rupture. Pseudotendon present. Extensive adhesions of tendon to local structures.	Persistent pain and weakness	Re-revision reconstruction with allograft
2	Double-incision, transosseous sutures	Double-incision, transosseous sutures with semitendinosus allograft	Partial rupture. Fibrosis of distal 4 cm of tendon. Circumferential scarring of tendon and adhesion to local structures.	None	No
3	Double-incision, transosseous sutures	Single-incision, interference screw and cortical button	Partial rupture. Fibrosis of distal 2 cm of the tendon.	None	No
4	Single-incision; interference screw	Single-incision, cortical button	Partial rupture. Fibrosis of distal 1 to 2 cm. Prominent hardware likely from local bone resorption. Significant adhesions along tendon.	Persistent pain and weakness	Tenolysis and neurolysis with neuroma resection and burial
5	Single-incision, interference screw and cortical button	Single-incision, cortical button with semitendinosus allograft	Complete rupture. Tendon retraction with severe fibrosis of distal 2 cm. Circumferentially scarred down. Loose interference screw with resorption of surrounding bone.	None	No
6	Single-incision, interference screw and cortical button	Single-incision, cortical button	No rupture. Fibrosis of the distal 2 cm of tendon. Large ridge (4 × 15 mm) of new bone along lateral aspect of radial tuberosity. Loose interference screw.	Numbness over dorsal radial sensory nerve	No
7	Single-incision, interference screw and cortical button	Single-incision, cortical button with semitendinosus allograft	Partial rupture. ~90% of tendon detached. Severe fibrosis (pseudotendon) of distal ~5 cm of tendon. Severe adhesions present.	None	No
8	Double-incision, transosseous sutures	Double-incision, transosseous sutures	Complete rupture. Tendon retracted with ~30% of width stripped. Tissue quality intact. Circumferentially scarred down.	None	No

surgery. Two patients (patients 1 and 3; 25%) demonstrated limitations in elbow range of motion (flexion and extension) in addition to pain and weakness. A single revision (patient 8; 12.5%) was performed due to an acute re-injury of the distal biceps.

Intraoperative Findings at Revision

Intraoperatively, 5 patients (62.5%) were found to have a partial rupture, 2 patients (25%) had complete rupture, and 1 patient (patient 6; 12.5%) had no rupture of the distal biceps tendon (Table 2). Seven patients (87.5%) had evidence of significant fibrotic degeneration of the distal tendon. Six revisions (75%) were complicated by significant adhesions and/or circumferential scarring requiring substantial tenolysis to free the tendon for repair/reconstruction. In 3 of the 4 revision cases that encountered an interference screw, it appeared to be loose and causing a foreign body reaction that resulted in local bone resorption or significant scarring of neighboring structures.

Outcome Assessments

Primary Postoperative Outcomes. After primary repair, PROs were available at a median of 8.7 months (IQR, 6.0-11.5 months) (Table 3, Figure 2). The median QuickDASH scores were 18.0 (13.4-30.7), and the median SF-12 scores were 50.3 (45.6-51.6) and 36.9 (32.8-39.2) for the mental and physical components, respectively. Outcomes data not reported in Table 3, including all PROs for patients 2 and 8, were not collected in the period between primary and revision surgery.

Revision Postoperative Outcomes. The median follow-up duration for patients after revision distal biceps repair/reconstruction was 33.7 months (IQR, 21.7-40.7 months) (Table 4). Overall, the median QuickDASH was 12.5 (1.7-23.3), the median MEPS was 92.5 (80.0-100.0), and the median VAS for elbow pain was 1.0 (0.0-2.0). The median SF-12 scores for all patients at follow-up were 53.4 (47.6-58.2) and 52.1 (36.9-55.4) for the mental and physical components, respectively.

Revision Postoperative Complications and Reasons for Additional Reoperation

After revision distal biceps surgery, 3 of the 8 patients experienced complications, for an overall complication rate of 37.5%. Patient 6 experienced numbness along the dorsal radial aspect of the forearm and wrist, with evidence of irritability of the dorsal radial sensory nerve, approximately 3 inches proximal to the radial styloid, and without evidence of recovery.

Patients 1 and 4 also experienced complications postrevision and underwent additional reoperations, for an overall reoperation rate of 25%. Patient 1 reported continued pain in the anterior elbow 6 months postrevision, especially with resisted supination and flexion. This patient underwent re-revision reconstruction with a semitendinosus allograft to provide length and healthier tissue for biceps tendon repair. Six months after re-revision, the patient continued to have daily pain in his elbow (>5 in VAS score) and was noted to have decreased range of motion and decreased grip strength compared with his uninjured arm. He ultimately was not able to return to work in any capacity. Patient 4 reported continued pain in the anterior elbow after surgery, with associated paresthesias along the LABC nerve and median nerve distributions. He underwent additional surgery consisting of tenolysis and neurolysis with local neuroma resection and burial. Three months post re-revision surgery, this patient reported persistent paresthesias, weakness, and pain but was able to return to work with permanent light duty restrictions (Table 2).

TABLE 3
Outcome Scores at Follow-Up After Primary Distal Biceps Repair Surgery[a]

Patient	SF-12 Mental	SF-12 Physical	QuickDASH	MEPS	VAS Elbow Pain	Follow-Up Time, months
1	34.5	25.7	—	—	—	5.8
2	—	—	—	—	—	—
3	51.9	35.6	—	—	—	4.4
4	44.1	31.8	57.5	—	—	10.7
5	50.6	38.1	14.2	—	—	12.7
6	59.4	50.3	10.8	—	—	11.8
7	49.9	39.5	21.7	—	—	6.6
8	—	—	—	—	—	—
Median	50.3	36.9	18.0	—	—	8.7

[a]MEPS, Mayo Elbow Performance Score; QuickDASH, shortened version of Disabilities of Arm, Shoulder and Hand; SF-12, 12-Item Short Form Health Survey; VAS, visual analog scale; —, data not available.

DISCUSSION

The three principal findings of this study were as follows: (1) revision after distal biceps repair surgery was found to be more often due to continued pain and weakness, as opposed to acute re-rupture; (2) while the majority of

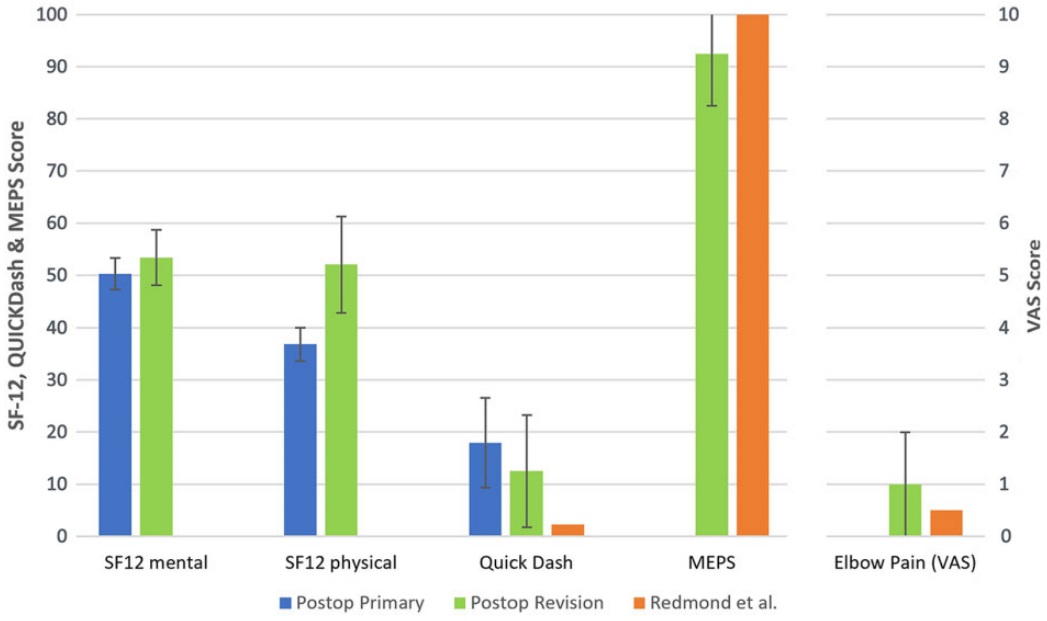

Figure 2. Median outcome measures from patients in the current study after primary and revision distal biceps surgery and compared with median outcomes as reported in Redmond et al[15] of the general population after primary distal biceps repair. Error bars indicate interquartile range. MEPS, Mayo Elbow Performance Score; Postop, postoperative; QuickDASH, shortened version of Disabilities of Arm, Shoulder and Hand; SF-12, 12-Item Short Form Health Survey; VAS, visual analog scale.

TABLE 4
Outcome Scores After Revision Distal Biceps Repair/Reconstruction Surgery[a]

Patient	SF-12 Mental	SF-12 Physical	QuickDASH	MEPS	Elbow Pain (VAS)	Follow-Up From Revision, months
1	19.8	28.4	75	65	7	8.1
2	59.3	49.0	20.5	85	1	15.1
3	57.8	55.5	2.3	100	0	23.9
4	49.6	37.3	31.8	80	5	31.6
5	55.9	55.9	0	100	1	35.8
6	50.9	55.2	0	100	0	40.1
7	41.7	35.8	15.9	80	1	42.3
8	60.7	55.3	9.1	100	0	73.0
Median	53.4	52.1	12.5	92.5	1.0	33.7

[a]MEPS, Mayo Elbow Performance Score; QuickDASH, shortened version of Disabilities of Arm, Shoulder and Hand; SF-12, 12-Item Short Form Health Survey; VAS, visual analog scale.

patients experienced improved functionality and pain after revision repair/reconstruction, outcomes were inferior to published reports after primary repair; and (3) the reoperation rate after revision distal biceps surgery was 25%.

The prevalence of distal biceps rupture is relatively uncommon, with a reported incidence of 2.55 per 100,000 per year.[12] The re-rupture rate is quite low as well, previously reported as a complication in approximately 1.6% to 4% of repairs.[3,5,10,11,19] Limited information exists regarding clinical outcomes in terms of pain and function after revision distal biceps repair. To our knowledge, this is the first case-series to look at the outcomes of revision distal biceps repair. The revision rate of 2.9% at our institution is comparable with the revision rates reported previously.[3,5,10,11,19] This similarity is likely due to widely accepted surgical techniques for this injury, with single- and double-incision techniques being the standard of care and choice of fixation method being limited to sutures, biceps buttons, and interosseous screws.

The incidence of single- and double-incision techniques among our patients was similar in both primary and revision repairs. All but 1 double-incision repair (primary and revision) utilized only transosseous sutures, with the sole exception being patient 2 who required the use of semitendinosus allograft in addition to sutures during reconstruction. All single-incision revision repairs/reconstructions utilized at minimum sutures and a biceps button. Patients 5 and 7 required the addition of a semitendinosus allograft, while patient 3 received an interference screw in addition to sutures and bicep button.

The majority of revisions were elicited due to physical examinations consistent with continued pain and weakness, with only patient 8 undergoing revision due to acute re-rupture of the distal biceps. Intraoperative findings at revision demonstrated a common theme of significant fibrotic degeneration (87.5%) of the distal tendon and adhesions (75%) to local tissue among the cases. Loosening of the interference screw may also cause a foreign body reaction, leading to local bone resorption or significant scarring around the tendon, as was seen in 3 of our revision cases. Interestingly, the distal tendon was found to be partially ruptured (62.5%) in the majority of revision cases, followed by complete rupture (25%) and no rupture (12.5%). This may explain the difficulty of identifying patients who require revision surgery as partial ruptures may present with ambiguous clinical and imaging findings. In addition, the degenerative tendons found in nearly all our patients requiring revisions highlight the importance of ensuring that high-quality tissue is used and maintained at the time of primary tendon repair. Further studies looking at factors that contribute to tendon degeneration, such as patient characteristics or local surgical factors, may help identify those patients at greatest risk of tendon re-rupture.

The primary outcome measures of the patients in this study were compared with the previously reported primary outcomes. The difference in median QuickDASH score in our study (18.0) compared with previously reported median QuickDASH scores (2.25)[15] after primary distal biceps repair is 15.75. This difference approaches the previously reported minimal clinically important difference (MCID) for QuickDASH of 15.9.[7] The MCID for QuickDASH, identified by Franchignoni et al,[7] is the numerical difference in the outcome scores that translates to a clinically meaningful difference for the patient. This indicates that patients demonstrating QuickDASH scores $\geq$18 after a primary distal biceps repair may have clinically significantly worse functional outcomes than expected and may be candidates for revision distal biceps repair. However, to our knowledge, this study is the first to report SF-12 measures in this patient population, and therefore, the SF-12 outcomes in this study cannot be compared with patients who underwent only primary repair.

When comparing revision PRO measures to each patient's own primary outcome measures, a trend toward improvement is demonstrated. Specifically, there was a clinically significant improvement in SF-12 physical component measures, with a median value of 36.9 after primary surgery compared with 52.1 after revision surgery (MCID of 3.29).[4] SF-12 mental component measures improved as well, nearly exceeding the clinically significant threshold, with a median value of 50.3 after primary surgery improving to 53.4 after revision surgery (MCID of 3.77).[4] QuickDASH scores also demonstrated an improvement in function, going from a median of 18.0 to 12.5 after primary and revision surgery, respectively. However, this change

was not greater than previously reported MCIDs for QuickDASH of 14 to 20.[7,18]

Our study demonstrated that patients tend to improve after revision surgery; however, their functionality after revision surgery is often still inferior to their primary repair counterparts. The overall median QuickDASH, MEPS, and VAS for elbow pain scores reported in the present study continue to represent decreased functionality when compared with previously reported outcomes for primary repair in the literature.[9,15] Redmond et al[15] demonstrated median QuickDASH of 2.25, MEPS of 100, and VAS of 0.5 for 23 patients who underwent primary repair, while our patient population demonstrated a median QuickDASH of 12.5 (IQR, 1.7-23.3; $P = .08$), MEPS of 92.5 (80.0-100; $P = .11$), and VAS of 1.0 (0-2; $P = .39$). Other studies[2,9-11,14,16,17] that looked at outcomes of distal biceps repair by specific patient subsets, such as chronic repair, surgical technique, and workers' compensation status, have reported similar PROs using DASH (range 1.9-7.5), MEPS (93.3-98.0), and VAS pain (0.6-1.5). These findings support our hypothesis that patients undergoing distal biceps revisions may ultimately have worse functionality than patients who underwent only primary repairs.

CONCLUSION

Revision distal biceps repair is relatively uncommon, with a prevalence of 2.9% at our institution. Patients requiring a revision may demonstrate decreased function and increased pain after their primary repair, with continued pain and weakness being the primary indications for revision surgery. Intraoperative findings during revision surgery most commonly resulted in a partially ruptured distal biceps tendon complicated by extensive fibrotic degeneration and adhesions. Although patients requiring a revision repair may demonstrate improved patient outcomes after the revision surgery, they continue to be associated with worse function and increased pain compared with those with a successful primary distal biceps repair. Future work should continue to investigate why certain patients may be at risk for a distal biceps revision.

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