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Distal Biceps Tendon Rupture

A New Repair Technique in 14 Patients Using the Biotenodesis Screw

Paul Fenton,* MRCS, Ford Qureshi,[†‡] FRCS (Tr & Ortho), Amjid Ali,[§] FRCS (Tr & Ortho), and David Potter,[§] FRCS (Tr & Ortho)
*From the *Royal Orthopaedic Hospital, Birmingham, United Kingdom, [‡]Orthopaedic Department, Doncaster Royal Infirmary, Doncaster, United Kingdom, and the [§]Shoulder & Elbow Unit, Department of Orthopaedics and Trauma, Northern General Hospital, Sheffield, United Kingdom*

Background: Distal biceps tendon ruptures are uncommon injuries. Operative treatment has been shown to improve functional outcomes. A variety of surgical repair techniques have been described for distal biceps ruptures.

Purpose: The authors present their experience with a new technique to anatomically repair distal biceps tendon ruptures through a single-incision approach that they believe is a safe and reliable method of achieving repair.

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

Materials and Methods: Fourteen patients with 14 biceps tendon ruptures underwent a repair with a bioabsorbable Biotenodesis screw. All 14 patients underwent clinical assessment using the Mayo Elbow Performance Score, measurement of range of motion, and flexion strength testing. Mean follow-up was 29.1 months.

Results: Three patients had a good result and 11 patients had an excellent result. The mean elbow flexion arc was 141.4° (range, 125°-155°; standard deviation, 7.19°) with no flexion contractures in the operated side compared with the unaffected elbow. All patients achieved an equal range of pronation/supination to the unaffected side. The mean flexion strength in the injured arm was 25.7 kg, compared with 26.9 kg in the uninjured side. No complications were noted about the elbow.

Conclusion: The authors believe this new technique gives a good functional outcome with reproducible results.

Keywords: biceps tendon rupture; Biotenodesis screw; anterior approach

Distal biceps tendon ruptures are rare. They occur as a result of forceful eccentric contraction with the elbow in extension and the forearm supinated. The majority of ruptures occur at the radial tuberosity, but intratendinous and musculotendinous ruptures have also been described.[4] They occur in men in the fourth decade of life and affect the dominant limb. The incidence has been reported as 1.24 per 100 000 annually.[27] Etiologic factors involved include mechanical impingement and hypovascularity.[28] Smoking has also been shown to increase the risk of tendon rupture.[27]

[†]Address correspondence to Mr Ford Qureshi, Doncaster Royal Infirmary, Thorne Road, Doncaster, United Kingdom DN2 5LT (e-mail: fordortho@hotmail.com).

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The patient usually reports an audible "pop" at the elbow and a palpable gap where the biceps tendon should be. A biceps squeeze test has been proposed as having increased diagnostic sensitivity[26] and, in cases where diagnostic doubt exists, ultrasound or MRI are the investigations of choice.[29]

Improved outcome in terms of strength of elbow flexion and supination as well as function has been shown with operative treatment of distal biceps tendon ruptures when compared with nonoperative treatment.[2] It has been suggested that repair of injuries to the dominant limb give improved outcomes compared with the nondominant limb.[18]

Several methods of reattaching the ruptured distal biceps tendon have been described. These include a tenodesis of the ruptured biceps tendon to the brachialis, although this produces worse functional results than an anatomic repair. Repair has been performed using transosseous sutures via a bone tunnel.[14] Original repairs required bone tunnels and needed 2 incisions to perform. There were problems with heterotopic ossification with these techniques, and methods were developed using bone anchors or EndoButtons (Smith & Nephew Endoscopy, Andover, Massachusetts) to repair ruptures through a single approach. Although these described techniques allow the use of a single incision, they still are associated with complications of nerve palsy.[22]

We describe our experience of a new technique for the repair of distal biceps tendon ruptures using a Biotenodesis screw (Arthrex, Naples, Florida) through a single anterior incision. This method provides an interference screw fixation to reattach the biceps tendon into the radial tuberosity. The purpose of this review of 14 consecutive patients was to evaluate the outcome of distal biceps tendon ruptures treated in this way. This method of treatment has been previously described only as a single case report.[15]

PATIENTS AND METHODS

Between 2005 and 2006, 14 patients with distal biceps tendon ruptures were referred to the care of one of the senior authors (D.P.). All patients were offered surgery, as we suggest that athletes and manual laborers not prepared to accept loss of flexion and supination strength associated with nonoperative treatment consider surgery. All 14 patients were male, and their mean age at injury was 39.4 years (range, 32-47 years; standard deviation, 4.24). All patients denied anabolic steroid use but 3 patients were smokers. The mechanism of injury was weight training in 6 cases, lifting heavy objects in 5 cases, and sports-related injuries in 3 cases (rugby union in 2 patients, martial arts in 1 patient). The mean time interval between injury and tendon repair was 14.6 days (range, 1-28 days; standard deviation, 7.24). In 10 patients, the dominant limb was injured and in 4 patients, the nondominant arm was injured.

All patients underwent repair of the tendon using a single anterior incision with the use of the Arthrex Biotenodesis screw to reattach the tendon to the radial tuberosity. Six of the patients required a further percutaneous incision proximal to the elbow joint to facilitate retrieval of a retracted biceps tendon. Three patients required a semitendinosus autograft to augment the biceps tendon repair.

All patients were followed up postoperatively between 16 and 42 months (mean, 29.1 months). Patients were assessed using the Mayo Elbow Performance Score (MEPS).[24] The MEPS is a functional score that assesses pain, range of motion, stability, and daily functions. The scores range from 0 (poor) to 100 (excellent). Isokinetic biceps flexion strength was assessed using the Nottingham Myometer (Arthrocare UK, North Yorkshire, United Kingdom). Strength was assessed with the myometer attached to a table anchored to the floor. The elbow was at 90° with the forearm supinated. Three attempts were allowed per side, with a 2-minute rest between each attempt. The maximum strength achieved was the measurement recorded. A goniometer was used to measure forearm pronation/supination with the elbow at 90° of flexion, and elbow flexion/extension.

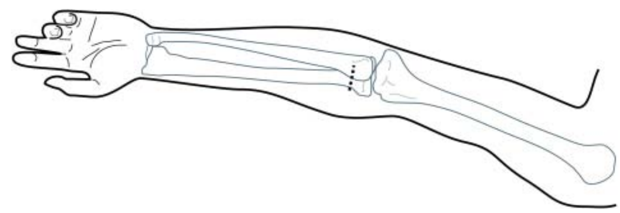

Figure 1. Site of incision.

The range of motion and strength measurements were compared with the uninjured arm using a paired *t* test; a *P* value of <.05 was considered significant. Regression analysis of the time to surgery and outcome was performed with the Pearson correlation coefficient.

Operative Technique

Under general anesthesia, all patients were placed supine on an operating table with the arm rested on a padded arm board. No tourniquet was used as it was thought that this would hinder the retrieval of a retracted ruptured biceps tendon. The proximal Henry approach was performed through a transverse incision, 3 cm distal to the elbow crease in the line of Langers (Figure 1). The distal end of the ruptured biceps tendon was then milked distally to deliver it through the anterior approach. In 6 cases, 3 patients with chronic injuries who required tendon grafting and 3 others, this was not possible, so a second percutaneous incision, just large enough to retrieve the tendon, was made more proximal to the elbow to exteriorize the retracted tendon and free it from any adhesions. The frayed distal end of the retrieved biceps tendon was then trimmed (up to 1 cm in most cases) before using a No. 2 FiberWire suture (Arthrex) to whipstitch the distal 2 cm of the tendon (Figure 2). If the tendon had been retrieved proximally, it was then passed subcutaneously through the anterior incision.

In 3 patients, the retrieved tendon was found to be attenuated and too degenerated to perform a direct repair and so the semitendinosus hamstring tendon was harvested, using a tendon stripper, from the ipsilateral knee through a small incision over the pes anserinus. A double-looped semitendinosus tendon graft was then fashioned and incorporated into the degenerated biceps tendon using a Pulvertaft weave by passing the tendon graft through the distal biceps tendon before suturing the 2 together (Figure 3). The length of the graft was measured so that the repaired tendon would not be under tension with the elbow flexed at 30º.

The muscular interval between the pronator teres and brachioradialis was then developed to identify the supinator muscle lying anteriorly on the radius. The leash of Henry was often ligated or electrocauterized to aid with deeper dissection. The forearm was then placed into maximal supination and extension and the supinator was

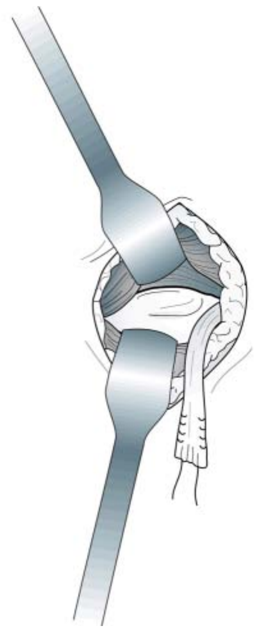

Figure 2. Radial tuberosity exposed, ruptured tendon whip-stitched.

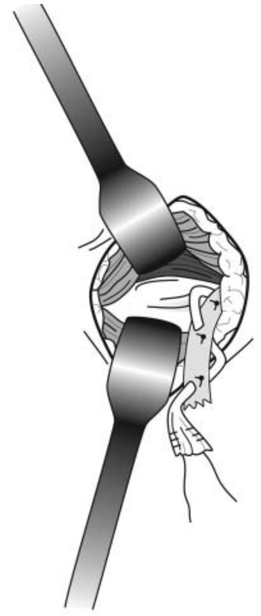

Figure 3. Use of semitendinosus graft in cases where the biceps tendon attenuated.

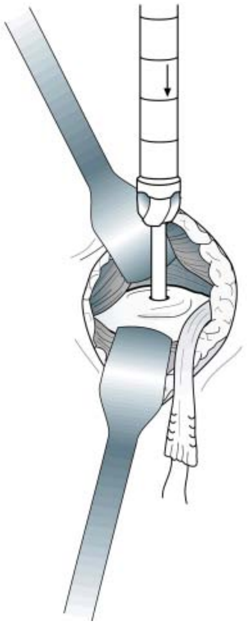

Figure 4. Radial tuberosity prepared with reamer.

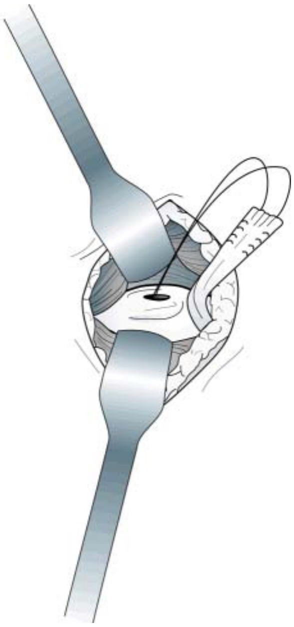

Figure 5. Whipstitched tendon passed through prepared tuberosity with Beath pin.

dissected longitudinally from the radial shaft to identify the radial tuberosity. The remnants of the ruptured biceps tendon were then debrided from the radial tuberosity and an Arthrex guide pin drilled through the center of the radial tuberosity until it just breached through the dorsal cortex. The guidewire was then over reamed with an 8-mm acorn reamer (Arthrex) to a depth of 15 mm (Figure 4). It was possible to ream to this depth, without breaching the far cortex, using the graduations of the reamer as a guide. This created an 8-mm × 15-mm hole within the radial tuberosity. The suture tails of the whip-stitched distal biceps tendon were then passed through the eyelet of a Beath pin (Figure 5). The guidewire was removed and the Beath pin was then passed through the small hole in the distal cortex and retrieved percutaneously on the dorsal aspect of the proximal forearm. The pin was then pulled out with the suture tails and the biceps tendon was manipulated to lie on the ulnar side of

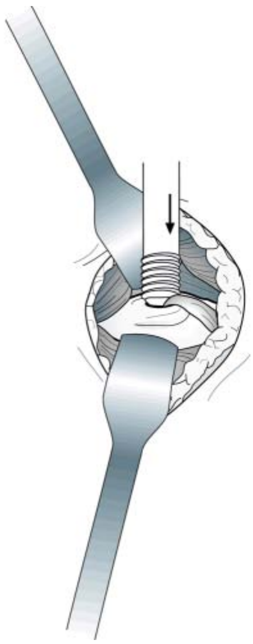

Figure 6. Biotenodesis screw inserted.

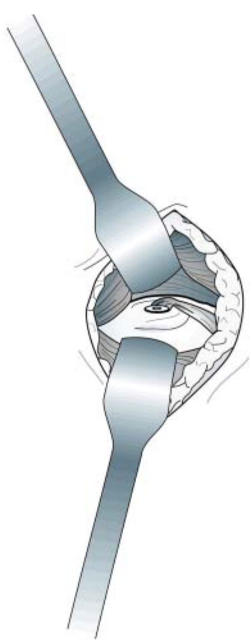

Figure 7. Repaired tendon and screw in situ.

the 8-mm hole. It was then secured in the prepared hole with an 8-mm × 12-mm Biotenodesis interference screw (Arthrex) while traction was maintained on the suture tails on the other side of the forearm (Figure 6). The interference screw was seated within the hole with the elbow positioned in 20° of flexion. Once the screw was buried, the driver was removed and the suture tails were tied against the radius and cut beneath the skin (Figure 7). The main function of the passed sutures is to allow adequate tensioning of the tendon as the screw is seated, and we encountered no problems with sutures pulling out through the far cortex. Elbow stability and the repair were then tested through 20° to 120° of flexion and all wounds closed.

Postoperative Rehabilitation

Postoperative rehabilitation consisted of 3 weeks of immobilization in an above-elbow plaster with the forearm in neutral rotation and 90° of elbow flexion. This was followed by 3 weeks within a poly sling, and thereafter gentle active-assisted exercises were begun with our physiotherapists. At 6 weeks postoperatively, full active mobilization was commenced

RESULTS

At a mean follow-up of 29.1 months (range, 16-42 months), all cases had undergone uncomplicated surgery and postoperatively all patients had returned to their preinjury occupation at a mean time of 11 weeks (range, 4-16 weeks). The mean return to previous recreational activities, including weight training or sports, was 4.2 months (range, 3-6 months).

One patient developed an ipsilateral adhesive capsulitis of the shoulder postoperatively that responded well and promptly to physiotherapy. There were no other reported complications, in particular no wound infections or nerve injuries. Table 1 summarizes the results of the 14 patients in the study. Patients 1 to 11 had undergone a biceps tendon repair and patients 12 to 14 had required an augmented repair using a semitendinosus hamstring graft. The mean postoperative flexion range of elbow movement was 142.5° degrees (range, 125°-155°; standard deviation, 7.19°) with no extension deficits noted (Figure 8). The mean value for the uninjured arm was 144.3° (range, 135°-150°; standard deviation, 5.14°) and although this difference was statistically significant ($P = .01$, correlated t test), it did not result in any functional impairment. All patients achieved an identical range of postoperative pronation/supination to their uninjured side.

Overall, the mean MEPS was 96.8 (range, 85-100). The score for pain ranged from 30 (mild) to 45 (no pain), with a mean of 40.5. All patients achieved the maximum score of 20 for range of motion and the maximum of 10 for stability. Similarly, all patients achieved the maximum score of 25 in the assessment of daily function. Thus, according to the MEPS grading, all patients achieved either a good (3 patients) or an excellent (11 patients) result.

In 2 patients, it was not possible to compare flexion strength with the nonoperated arm due to contralateral arm injury. In the remaining 12 patients, the mean flexion strength in the injured arm was 25.7 kg (±3.25, 95% confidence interval [CI]) compared with a mean of 26.9 kg (±3.29, 95% CI) in the uninjured arm (paired t test, $P = .006$).

In the 3 patients who required a semitendinosus hamstring graft, there were no reported complications from the knee wounds or deficits in knee function.

TABLE 1
Patient Clinical Data[a]

Patient	Side	Follow-up, mo	Strength Loss (%)	Supination-Pronation Normal Side, deg	Supination-Pronation After Repair, deg	Flexion Range of Motion Normal Side, deg	Flexion Range of Motion After Repair, deg	MEPS (0-100)
1	D	25	2.4	80-80	80-80	140	140	100
2	D	25	3.1	75-80	75-80	140	140	100
3	D	41	9.4	90-60	90-60	155	155	100
4	D	26	N/A	80-80	80-80	150	145	100
5	ND	42	5.6	85-85	85-85	150	145	100
6	D	25	2.9	70-80	70-80	145	145	100
7	D	26	4.9	80-80	80-80	140	140	100
8	ND	37	3.4	90-90	90-90	145	145	100
9	D	16	0.5	80-80	80-80	145	140	100
10	ND	39	N/A	80-90	80-90	135	130	100
11	D	24	0	80-80	80-80	145	145	100
12	ND	25	1.9	70-70	70-70	145	145	85
13	D	21	7.4	85-85	85-85	145	140	85
14	D	35	5.2	70-70	70-70	140	125	85
Average		29.1	3.9	79.6-79.3	79.6-79.3	144.3	142.5	96.8

[a]MEPS, Mayo Elbow Performance Score; D, dominant; ND, nondominant; N/A, not available.

Figure 8. Full extension postoperatively. Note proximal scar used to retrieve retracted tendon.

The relationship between time to surgery and outcome was assessed using the Pearson correlation coefficient with $r = -.75$ (95% CI, –0.96 to –0.365). When interpreting this result, it should be noted that the 3 patients with the longest time to surgery underwent semitendinosus tendon grafting and therefore the study group is not homogeneous.

DISCUSSION

We report on 14 patients who underwent repair of distal biceps tendon ruptures via a single volar incision, without complications about the elbow, using a Biotenodesis screw. Three patients had the repair augmented with a semitendinosus graft. We recognize that repair in these 3 patients differs significantly from repair in the other patients; however, the aim of this article is to describe the use of the Biotenodesis screw in distal biceps tendon repair. All patients returned to work at a mean of 11 weeks and recreational activities at a mean of 4.2 months without reported functional impairment. They achieved a mean range of movement of 141.4° (standard deviation, 7.19). The MEPS in 11 patients was excellent; in the 3 patients who required graft, the MEPS outcome was good.

Avulsion of the distal biceps insertion is uncommon, but represents 3% of all injuries to the biceps brachii; 1% involve the short head and 96% involve the long head.[9] Nonoperative treatment is better offered to lower-demand patients who are not reliant on the endurance of elbow flexion and forearm supination.[3]

Repair of the distal biceps tendon rupture can be achieved by an anatomic reattachment to the radial tuberosity or by a nonanatomic tenodesis to the brachialis muscle. It has been suggested that nonanatomic repair reduces the risk of complications; however, the biceps muscles contribute strongly to forearm supination and studies have demonstrated a 40% to 56% reduction in supination strength with nonanatomic repair.[16,25]

The surgical approach for those patients who require biceps tendon repair remains debatable. Boyd and Anderson[5] described a 2-incision approach to reduce the risk of radial nerve injuries associated with the previously used extensive volar approach. Morrey et al[25] performed the approach without subperiosteal dissection in an attempt to avoid heterotopic ossification, a recognized complication with the 2-incision approach. However, 2-incision techniques have been associated with radioulnar synostosis and posterior interosseous nerve injury.[7,14]

More recent fixation methods have allowed the use of a single-incision anterior approach. Several studies report using this approach with no complications.[3,19] In a larger study, McKee et al[22] followed 53 patients after repair with a single-incision technique and identified 4 complications: 1 wound infection, 2 transient lateral cutaneous nerve paresthesias, and 1 posterior interosseous nerve palsy that resolved within 6 weeks. El-Hawary et al[8] compared a modified Boyd and Anderson 2-incision technique with a single volar incision method. They reported complications in 44% treated with a single-incision technique and 10% treated with the 2-incision technique, with most complications being transient nerve paresthesias. In a recent systematic review, Chavan et al[6] reported statistically significantly more unsatisfactory clinical results in repairs via a 2-incision technique. Henry et al[12] noted that the tendon is reinserted differently with 1-incision and 2-incision techniques; however, in their cadaveric study, they found no statistically significant difference in flexion force or supination torque with anterior or posterior reconstruction techniques.

Several methods of anatomic fixation for distal biceps tendon ruptures have been described. Various studies describe reattachment using a bone tunnel and transosseous sutures[14,23]; however, this method requires 2 incisions, with the attendant risk of complications as described above.

Repair with suture anchors has gained popularity. McKee et al[22] reported on 53 patients treated using this technique and found it effective in restoring function. Other smaller studies reported similar results.[3,19]

Repair can also be achieved using an EndoButton. Greenberg et al[10] performed cadaveric studies and found that an EndoButton repair was stronger than both bone bridge and suture anchor repair. Bain et al[1] used the EndoButton to repair 12 distal biceps tendon ruptures with satisfactory outcomes and no neurovascular complications or synostoses. Although it has been suggested that the EndoButton can produce soft tissue irritation,[13] we noted no such problems relating to sutures in our series. Hallam and Bain[11] repaired 9 chronic ruptures with a semitendinosus autograft and an EndoButton and found all patients to have satisfactory outcomes. We report no direct complications of the repair in our series and postulate that this is due to our use of a single-incision volar approach, although we acknowledge the limited numbers in our series.

The bioabsorbable tenodesis screw has previously been used in cruciate ligament injuries and the repair of proximal biceps tendon ruptures. Several in vitro studies have suggested that distal biceps tendon ruptures would be amenable to repair with a Biotenodesis screw. Idler et al[13] studied failure strength, maximum strength, and stiffness in a cadaveric study and found that repair with the Biotenodesis screw was significantly stronger than a repair with transosseous suture tunnels. They found no significant difference in strength and stiffness between intact biceps tendon and tendon repaired with the Biotenodesis screw.[13] Mazzocca et al[20] found that repair in cadavers with the Biotenodesis screw was stronger than repair with bone tunnels, although the difference was not statistically significant. They also found that the Biotenodesis screw allowed more of an anatomic placement of the repaired tendon that cannot always be created with a bone tunnel technique with transosseous sutures.[20] In a separate cadaveric study, Mazzocca et al[21] compared pullout strength of repairs using bone tunnels, suture anchors, interference screws, and EndoButtons, finding a statistically significant greater load to failure with EndoButton repair compared to the other methods. In their systematic review, Chavan et al[6] noted that EndoButton repair performed best in biomechanical studies. Krushinski et al,[17] in a further cadaveric study, found the mean pullout strength of distal biceps tendons repaired with a Biotenodesis screw repair to be statistically significantly higher than those repaired with suture anchors. In the only previous clinical report of repair with a Biotenodesis screw, Khan et al[15] found a recovery of full range of motion and strength at 3 months postoperatively in a single case report.

Our study also showed a return of biceps strength and range of motion with excellent or good functional results in all of the 14 cases. One of the patients had a 20° reduction in his postoperative flexion-extension range of motion at a follow-up of 29 months that was attributed to his prolonged rehabilitation, which had been complicated from an adhesive capsulitis of the ipsilateral shoulder. Some power loss was noted, but other factors may have influenced these results, such as the dominance of the arm. All patients returned to their preinjury levels of work and sporting activities.

Our experience with this technique has shown that it does allow reattachment of the biceps tendon into a position that closely correlates with the true anatomic position. The use of the Biotenodesis screw allows fixation via a limited volar approach, thereby reducing the risks of complications seen with the 2-incision technique. It is a successful method for integrating a tendon into bone, as has been shown in knee and shoulder soft tissue reconstruction surgery. A strong fixation can be achieved that closely matches the anatomic attachment and is technically less demanding than other methods as well as being reproducible. Functional results are uniformly good or excellent, with all patients achieving return of strength and a prompt return to work.

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