Outcome of Distal Biceps Tendon Repair With and Without Concomitant Bicipital Aponeurosis Repair

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Background: The bicipital aponeurosis (BA) can often be torn concomitantly with a distal biceps tendon (DBT) rupture. Its repair, although recommended by some, has not commonly been addressed during the surgical management of DBT ruptures, and to date, surgical repair of the BA with DBT repair has not been evaluated clinically.

Purpose: To utilize subjective and objective outcome measures to examine the safety and efficacy of 2-incision DBT repair with and without repair of the BA in patients with a DBT rupture.

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

Methods: Demographic and surgical data were reviewed retrospectively. Patients returned to the clinic to complete subjective outcome measures and objective measurements of range of motion, strength, and biceps contour. All patients were evaluated at least 1 year after surgical treatment.

Results: Data from 24 male patients with a DBT rupture were used for the analysis; 13 (54%) underwent concomitant DBT and BA repair, and 11 (46%) underwent isolated DBT repair. There were no complications at 1 year in either group. The DBT + BA repair group returned to recreational activities faster (77% within 6 months and 100% within 1 year) than the isolated DBT repair group (36% within 6 months, 91% within 1 year, and 100% after more than 2 years) ($P = .05$). There was a trend toward better Patient-Rated Elbow Evaluation pain scores in the DBT + BA repair group than in the isolated DBT repair group (1.2 vs 5.3, respectively; $P = .18$). A trend also emerged toward closer return to subjective preinjury strength (77% vs 44%, respectively; $P = .14$). No significant difference emerged in patient satisfaction with the biceps contour, subjective scores on functional activities and disability, or objective measurements of strength, contour, and range of motion.

Conclusion: This pilot study suggests that repair of the BA in conjunction with DBT repair leads to a faster return to recreational activities compared with isolated DBT repair. Also noted was a trend toward subjectively improved pain and greater perceived strength, after DBT + BA repair, although this was not statistically significant. Further investigation with a larger population is required to better elucidate these potential differences.

Keywords: distal biceps tendon; bicipital aponeurosis; lacertus fibrosus; bicipital crease interval; bicipital crease ratio

Distal biceps tendon (DBT) tears usually occur secondary to a sudden eccentric load applied to a flexed elbow. This relatively uncommon condition typically affects 40- to 60-year-old male patients and has a reported incidence of 1.2 ruptures per 100,000 people per year.[3,15] Nonoperative treatment is an option, but it can cause significant weakness of forearm supination and elbow flexion. Surgical treatment has consistently demonstrated better functional results.[1,3]

The bicipital aponeurosis (BA), also known as the lacertus fibrosus, is a trapezoidal band of fascial fibers with a narrow origin from the medial, distal border of the short head of the biceps muscle and tendon.[2,16] Distally, it widens and merges with the fascia of the flexor muscles and eventually attaches to the medial side of the proximal ulna. Contraction of the forearm flexor muscles tensions the BA

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and pulls the biceps tendon distally and medially.[4,7] A BA rupture may occur concomitant to a rupture of the DBT, and the BA fails most often from its proximal origin near the short head of the biceps muscle and tendon.[16] Multiple theories exist about normal BA function. Proposed roles include protecting underlying neurovascular structures, providing an additional anatomic anchor to the DBT, and providing pretension proprioceptive information to the biceps based on forearm muscular activities.[4,11,13] Some have hypothesized that the BA may significantly contribute to elbow flexion.[8] Support for this idea is found in a report of a patient with weakness in elbow flexion who was found to have a torn BA and an intact DBT intraoperatively.[14] The restoration of normal BA anatomy would theoretically reestablish those normal functions.

In addition, the status of the BA is clinically important in cases of a suspected DBT rupture. An intact BA may contain hematomas and limit the extent of associated ecchymosis.[1,3] Even more importantly, the integrity of the BA can mask the typical deformities of proximal tendon retraction and alterations in the biceps contour associated with a DBT rupture, even when the distal tendon has completely avulsed from the radius. This may lead some clinicians to misdiagnose the tendon as being intact.[6,10,11] The presence or absence of the BA can be accurately tested clinically using the Bicipital Aponeurosis Flex Test.[8] If intact, the sharp, thin edge of the BA can be felt on the medial side of the elbow while the patient flexes the wrist, supinates the forearm, and isometrically contracts the biceps.

There is no consensus as to whether a torn BA should be repaired during repair of a DBT rupture. Over half a century ago, Congdon and Fish[4] concluded that repair "is justified by the fact that the aponeurosis has considerable effectiveness in forearm flexion." Others have suggested that repair of the BA may confer potential benefits when combined with DBT repair, such as increased strength, proprioception, and protection of the neurovasculature.[7] A study on cadaveric specimens showed that concomitant DBT and BA repair increases the mean failure strength and mean maximum strength of 2-incision DBT repair constructs by over 50%.[12] Despite numerous studies evaluating the strength of various methods of DBT repair, there has been no clinical study of concomitant repair of the BA with DBT repair to date.

The purpose of this pilot study was to utilize subjective and objective outcome measures to examine the safety and efficacy of 2-incision DBT repair with and without repair of the BA in patients with DBT ruptures. We hypothesized that there would be no difference in the complication rate between the 2 techniques and that concomitant BA repair would result in better biceps contour, flexion strength, and subjective functional outcomes.

METHODS

Institutional review board approval was obtained before starting the study. A retrospective cohort study of patients who underwent unilateral acute DBT repair in Toronto at St Joseph's Health Centre was performed. All procedures

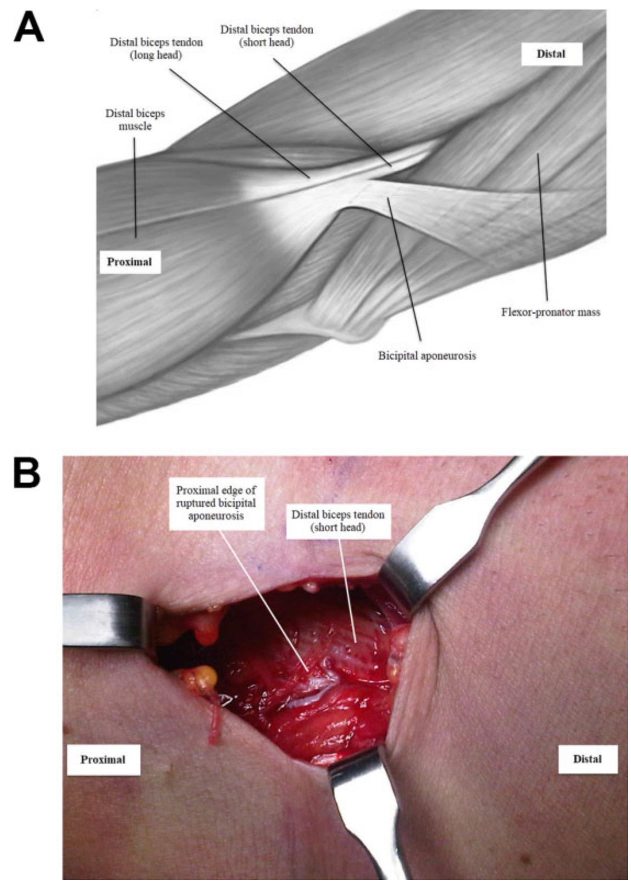

Figure 1. (A) Orientation drawing of a right elbow showing the bicipital aponeurosis anatomy. (B) Intraoperative photograph of a right elbow showing the proximal edge of a ruptured bicipital aponeurosis.

had been performed by a single fellowship-trained upper extremity surgeon using a 2-incision technique. For the period from February 2007 to December 2011, eleven patients underwent isolated DBT repair, whereas from March 2012 to May 2014, thirteen patients underwent DBT repair and concomitant BA repair. After publishing the Bicipital Aponeurosis Flex Test[8] and being able to reliably predict the preoperative status of the BA, the philosophy and practice of the senior author (A.E.) regarding DBT repair evolved from simply being able to include the integrity of the BA into the triage decision-making process for DBT repair to contemplating the possible incremental benefit of repairing the BA during DBT repair. Reflecting this shift, for all cases in the earlier, isolated DBT repair group, the documented preoperative test findings (Bicipital Aponeurosis Flex Test, bicipital crease interval [BCI]) were confirmed surgically to be associated with a ruptured BA, but these cases did not have the BA surgically repaired (Figure 1). For the later cases in the DBT + BA repair group, when the documented preoperative test results were similarly confirmed surgically to be associated with a ruptured BA, the BA was routinely repaired through the same antecubital crease incision (Figure 2) used for DBT repair.

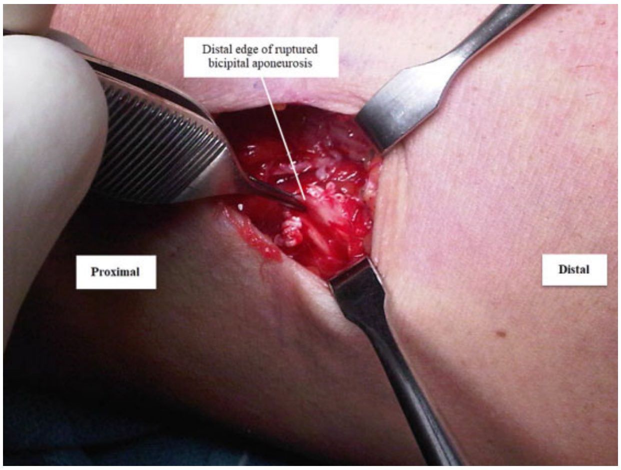

Figure 2. Intraoperative photograph of a right elbow showing the distal edge of a ruptured bicipital aponeurosis.

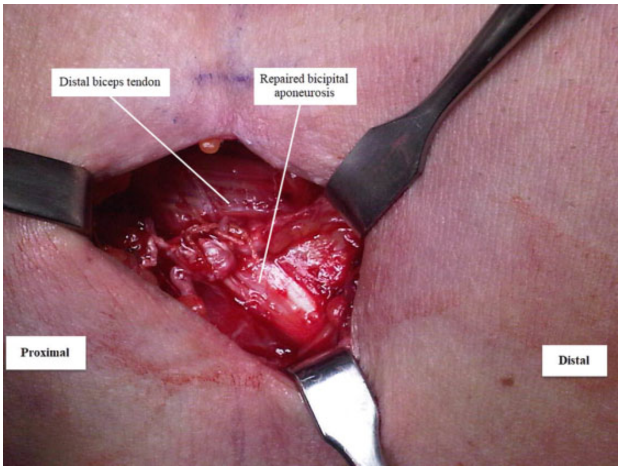

Figure 3. Intraoperative photograph of a right elbow showing a repaired bicipital aponeurosis.

Surgical Technique

The patient was supine with his affected arm on an arm board. A tourniquet was not used for any of the procedures. An anterior incision was made first, approximately 3 cm long within the main antecubital elbow crease. Careful dissection protected the antecubital veins and then identified and protected the lateral antebrachial cutaneous nerve. The torn end of the DBT was identified within and gently delivered out of the anterior wound. With gentle traction, the short head muscle-tendon junction was identified to confirm the absence of the normal BA attachment. The torn distal end was identified and separated from the subcutaneous and deeper neurovascular structures to facilitate later repair.

The DBT was then purchased with 2 pairs of high-tensile braided absorbable sutures in a running, locking fashion. Blunt dissection then identified the pathway just above the brachialis distally toward the radial tuberosity. A curved Kelly hemostat was then delivered from the anterior wound, along this pathway, and then advanced through the common extensor musculature and fascia, taking care to curve away from the ulna. A second longitudinal incision of similar length was then marked, keeping centered on the subcutaneous prominence of the advanced Kelly hemostat. After incising the superficial fascia, the muscular split created by the Kelly hemostat was carefully retracted and followed to the level of the supinator fascia, which was also incised. The oblique fibers of the supinator muscle were then retracted on the radial side with a small Jackson retractor, and small Hohmann retractors were placed on the ulnar side. At this point, pronation of the forearm allowed the visualization of the curved ridge of the radial tuberosity within the posterior wound. The radial tuberosity was prepared with a small trough using a high-speed bur. Three small drill holes were then created radial to the trough, with both communicating with the intramedullary canal of the proximal radius.

The DBT sutures were then delivered by the Kelly hemostat from the anterior wound to the posterior wound, respecting the normal 90° supination of the tendon, such that the pair of sutures on the long head was proximal along the radial tuberosity. The sutures were next shuttled into the trough and out their respective drill holes, such that each pair of sutures had a dedicated bone bridge on the radial side of the tuberosity. The forearm was then placed in slightly less pronation, and the ulnar Hohmann retractors were replaced with a small Jackson retractor, such that visualization of the 3 drill holes was centered in the extensor wound. Tension on the sutures could then fully deliver the torn end of the DBT and dock into the radial tuberosity trough. Repair was completed by maintaining tension on one pair of sutures while a secure knot was created in the first pair. The second pair was then tied. Gentle passive pronation and supination under direct visualization confirmed stable DBT repair. The BA was repaired anatomically with multiple figure-of-eight 2.0 absorbable sutures (Figure 3).

Postoperative Rehabilitation

Postoperatively, both groups were protected in a plaster splint until week 2. They were then allowed to begin passive range of motion (ROM) until week 6, when active ROM was allowed. Strengthening was not initiated until week 12.

Outcome Measures

Designated information was obtained from medical charts and by completion of study questionnaires and objective measures when patients returned to the clinic. Patients with bilateral DBT ruptures, reconstruction of a chronic tear, and less than 1 year of follow-up were excluded from the study. The following data were extracted and collected in an anonymized database: demographic data, preoperative physical examination findings, surgical information, objective outcome measurements (ROM, elbow flexion strength, forearm supination strength, BCI, and bicipital crease ratio [BCR]), and subjective outcome measurements

(Disabilities of the Arm, Shoulder and Hand score, Patient-Rated Elbow Evaluation [PREE], Oxford Elbow Score, and a 12-item questionnaire on outcomes after a DBT rupture) (Appendix). The questionnaire on DBT outcomes was created to capture information about patient-reported time to return to work, time to return to recreational activities, and patient satisfaction. The BCI is a measurement of the altered surface anatomy that results from DBT retraction. The distance between the antecubital crease and the most distal part of the biceps muscle contour cusp is measured in centimeters. The BCR is then calculated as the BCI of the injured arm divided by the BCI of the unaffected arm. A BCI >6.0 cm or a BCR >1.2 is diagnostic of a complete DBT rupture.[5,9]

Objective measurements were obtained by a single clinician. This clinician (C.E.C.) was not involved in any of the related surgical procedures or in previous care of the studied patients. Also, the clinician could not identify the performed procedure and patients' treatment group according to appearance and surgical scarring, as BA repair is performed through the same incision for DBT repair and both groups will look the same. Elbow flexion strength and forearm supination strength were measured using a handheld dynamometer. Isometric strength was measured with the arm in a static position of neutral shoulder flexion and abduction as well as at 90° of elbow flexion and neutral rotation, with the participant in a sitting position. Each objective outcome was measured for both affected and unaffected upper extremities of all patients in 3 separate readings. The calculated averages of these readings were used for statistical analysis.

Statistical Analysis

Descriptive statistics were calculated. All variables were tested for normality of distribution. Those variables that were normally distributed were compared using the Student *t* test. Those variables that were not normally distributed were compared using the Wilcoxon rank-sum test. Statistical significance was considered to be present for *P* values <.05. All statistics were calculated with SAS (version 9.4; SAS Institute).

RESULTS

A total of 24 patients met the criteria to be included in the study. All patients were males between 32 and 72 years of age (mean age, 52 years). The DBT + BA repair group had 13 patients, whereas the isolated DBT repair group had 11 patients. Age distribution and demographic data were not significantly different between groups (Table 1).

No patients in either group suffered a complication. After a minimum 1-year follow-up, there were no reported nerve injuries, vascular injuries, wound complications, infections, heterotopic ossification, or reruptures. The surgical time for the DBT + BA repair group was, on average, 5 minutes longer than that for the isolated DBT repair group (97.5 vs 92.6 minutes, respectively).

TABLE 1
Patient Demographic Characteristics[a]

	Isolated DBT Repair	DBT + BA Repair	*P* Value
Age, mean ± SD, y	50.1 ± 8.3	54.0 ± 11.2	.37
Male sex	11 (100)	13 (100)	>.99
Hand dominance			.66
Right	10 (91)	11 (85)	
Left	1 (9)	2 (15)	
Dominant arm injured	5 (45)	7 (54)	.70

[a]Data are presented as n (%) unless otherwise specified. BA, bicipital aponeurosis; DBT, distal biceps tendon.

TABLE 2
Time to Return to Recreational Activities[a]

	Isolated DBT Repair	DBT + BA Repair
6 mo	4 (36)	10 (77)
12 mo	6 (55)	3 (23)
>24 mo	1 (9)	0 (0)

[a]Data are presented as n (%). Statistically significant difference between groups (*P* = .05). BA, bicipital aponeurosis; DBT, distal biceps tendon.

Among subjective outcome measures, the time to return to recreational activities was significantly shorter in the DBT + BA repair group (77% of patients returned within 6 months and 100% within 1 year) than in the isolated DBT repair group (36% returned within 6 months, 91% within 1 year, and 100% after more than 2 years) (*P* = .05) (Table 2). There was a trend toward a subjective return to preinjury strength in the DBT + BA repair group compared with the isolated DBT repair group (77% vs 44%, respectively; *P* = .14). A trend also emerged toward better PREE pain scores in the DBT + BA repair group than in the isolated DBT repair group (1.2 vs 5.3, respectively; *P* = .18).

The remainder of the subjective outcome measures, including subjective contour, postoperative pain, reported complications, patient satisfaction, subjective scores on functional activities and disability, time to return to work, time to reach the previous level of activity, and 1-year ultimate strength, were not significantly different between groups (Table 3). Analysis of objective outcome measures did not show any significant difference in the final ROM, elbow flexion strength, forearm supination strength, contour, BCI, or BCR between groups (Table 4).

DISCUSSION

This work represents, to our knowledge, the first clinical study that has examined the safety and clinical outcomes of a novel approach to routine repair of a ruptured BA in the setting of a concomitant DBT rupture. The function of the BA and the indications for BA repair after traumatic

TABLE 3
Subjective Outcomes[a]

	Isolated DBT Repair	DBT + BA Repair	P Value
PREE pain	5.3	1.2	.18
PREE function	4.5	1.7	.63
Oxford Elbow Score pain	30.7	26.4	.14
Oxford Elbow Score function	25.0	26.4	.21
Oxford Elbow Score social	31.3	30.3	.28
DASH	26.1	26.4	.63
Overall satisfaction	9.8	9.7	.99
Subjective return to preinjury strength, %	44	77	.14

[a]BA, bicipital aponeurosis; DASH, Disabilities of the Arm, Shoulder and Hand; DBT, distal biceps tendon; PREE, Patient-Rated Elbow Evaluation.

TABLE 4
Objective Outcomes[a]

	Isolated DBT Repair	DBT + BA Repair	P Value
Flexion ROM (Δ), deg	0.0	0.2	.89
Extension ROM (Δ), deg	–0.1	0.3	.24
Supination ROM (Δ), deg	2.9	0.8	.40
Pronation ROM (Δ), deg	–0.3	1.1	.63
Flexion strength (Δ), lbs	–0.2	–1.5	.75
Supination strength (Δ), lbs	1.0	0.1	.29
BCI (Δ), cm	–1.4	0.8	.46
BCR (Δ)	1.2	1.1	.39

[a]BA, bicipital aponeurosis; BCI, bicipital crease interval; BCR, bicipital crease ratio; DBT, distal biceps tendon; ROM, range of motion. Δ = difference between unaffected side and affected side.

ruptures remain controversial. Those who have not considered or do not favor BA repair may cite the lack of clinical evidence and potential risk of damaging underlying neurovascular structures. Clarification of this controversy will help to achieve a better treatment plan with potentially higher patient satisfaction, improved functional outcomes, and faster recovery. This pilot study was designed to examine the safety and efficacy of the addition of BA repair to standard DBT repair using subjective and objective outcome measures in patients with DBT ruptures. An important finding of this pilot study is that repair of the BA is a safe procedure, as no patients suffered any complications after a minimum of 1-year follow-up.

Our findings suggest that combined repair of the DBT and the BA leads to a faster return to recreational activities and may lead to better subjective outcomes after a DBT rupture. Specifically, there was a trend toward improved pain scores on a validated self-reported measure, the PREE score. Although the mechanism of the trend toward improved pain is not clear, it seems that patients' pain may be improved after repairing the BA and re-creating the normal anatomy. Also, patients reported earlier return to recreational activities and a trend toward better subjective biceps strength after DBT + BA repair, which may be related to their improved pain scores. Patients in the DBT + BA repair group did not report higher satisfaction with the biceps contour; however, both groups reported good to excellent satisfaction with the contour. Given the obvious deformity present after DBT ruptures, it is quite likely that any improvement in the contour results in significant patient satisfaction.

We acknowledge some limitations to this study. The available sample size was less than optimal because of the relative rarity of this traumatic condition, which may work well for a pilot study but often precludes obtaining statistically significant results. Also, the subjective measures were relying on patients' recall of past events and comparing their current strength with a preinjury level, which is subject to recall bias. We tried to minimize the recall bias by recruiting different questionnaires that assess patient-reported subjective outcomes. Also, all procedures were performed by a single surgeon using the same technique in each group, which yielded a more homogeneous sample.

CONCLUSION

Concomitant repair of the BA after a DBT rupture represents a novel approach. This study demonstrates that the procedure is safe, results in a faster return to recreational activities, and may contribute to a trend in improved pain and greater perceived strength, although this was not statistically significant. The findings warrant further investigation with a larger sample size to better elucidate potential improvements in subjective and objective outcomes.

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APPENDIX

Questionnaire of Outcomes After Distal Biceps Tendon Ruptures

Please complete all questions, keeping in mind your recovery after a rupture of your distal biceps tendon.

1. How soon after your injury did you return to your regular occupation?

- ☐ Within 3 months
- ☐ Within 6 months
- ☐ Within 1 year
- ☐ Within 2 years
- ☐ More than 2 years (Please provide number of months: ________)
- ☐ Never
- ☐ Not applicable (Not working at the time of the injury)

2. What was your activity level while working before you injured your arm?

- ☐ Light
- ☐ Moderate
- ☐ Heavy

3. What is your activity level while working now?

- ☐ Light
- ☐ Moderate
- ☐ Heavy

4a. Did you return to your regular recreational activities after you injured your arm?

☐ Yes ☐ No

b. How soon after you injured your arm did you return to your regular recreational activities?

- ☐ Within 6 months
- ☐ Within 1 year
- ☐ Within 2 years
- ☐ More than 2 years (Please provide number of months: ________)
- ☐ Never

5. Do you ever feel pins and needles or numbness in your arm on the side that was injured?

☐ Yes ☐ No

6. When comparing your strength with your preinjury level, has your strength returned to the same level?

☐ Yes ☐ No

7a. Did your biceps tendon rerupture after the initial injury?

☐ Yes ☐ No

b. If yes, did you undergo surgery for your reruptured distal biceps tendon?

☐ Yes ☐ No

8. Please put a vertical mark on the line below to indicate the intensity of your elbow PAIN over the past 24 hours.

No pain ———————————— Worst possible pain

9. Please put a vertical mark on the line below to indicate your satisfaction with the FUNCTION of your arm.

Not satisfied ———————————— Extremely satisfied

10. Please put a vertical mark on the line below to indicate your satisfaction with the COSMETIC APPEARANCE (contour) of your arm.

Not satisfied ———————————— Extremely satisfied

11. If you underwent surgery, please put a vertical mark on the line below to indicate your satisfaction with the APPEARANCE of your scar.

☐ Not applicable

Not satisfied ———————————— Extremely satisfied

12. Please put a vertical mark on the line below to indicate your OVERALL satisfaction with the outcome after a distal biceps tendon rupture.

Not satisfied ———————————— Extremely satisfied