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Management of chronic distal biceps tendon ruptures: primary repair vs. semitendinosus autograft reconstruction

Tym Frank, MD, FRCSC, Anna Seltser, MD, Ruby Grewal, MD, MSc, FRCSC, Graham J.W. King, MD, MSc, FRCSC, George S. Athwal, MD, FRCSC*

Roth|McFarlane Hand and Upper Limb Center, St Joseph's Health Care, London, ON, Canada

Background: Delayed presentation of distal biceps tendon ruptures can make primary repair difficult, in which case reconstruction using a tendon graft is an option. The aim of this study was to compare outcomes and complications between delayed distal biceps tendon ruptures managed with repair vs. semitendinosus autograft reconstruction.

Methods: Nineteen delayed distal biceps tendon rupture cases treated with a tendon reconstruction were compared with 16 delayed primary repair cases (>21 days). The reconstructions were performed using a semitendinosus autograft looped through a transosseous tunnel in the bicipital tuberosity and secured with a Pulvertaft weave to the remnant distal biceps tendon. The patient groups were reviewed and completed functional outcomes testing including range of motion, isometric elbow flexion and supination strength, Disabilities of the Arm, Shoulder, and Hand, Patient-Rated Elbow Evaluation, Single Assessment Numeric Evaluation, and Mayo Elbow Performance Index.

Results: Mean patient age (49 ± 9 vs. 46 ± 8 years, $P = .65$) and follow-up (47 ± 25 vs. 45 ± 27 months, $P = .45$) were similar between delayed primary repair and reconstruction groups. Range of motion ($P = .62$), supination strength ($P = .26$), elbow flexion strength ($P = .93$), Disabilities of the Arm, Shoulder, and Hand ($P = .08$), and Single Assessment Numeric Evaluation ($P = .22$) were not significantly different between groups. The Patient-Rated Elbow Evaluation ($P = .02$) and Mayo Elbow Performance Index ($P = .04$), however, were better in the delayed repair group compared with the reconstruction group. Complications were similar between groups ($P = .87$).

Conclusion: Delayed reconstruction of irreparable distal biceps tendon ruptures with semitendinosus autograft produces similar strength, range of motion, and complication rates but slightly worse functional outcome scores compared with delayed primary repair. This suggests that when possible direct repair is preferred, however, if not possible, reconstruction with an autologous tendon graft results in predictably good outcomes.

Level of evidence: Level III; Retrospective Cohort Design; Treatment Study

Keywords: Distal biceps rupture; distal biceps tendon; chronic; tendon graft; reconstruction; biceps reconstruction

The Health Science Research Ethics Board at the University of Western Ontario has approved this study (IRB 00000940).

*Reprint requests: George S. Athwal, MD, FRCSC, PO box 5777, STN B, London, ON N6A 4V2, Canada.
E-mail address: gathwal@uwo.ca (G.S. Athwal).

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Distal biceps tendon ruptures are relatively uncommon injuries that typically affect middle-aged men.[5,17] If left untreated, a complete rupture of the distal biceps tendon leads to an approximately 40% to 50% loss of supination and a 20% to 30% loss of flexion strength.[14] Surgical repair, therefore, is usually performed in younger and more active patients, with surgery in the acute phase yielding the best results.[12,14]

Occasionally, distal biceps tendon injuries are not initially recognized or referred promptly and may present to surgeons after a delay. In patients with a delayed presentation, higher complication rates have been reported because surgical dissection and repair is more difficult due to tendon retraction, muscle atrophy, and scar formation.[10] Previous literature has noted that early repair results in better functional and patient-reported outcomes compared with delayed repair or reconstruction.[8,10] More recent studies, however, have shown that despite a higher rate of initial complications, patients treated with a distal biceps tendon repair after a delay (>21 days) can expect similar functional outcomes to those treated acutely.[3,9,13]

At times, direct repair of the distal biceps tendon to the bicipital tuberosity is not possible after a delay due to muscle retraction and insufficient tendon length. In these irreparable tears, reconstruction with a tendon graft, either autograft or allograft, may be indicated. Although literature exists describing tendon reconstruction in this patient population, the literature on longer term outcomes and comparative studies to primary repair is limited.[13,19] As such, the purpose of this study was to report the mid-term results of delayed distal biceps reconstruction using semitendinosus autograft and to compare the outcomes of reconstruction with delayed direct repair. We hypothesized that the majority of complications associated with reconstruction with autograft tendon would be relatively minor and the outcomes would be comparable with those treated with delayed direct repair.

Methods

Study design

This is a retrospective comparative cohort study of patients presenting with delayed distal biceps tendon ruptures managed with either delayed direct repair or distal biceps tendon reconstruction with autograft semitendinosus tendon.

Patients

The reconstruction study group consisted of a retrospectively collected consecutive series of distal biceps tendon ruptures treated with distal biceps tendon reconstruction using autograft semitendinosus tendon between the years 2008 and 2016. The control group consisted of a consecutive series of distal biceps ruptures surgically repaired in a delayed fashion (>21 days) that were extracted from a database of distal biceps repairs available at our institution. Patients who had allograft tendon reconstruction were excluded. Once the study groups were identified, patients were contacted to return for physician review and functional testing. This study was approved by our institutional ethics review board.

Surgical reconstruction

All patients in the reconstruction group had a semitendinosus autograft, usually harvested from the contralateral leg. An anterior approach to the antecubital fossa and the distal biceps tendon insertion was used. The tendon graft was secured to the bicipital tuberosity by passing it through a transosseous tunnel (Fig. 1). The transosseous tunnel was created by using a small burr to create 2 tunnels in the ulnar side of the bicipital tuberosity. Using a 4.5-mm burr, 1 tunnel was made at the distal ulnar aspect to the tuberosity, and the other was made at the proximal ulnar aspect of the bicipital tuberosity. The tunnels were then linked and enlarged in the intramedullary cavity of the radius with an angled curette to facilitate easy tendon passage. The semitendinosus graft was whip-stitched on either end with No. 2 Ethibond sutures (Ethicon, Somerville, NJ, USA), and then passed in 1 tunnel and out of the other, resulting in 2 limbs exiting the antecubital fossa that were looped through the transosseous tunnel in the bicipital tuberosity (Fig. 2). One limb of the tendon graft was then secured to the remnant distal biceps tendon and muscle in a Pulvertaft weave method. Once 1 limb was secured, the remaining free limb of tendon was pulled up, which delivered the biceps tendon and muscle reconstruction into the antecubital fossa (Fig. 1, *A*). The reconstruction was then tensioned in 70° to 80° of elbow flexion. Ideally, the graft limb exiting the distal tunnel in the bicipital tuberosity was secured to the medial side of the distal biceps tendon remnant, reconstructing the short head tendon.[1] The other limb that is exiting the proximal transosseous tunnel was secured to the lateral side of the distal biceps tendon, which reconstructs the long head aspect of the biceps complex[1] (Fig. 1, *B*).

The delayed primary surgical repair technique was at the discretion of the 3 upper limb surgeons at our institution and was either a 1-incision repair using 2 Mitek G4 Super Anchors (Mitek Surgical Products, Norwood, MA, USA) or a 2-incision repair using a radial bone tunnel and 2 No. 2 Ethibond sutures (Ethicon). There were equal numbers of 1-incision and 2-incision techniques used in the delayed direct repair group. It is our practice to prescribe indomethacin, 25 mg orally 3 times a day, for 3 weeks in both direct repairs and reconstructions for heterotopic ossification prophylaxis. A standardized physiotherapy regimen was prescribed with gradual return of full extension by 6 weeks and progressive strengthening beginning at 3 months.

Outcome measures

At the time of the final study follow-up, several outcome scores were administered by a research assistant. The Disabilities of the Arm, Shoulder, and Hand is a 30-question patient outcome measure for which each item is scored from 1 to 5; the completed score has a range from 0 to 100, with higher scores denoting greater disability and symptoms. It has been suggested that the minimal clinically important difference for the Disabilities of the

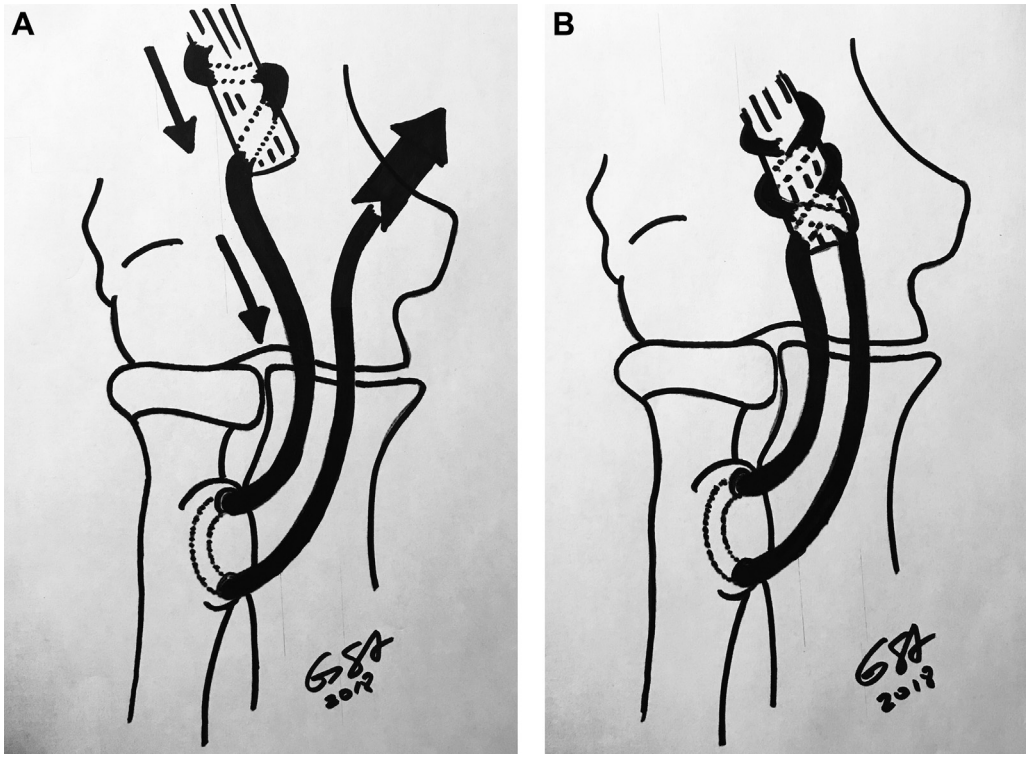

Figure 1 A medical illustration demonstrating the autologous semitendinosus distal biceps tendon reconstruction. The tendon graft is looped through a transosseous tunnel created on the ulnar aspect of the bicipital tuberosity. Initially, 1 limb of the tendon graft is secured to the remnant distal biceps tendon in a Pulvertaft weave method. Once 1 limb was secured, the remaining free limb of the graft (**A**) is pulled up (thick black arrow), which delivers the biceps muscle and tendon reconstruction into the antecubital fossa (thin arrows). Ideally, the graft limb exiting the distal tunnel in the tuberosity is secured to the medial side of the distal biceps tendon remnant, reconstructing the short head tendon (**B**). The other limb that is exiting the proximal transosseous tunnel is secured to the lateral side of the distal biceps tendon, which reconstructs the long head portion of the biceps complex.

Arm, Shoulder, and Hand is 11.[7] This was reported as our primary outcome.

The Patient-Rated Elbow Evaluation is an elbow-specific outcome questionnaire that measures pain and disability.[11] Patients rate their pain and functional difficulty from 0 to 10 (with higher numbers equating to greater pain and disability); the total score is calculated out of 100.

The Mayo Elbow Performance Index is a widely used performance index for the evaluation of clinical outcomes for a variety of elbow disorders. This scoring system was described by Morrey and Sanchez-Sotelo[15] and is a modification of the system reported by Broberg and Morrey[4] for the evaluation of the results of treatment of elbow fractures and dislocations. It consists of assessment of pain, arc of motion, stability, and a patient rating of daily function. Pain is weighted highest of the 4 variables. The scale ranges from 0 to 100, with a higher score indicating a better outcome.

The Single Assessment Numeric Evaluation is a single question posed to the patients asking them to report, on a scale of 0 to 100, with 100 being normal, how they rate their elbow.

Strength testing

Elbow flexion and supination strength were measured using a Biodex System 3 Pro (Biodex Medical Systems, Shirley, NY, USA). Isometric flexion and supination strength were tested with the forearm in neutral rotation and the elbow flexed to 90°. The strength was reported as a percentage of the unaffected side. A research assistant was trained to perform the testing in a standardized fashion, and the best effort of 3 trials was recorded.

Range of motion

Range of motion was estimated by the treating surgeon in the operating room after repair/reconstruction and was obtained from the operative record. This was compared with the range of motion measured with a long-arm goniometer by a trained research assistant at the final follow-up in the outcomes testing lab.

Biceps-crease interval

Biceps-crease interval (BCI) is defined as the distance between the antecubital crease of the elbow and the cusp of distal descent of the biceps muscle.[6] It is an objectively measurable anatomic landmark, and the ratio between injured and uninjured biceps tendons can estimate the proximal retraction of the musculotendinous junction, which can be useful when attempting to restore the length tension relationship of the myotendinous unit. The BCI of both the injured and uninjured side was measured in millimeters by a trained research assistant at the final follow-up. This measurement allows an assessment of the location of the biceps muscle at follow-up.

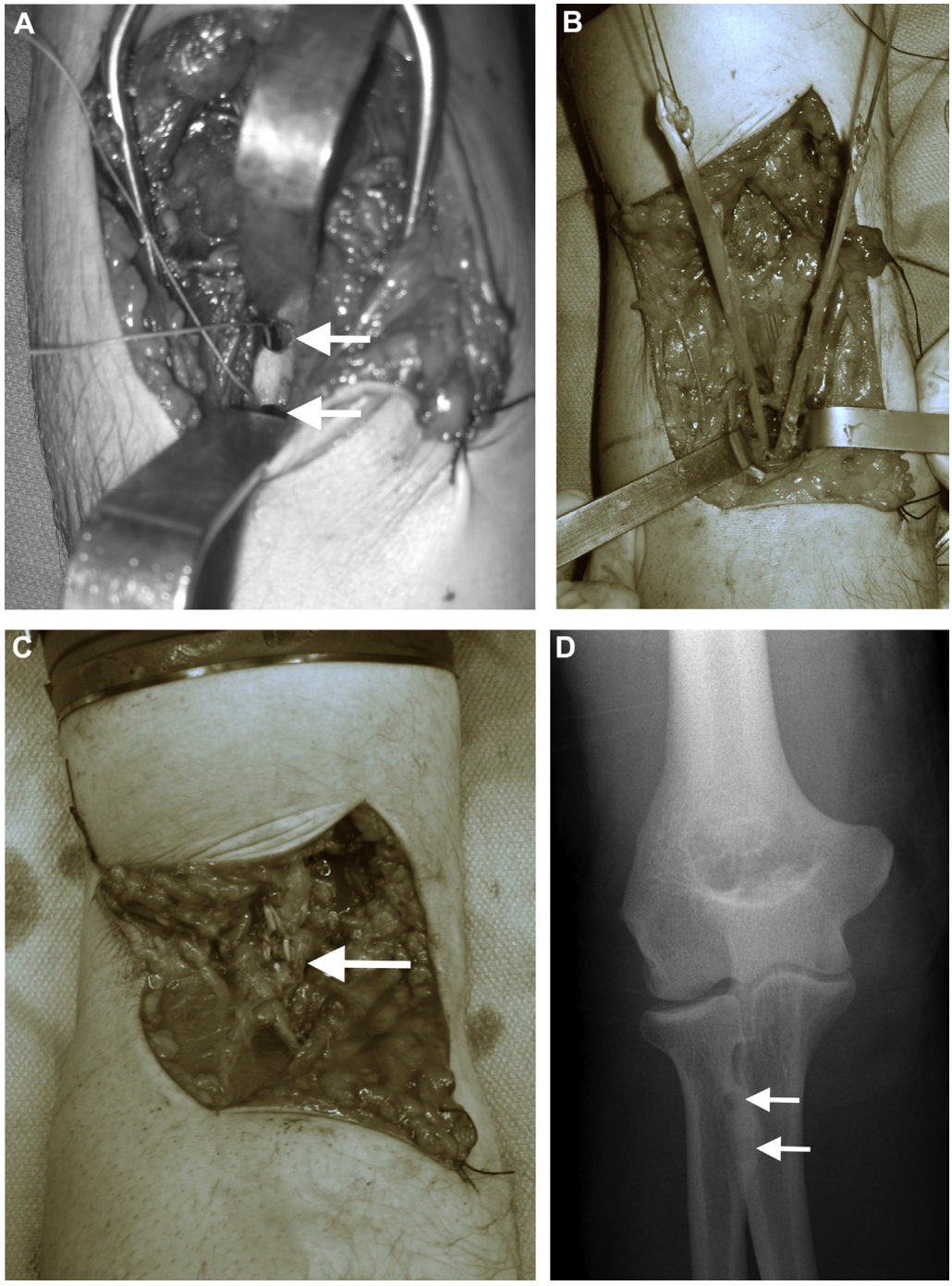

Figure 2 An intraoperative clinical photograph of the anterior approach to a right elbow (**A**) with the 2 tunnels (white arrows) created in the ulnar side of the bicipital tuberosity. A suture is passed through the transosseous tunnel for assistance with semitendinosus graft shuttling. Once the graft is shuttled through the tunnel (**B**), it is Pulvertaft weaved (**C**) into the distal biceps tendon remnant (white arrow). A postoperative posteroanterior radiograph (**D**) of a right elbow demonstrating the 2 transosseous tunnels along the ulnar margin of the bicipital tuberosity (white arrows).

Radiographs

Standard posteroanterior and lateral radiographs were obtained postoperatively and at the patient's most recent follow-up and heterotopic ossification was graded.

Complications

The clinical record was evaluated for any adverse events, and the patients were asked at their final review whether or not they had experienced any complications. Major complications were defined

as anything that required reoperation or resulted in sustained functional impairment (posterior interosseous nerve palsy, rerupture, heterotopic ossification). Minor complications, such as superficial infection and lateral antebrachial cutaneous nerve sensory paresthesias, were defined by their self-limited nature.

Statistical analysis

Outcomes including scores, strength, range of motion, and complications in the reconstruction group at the final follow-up were compared with outcomes in the delayed direct repair group.

Results

Demographics

From 2008 to 2016, 24 patients with chronic distal biceps tendon injuries underwent reconstruction with autograft semitendinosus tendon; of these, 4 were lost to follow-up or failed to return 2 IRB-approved contact phone calls and 1 declined to participate, leaving 19 patients defined as the reconstruction group. The control group was selected from a previously published group of 43 patients having a delayed repair greater than 21 days from the time of injury[9] between the years 2008 and 2013; of these, 19 were lost to follow-up or did not return 2 IRB-approved contact phone calls. In addition, 8 declined to participate in the study, leaving 16 participants at the final follow-up defined as the delayed direct repair group. Table I shows demographics and details of the groups.

The mean patient age was 46 ± 8 years in the reconstruction group vs. 48 ± 9 years in the delayed repair group ($P = .65$). The mean duration of follow-up was 45 ± 27 months in the reconstruction group vs. 47 ± 25 months in the delayed group ($P = .45$). The time from injury to surgery averaged 9 ± 8 months in the reconstruction group vs. 37 ± 12 days in the delayed direct repair group ($P < .001$).

Subjective outcomes

Subjective outcomes were better in the delayed primary repair group when compared with the reconstruction group. The difference was statistically significant in mean postoperative Patient-Rated Elbow Evaluation (4 ± 4 vs. 14 ± 19, $P = .02$) and the Mayo Elbow Performance Index (95 ± 7 vs. 86 ± 14, $P = .04$) and was trending toward significance in the Disabilities of the Arm, Shoulder, and Hand questionnaire (3 ± 5 vs. 7 ± 9, $P = .08$). There was no difference in the postoperative Single Assessment Numeric Evaluation ($P = .22$).

Strength and range of motion

The average maximum elbow extension achieved in the operating room immediately after direct primary repair was 48° ± 22° (data available for 14 of 16 patients) vs. 57° ± 18° (data available for 16 of 19 patients) for the reconstruction group ($P = .12$). At the final follow-up, range of motion, supination strength, and elbow flexion strength were not statistically different between groups ($P = .62$, $P = .26$, and $P = .93$, respectively). Subjective and objective measures are reported in Table II.

Table I Patient demographics

	Study cohort: distal biceps reconstruction (n = 19)	Control cohort: delayed distal biceps tendon repair (n = 16)
Age (yr)	46 ± 8	48 ± 9
Sex (M/F)	19/0	16/0
Dominant arm affected (Y/N)	10/9	12/4
Surgical delay (d)	266 ± 248	37 ± 12
Follow-up duration (mo)	45 ± 27	47 ± 25
Technique		
2 incision	0	8
1 incision	19	8

Biceps-crease interval

The difference in the BCI between injured and uninjured arms in the reconstruction group (13 ± 11 mm) was significantly greater ($P = .01$) than that in the delayed direct repair group (1 ± 12 mm).

Complications

Complications were similar between groups ($P = .87$). The most common complication was transient lateral antebrachial cutaneous nerve palsy in 3 patients (16%) in the reconstruction group and in 3 patients (19%) in the delayed repair group lasting beyond 6 months. One patient (5%) in the reconstruction group had an early graft failure at the muscle-tendon graft interface after repeat trauma, experienced due to patient noncompliance. Complications are reported in Table III.

Discussion

In this study, we compared the longer term subjective and functional outcomes of graft reconstruction with direct repair of patients presenting after a delay with distal biceps tendon ruptures. Our results indicate that where possible, delayed direct repair is preferable to reconstruction, despite having to intraoperatively place the elbow in high flexion angles to achieve contact of the distal biceps tendon to the tuberosity. Patients undergoing reconstruction with a tendon autograft had similar strength and range of motion

Table II Comparison of outcomes between distal biceps reconstruction and delayed distal biceps repair

	Study cohort: distal biceps reconstruction (n = 19)	Control cohort: delayed distal biceps tendon repair (n = 16)	*P* value
PREE	14 ± 19	4 ± 4	.04*
DASH	7 ± 10	3 ± 5	.08
MEPI	86 ± 14	95 ± 7	.02*
SANE	88 ± 14	93 ± 10	.22
Isometric supination strength (% of uninjured)	78 ± 22	78 ± 29	.98
Isometric flexion strength (% of uninjured)	90 ± 19	89 ± 16	.81

PREE, Patient-Rate Elbow Evaluation; *DASH*, Disabilities of the Arm, Shoulder, and Hand; *MEPI*, Mayo Elbow Performance Index; *SANE*, Single Assessment Numeric Evaluation.
* Indicates statistical significance.

relative to delayed primary repairs; however, patients reported slightly worse patient-reported outcomes.

The BCI, which is a measure of the location of the distal biceps muscle belly, was substantially different between repairs and reconstructions. In the reconstruction group, the distal aspect of the biceps muscle belly was, on average, 13 mm more proximal than the contralateral normal side. This indicates that although the reconstructions were successful, the grafts did over time elongate to over a centimeter leaving a visibly higher distal biceps muscle. Interestingly, although the biceps muscle was foreshortened in the reconstruction group, it did not result in significant differences in flexion or supination strength (Table II).

As with previous distal biceps repair and reconstruction studies,[2,10,13,16] the most common complication encountered was lateral antebrachial cutaneous nerve neurapraxia lasting beyond 6 months. One major complication occurred in the reconstruction group, which was a rerupture. In this patient, the reconstruction failure was directly related to patient noncompliance with postoperative restrictions and led to poor functional as well as subjective outcome scores. Despite the poorer functional outcomes scores with the reconstructions, each patient aside from the one with a rerupture would have had the surgery again.

In patients with a chronic distal biceps tendon rupture indicated for surgery, having a flexible operative plan allows the surgeon to address all possible scenarios and can mitigate some complications. For delayed cases, we consent the patient for repair with possible reconstruction, and the contralateral lower extremity is prepped and draped for potential semitendinosus graft harvest. We typically begin with a small anterior incision appropriate for a 2-incision technique, increasing the anterior exposure with proximal extension of the incision as needed. The residual biceps tendon is located and evaluated for suitability of primary repair. If the tendon reaches the bone with the elbow in flexion ($\leq 90^{\circ}$), we will complete the repair with a second dorsal extensor-splitting incision in an effort to minimize deep retraction and restore the anatomic insertion point of the distal biceps tendon, which maximizes supination strength.[18] If the tuberosity is not palpable, then the anterior incision is extended distally to expose it. After a more complete exposure of the tuberosity, a direct single incision repair can be conducted, or still a 2-incision technique can be used. If the tendon is not suitable for repair, then the semitendinosus autograft is harvested for reconstruction.

The strengths of our study include the longer term objective and patient-oriented outcomes in comparison with delayed direct repairs. In addition, a validated and comprehensive strength assessment was done to specifically assess the biceps in flexion and supination. The weaknesses of the study include the relatively small numbers of patients in each comparison group and the lack of preoperative patient-rated scores and strength data. In addition, we did not measure supination strength in terminal supination, which may be more discriminating in

Table III Summary of complications

	Study cohort: distal biceps reconstruction (n = 19)	Control cohort: delayed distal biceps tendon repair (n = 16)
Patient affected by any complication	4/19 (21%)	3/16 (19%)
Lateral antebrachial nerve neurapraxia	3/19 (16%)	3/16 (19%)
Rerupture	1/19 (5%)	0

determining strength differences between the 2 techniques, as reported by Schmidt el al.[18] Finally, we classified delayed repair as greater than 21 days as in previously published literature; however, there is little consensus on the definition of subacute, chronic, and delayed as it pertains to distal biceps tendon injuries.

Conclusion

Delayed reconstruction of irreparable distal biceps tendon ruptures with a semitendinosus autograft produces similar strength, range of motion, and complication rates, but slightly worse functional outcome scores, as compared with delayed primary repair. Despite placing the elbow into high degrees of flexion intraoperatively to achieve primary repair, this did not impede the final range of motion, strength, or functional outcome scores. This suggests that when possible, direct repair is preferred; however, if not possible, reconstruction with a semitendinosus tendon autograft results in predictably good outcomes.

Disclaimer

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