

A Simple Grafting Method to Repair Irreparable Distal Biceps Tendon

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Abstract Irreparable distal biceps tendon tears typically are treated using a free tendon graft. We asked whether our new method to fix the graft—using two suture anchors—yields similar results to our previous bone canal method. We compared the two methods for strength, endurance, and clinical findings. There were two groups, the suture anchor group (Group A, seven patients) and the bone canal group operated on before suture anchors (Group B, seven patients). The patients were males with a mean age at surgery of 44.9 years. The operative delay from primary trauma to index surgery averaged 5.9 months. The minimum followup was 2 years (mean, 11.1 years; range, 2–23 years). The mean arc of elbow motion was 0° to 132°, pronation 83°, and supination 80°. Compared with the contralateral side, the maximal peak torque was 84% in supination and 91% in pronation, and the maximal static elbow flexion strength was 94%. The Mayo elbow score averaged 99 in Group A and 100 in Group B. There were no major differences between the two groups. Our novel modification to fix a tendon graft yields equal clinical

outcomes compared with the bone canal method for treatment of irreparable distal biceps tendon injuries.

Level of Evidence: Level IV, therapeutic study. See the Guidelines for Authors for a complete description of levels of evidence.

Introduction

Primary surgical repair generally is accepted as the preferred treatment of complete distal biceps tendon avulsions [3, 19, 24]. Because of the rarity of this entity, the diagnosis often is delayed and the distal tendon may retract sufficiently to make primary repair difficult or impossible. To address tendon retraction, a graft usually is needed to restore the length [6, 8, 26]. Previously, we introduced the graft through two drill canals into the radial tuberosity, but suture anchors allowed an easier way to fix the graft [25].

Numerous articles report recovery of strength and endurance after surgery [6, 8, 20, 26]. Ryhänen et al. [20] reported static supination strength of 78% and flexion strength of 90% compared with the nonoperated side. Only three of the 16 patients had tendon transfer. Darlis and Sotereanos [6] achieved mean supination strength of 87% of the contralateral healthy extremity in their seven Achilles tendon allograft cases. Hallam and Bain [8] reported only one patient with autologous hamstring graft and isometric strength measurement. That patient achieved 92% flexion strength and 90% supination strength. Wiley et al. [26] reported recovery of flexion and supination strength to the normal range in seven semitendinosus allograft cases.

We began using suture anchors in the late eighties [25]. We presumed our suture anchor fixation method offered an equal alternative to bone tunnel fixation for repair of the

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Each author certifies that his or her institution has approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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irreparable distal biceps tendon with a free tendon graft in strength, endurance, and clinical findings of the elbow.

Materials and Methods

We retrospectively reviewed 40 patients who had distal biceps tendon repairs for tendon avulsion from 1983 to 2005. In 20 of these patients with a long-standing avulsion, repair was not possible without a free tendon graft. All patients were males; 15 of the 20 patients agreed to complete a questionnaire and report for a clinical followup at a minimum of 2 years (mean, 11.1 years; range, 2–23 years) after surgery, whereas five chose not to participate. In seven patients, the graft was fixed using two bone anchors (Group A), and in seven the graft was introduced through two drill canals into the radial tuberosity (Group B). We excluded one (Group A) of the 15 patients who completed the followup because his distal biceps tendon had been fixed elsewhere to the ulna using a gracilis tendon graft. We released the graft and fixed it correctly. The followup included biomechanical testing performed by a physiotherapist and clinical examination by an independent examiner who had not participated in the treatment of the patients. The mean age of the patients at surgery was 44.8 years (range, 26–57 years).

The diagnosis was established by clinical examination without imaging. The ruptures were caused by a sudden violent pull with the elbow in flexion (11 patients) or by lifting a heavy object (three patients). Six patients had sports accidents, five had work injuries, and three fell and caught themselves with the right hand. Preoperatively, flexion-extension range of motion (ROM) of the elbow was normal but ROM of supination was 80°. The main indication for surgery was weakness of supination, but most also reported weakness in elbow flexion. The operative delay from the primary trauma to the index surgery averaged 5.9 months (range, 16 days–22 months). The delay was caused by missed diagnoses, mostly owing to inexperienced doctors. One patient had a failed biceps tendon repair elsewhere before the index operation. All patients were right-handed. The left hand was involved in three patients.

We used a single-incision technique in all patients. A 15-cm S-shaped incision for tendon graft repair was typically longer than in primary repair (Fig. 1). The major neurovascular structures were not exposed, but Hohmann retractors were used around the radial neck for exposure of the radial tuberosity. All surgery was performed by the senior author (MV). A plantaris longus tendon was used in seven patients, long extensors of the second and third toes in six patients, and a palmaris longus in one patient. A plantaris longus tendon was our primary choice because

it is easiest to harvest. If the plantaris longus tendon did not exist, we harvested long extensors, which are always stronger than even the best plantaris tendon but more cumbersome to harvest. We preferred not to use a palmaris longus tendon for this repair because of its shortness. The gap between the radial tuberosity and the stump of the biceps tendon was approximately 4 to 5 cm when the elbow was in 90° flexion. The shortest gap needing grafting was 3 cm. We wove the graft two or three times through the stump. Normally, the graft was double- or triple-folded, ie, four or six tendons together (Fig. 2), and in some cases, also twisted. First we estimated the suitable length of the graft of the elbow in 90° flexion so it reached the tuberosity with almost maximal downward pull of the biceps, tied it, and secured the knots using Number 000 nonabsorbable sutures. We fixed the graft into the ulnar side of the roughened radial tuberosity by means of two Mitek GII



Fig. 1 A scar after the second surgery for a distal biceps tear measures approximately 15 cm.



Fig. 2 A double-folded free tendon graft is fixed to the stump of the distal biceps tendon.

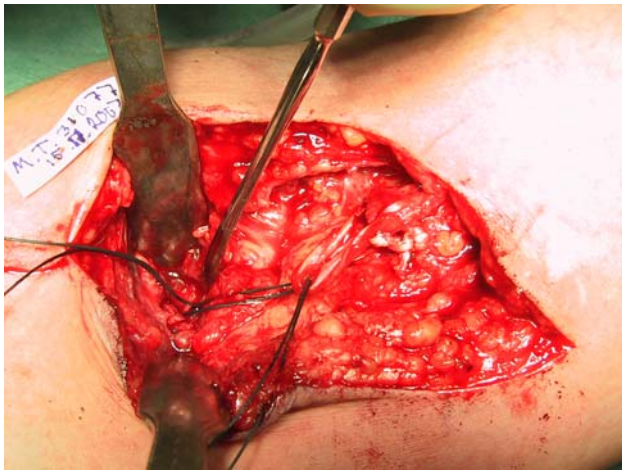


Fig. 3 Sutures of two suture anchors are shown before tying.

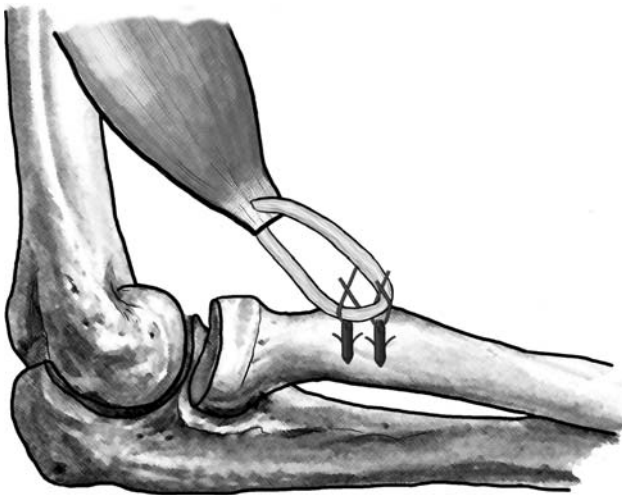


Fig. 4 A line diagram shows the bone anchor method using a free tendon graft.

anchors (DePuy Mitek, Norwood, MA) approximately 8 to 10 mm apart. The roughened and drilled area was irrigated carefully to minimize postoperative heterotopic ossification. It then was easy to tie anchor sutures over the tendon loop (Figs. 3 and 4). Thus, firm contact of approximately 8 to 10 mm diameter (the surface area of the contact between the tendon graft and the radial tuberosity) was created between the bone and the tendon graft. After completing the procedure, it is not possible to extend the elbow more than approximately 30° beyond a right angle (ie, 60° flexion). Seven patients were operated on in the 1980s when bone anchors were not yet available and the tendon loop was attached by conducting the graft twice through two drill canals into the tuberosity.

Postoperatively, we immobilized the arms in a long arm cast in slight supination and at 90° flexion for 6 weeks. We then recommended gradual self-managed mobilization.

Full ROM usually was achieved within 2 to 4 weeks after cast removal with no formal physical treatment. We recommended patients avoid strenuous exercise for 3 months after surgery.

Clinical followup was scheduled 6 weeks after surgery, at 9 weeks, and in most cases, also at 12 weeks. At the last regular visit, we manually tested ROM, strength, and the condition of the biceps muscle and distal biceps tendon. The final followup was performed by an independent examiner (HV) who was not involved in the treatment of the patients. In addition, a questionnaire assessing the patients' subjective opinion was completed, and biomechanical strength testing was conducted by an experienced physiotherapist (MV). The Mayo elbow score was used to assess the overall results [19].

We conducted biomechanical strength testing using a computer-based isokinetic dynamometer (Lido Multijoint II; Loredan Biomedical Inc, West Sacramento, CA). Isometric supination and pronation strength were measured at 60° per second. The average peak torque of three repetitions in Newton-meters was calculated bilaterally. Normally, the differences between three repetitions were less than 15%. If there was a discrepancy greater than 15%, we repeated the test bilaterally. The maximal static flexion strength of both arms was measured at three angles: 45°, 90°, and 135° flexion.

In a questionnaire, the patient had to choose one of three responses concerning elbow flexion and supination strength (normal, a little diminished, a lot diminished), and the shape of the biceps muscle (normal, a little abnormal, a lot abnormal). They also assessed the subjective end result of surgery (excellent, good, fair, poor).

The results are presented as mean values and 95% confidence intervals. We compared the two sides using a paired t-test and the groups using an unpaired t-test. The data were normally distributed with similar variances. All analyses were performed with SPSS 11.0 for Windows (SPSS Inc, Chicago, IL) (JK).

Results

Maximal elbow flexion strength was similar ($p = 0.63$) in the two groups: 63 Nm in Group A and 59 Nm in Group B (Table 1). Each group also had similar ($p = 0.88$) strength on the operated as compared with the contralateral control side: 93% in Group A and 97% in Group B. Maximal peak torque for forearm supination also was similar ($p = 0.16$) in the two groups (8.3 Nm in Group A and 10.9 Nm in Group B). Both groups had similar maximal peak torque for supination compared with the contralateral side: 73% in Group A ($p = 0.08$), and 94% in Group B ($p = 0.73$).

We noted no major clinical differences between Groups A and B at last followup. All patients had a palpable distal

Table 1. Results of biomechanical strength testing

Test muscle strength measurement	Group A			Group B			Group A vs. B	
	Operated	Nonoperated	p value ¹	Operated	Nonoperated	p value ²	Operated ³	p value
Maximal isometric peak torque; Nm								
Pronation, mean (SD)	9.4 (1.5)	11.6 (3.1)	0.136	11.3 (3.4)	10.7 (3.3)	0.752	-1.9 (-4.9 to 1.2)	0.206
Supination, mean (SD)	8.3 (1.9)	11.3 (3.6)	0.082	10.9 (4.0)	11.6 (4.3)	0.753	-2.6 (-6.4 to 1.3)	0.162
Maximal static strength; Nm								
Elbow flexion, mean (SD)	63 (8)	68 (8)	0.341	59 (25)	61 (23)	0.878	4.9 (-16.8 to 26.5)	0.634

¹ p values are for differences between operated vs. nonoperated in Group A; ² p values are for differences between operated vs. nonoperated in Group B; ³ Values are mean differences (95% confidence intervals) of operated upper limb muscle strength between Group A and Group B.

biceps insertion to the biceps during the physical examination. The neurovascular status of the upper extremity of all patients was intact, but one patient in Group A had a permanent painful cutaneous nerve lesion in his foot resulting from harvesting of the long extensors of the second and third toes. Heterotopic ossification occurred in two patients, one causing substantial reduction in ROM (25°–120°) of the elbow.

All patients were pain-free at rest, but two patients in Group A reported some discomfort with strenuous activities. The ROM was similar in both groups (Table 2). One patient in Group A had an extension deficit of 25° resulting from heterotopic ossification (Fig. 5), and supination of 45°. The maximal circumference of the biceps muscle compared with the contralateral side was the same in both groups (Table 2). The shape of the biceps muscle compared with the healthy side was normal or nearly normal in 11 patients and deformed, stretched, or atrophied in three patients (Table 3). The left hand was operated on in three patients, two in Group A and one in Group B. Six patients did the same work as before the injury, two had moved to lighter work, and six had retired, one in Group A as a result of the index injury. That patient (now 58 years old) retired after 12 months sick leave after the injury and was receiving workers' compensation. He had marked heterotopic ossification at the operative area (Fig. 5) limiting motion: extension deficit 25°, flexion 120°, pronation 80°, and supination 45°. His Mayo elbow score was 95; that of the others was 100. Five other patients receiving workers' compensation did well. The length of the S-shaped operative scar averaged 18 cm (range, 13–24 cm) (Fig. 1).



Fig. 5 Marked heterotopic ossification after distal biceps tendon repair is seen on the radiograph.

Most patients considered their elbow flexion and supination strength normal or almost normal (Table 3).

Discussion

Irreparable distal biceps tendon tears typically are treated using a free tendon graft. Numerous approaches have been

Table 2. Results of clinical findings

Group	Elbow extension-flexion	Range of motion (°)		Biceps circumference (cm)		Grip strength (kg)	
		Pronation	Supination	Operated	Contralateral	Operated	Contralateral
A	1–131	86	76	38	38	51	56
B	1–133	78	84	35	35	51	50

Table 3. Patients' subjective assessment

Result	Strength				Shape of biceps			Result of surgery	
	Elbow flexion		Supination		A	B		A	B
	A	B	A	B					
Normal	4	5	2	5	2	3	Excellent	1	4
A little diminished	2	2	3	2	4	2	Good	5	3
A lot diminished	1	—	2	—	1	2	Fair	1	—
							Poor	—	—

advocated to fix the graft distally. We previously used a method inserting the graft into a bone canal method but more recently used two suture anchors. We asked whether our suture anchor fixation method would offer an equal alternative to bone tunnel fixation for repair of an irreparable distal biceps tendon with a free tendon graft for strength, endurance, and clinical findings of the elbow.

The small number of patients is a limitation of this retrospective study. Only 75% of the patients asked to participate agreed, and of those 15 patients, we excluded an additional patient because a new tendon graft was not needed as we used the graft transferred during the primary delayed surgery. These numbers do not allow for formal assessment of factors predicting better outcomes.

Ruptures of the distal biceps tendon occur mostly in men. The senior author (MV) has operated on only two females with distal biceps tendon ruptures, one of which was bilateral; in both patients, primary repair was possible. In the current study using grafts for repairs, all patients were men. Rupture usually occurs when unexpected extension force is applied to a flexed arm. A palpable and visible deformity of the distal biceps muscle belly is usually obvious with complete rupture. The diagnosis in this series was clinical in all patients, the most prominent symptom being diminished strength in supination. Unfortunately, the patients were seen by an experienced doctor so late that primary repair no longer was possible. Mostly, proximal migration was encountered causing asymmetry of the biceps muscle and lack of or some weakness of the distal biceps tendon.

Primary direct repair through one incision is the preferred method [2, 7, 11, 12, 16, 19, 20, 22], although some authors, before the time of bone anchors, preferred two-incision repair [26]. However, if the correct diagnosis is delayed, the distal biceps tendon retracts and repairs without interposition grafting may be impossible. Various autologous substances have been used, including fascia lata [5, 10], semitendinosus [2, 8, 9, 26], flexor carpi radialis [14, 22], and palmaris longus [20]. Allografts also have been used [6, 18, 21, 27]. We attempted repair of two of our 14 patients without a free tendon graft, but the distal tendon

appeared too short even with the elbow in 90° flexion. The operative delay in those patients was 16 days and 6 weeks. Some authors have reported successful direct repair months after the injury [20]. Perhaps the thickened synovial tendon sheet has prevented the distal stump from retracting in such cases (as sometimes observed by the senior author [MV]). However, a long operative delay did not appear harmful when using a free tendon graft, because it was possible to have a favorable result as much as 2 years after the injury. In the patient treated only 16 days after the injury, direct repair did not provide sufficient fixation owing to poor quality of the distal tendon, and we had to use a free tendon graft. In our experience, the limit usually is approximately 3 to 5 weeks.

After using a plantaris longus tendon in approximately 100 cases, mostly for repair of chronic rotator cuff tears, we found tendon sufficiently strong and long enough (greater than 30 cm) for successful repair of a retracted distal biceps tendon. Unfortunately, a strong enough plantaris longus tendon existed only in half of the patients, and thus the long extensors of the second and third toes were used. Harvesting a plantaris longus tendon using a one-incision technique and a long stripper is a quick, easy, and safe procedure taking only 5 minutes, whereas in harvesting long toe extensors, at least two incisions are needed and the procedure may take as much as 20 minutes, resulting in complications much as experienced by one of our patients. The palmaris longus tendon was used in a case in which we did not realize preoperatively the need for a tendon graft; the leg was not wrapped, and we decided to explore the palmaris longus tendon. In that patient, the tendon was long and strong enough. However, in our experience after using the palmaris longus tendon for flexor tendon repair for several years, it is not the best choice for distal biceps repair.

The easiest way to reattach a ruptured distal biceps tendon is to use suture anchors or some other device such as an interference screw or Endobutton (Smith & Nephew, Andover, MA). They are mechanically almost equal, although the Endobutton had the highest load to failure rate [15, 23]. Suture anchors can be placed more ulnarly or

posteriorly than a bone tunnel. In our technique, suture anchors were placed close to the ulnar rim of the radial tuberosity. Suture anchors have superior yield strength to bone tunnel fixation for distal biceps tendon repair in vitro [13]. Suture anchors also have worked well with fascia lata grafts [10]. In half of our patients, a tendon graft was reattached to the radius by using suture anchors. The method guaranteed good results with an immobilization of 6 weeks. The present-day tendency is to shorten the immobilization time as a result of better tendon reattachment methods [2, 6, 8, 11], especially in patients with acute injury up to a few days. In our experience however, it may result in failure as we observed in two patients treated elsewhere. If a free graft is used, we still recommend immobilization for 5 to 6 weeks.

Isokinetic testing after acute distal biceps tendon repair showed good recovery of strength and endurance in the repaired extremity for flexion-concentric testing and supination [4]. However, at 1 year followup after the Boyd-Anderson technique, the elbow flexion strength was reduced by 13% and supination strength by 19% [17]. Other than isolated case reports [8, 19], there are few studies reporting biomechanical testing after late repair of the distal biceps tendon [6, 20, 26]. Late reconstruction with a semitendinosus autograft restored flexion and supination strength and endurance to the normal range [26]. Reconstruction using an Achilles tendon allograft yielded a mean 87% maximum torque for supination compared with the contralateral side [6]. When palmaris longus or fascia lata grafts were used, the flexion was 77% weaker at the 90° angle, and the supination strength decreased by as much as 54% compared with the nonoperated extremity [20]. We found that the maximal static elbow flexion strength was 94% when compared with the contralateral side, and the maximal peak torque for supination averaged 84% and 91% for pronation indicating the method used is accurate.

Late repair of the distal biceps tendon needs more exposure than acute repair, thus raising the possibility of two major complications: injury to the posterior interosseous or lateral antebrachial cutaneous nerve [16, 20] and heterotopic ossification [1, 11, 17]. New reattachment methods have substantially diminished nerve injuries, and careful irrigation is needed to prevent heterotopic ossification. We did not perform surgical resection of heterotopic ossification, but it may provide a good result [28]. In the current patients, we used an S-shaped, approximately 15-cm-long incision. We observed no nerve injuries of the upper extremity, but one patient had a cutaneous nerve injury of the foot from tendon graft harvesting. Problems at the donor site are possible when using autografts. We prefer using a plantaris longus tendon because the risks seem low; however, we avoid problems with allograft material or synthetic augmentation.

Reconstruction of an irreparable distal biceps tendon using a plantaris longus or long extensors of the second and third toes and two suture anchors is a reasonable and reproducible option with satisfactory results, although the bone tunnel technique is still a sufficient and cost-saving alternative.

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