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Acute Distal Biceps Brachii Tendon Ruptures: Medium-Long Term Results with Tension-Slide Technique and Interference Screw

Fernando De Maio, Alessandro Caterini, Francesco Liuzza, Giuseppe Rovere, Pasquale Farsetti, Vincenzo De Luna

Department of Clinical Science and Translational Medicine, Section of Orthopedics and Traumatology, University of Rome "Tor Vergata", Rome, Italy

CORRESPONDING AUTHOR:
Vincenzo De Luna
Department of Orthopedic Surgery
University of Rome "Tor Vergata"
viale Oxford 81
00133 Rome, Italy
E-mail: videluna@hotmail.com

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SUMMARY

Introduction. A complete tear of the distal biceps tendon is a relatively rare injury and generally occurs in middle-aged men. Primary surgical anatomical reinsertion is a commonly used treatment, but conservative treatment can be performed in some cases. Two surgical approaches are reported: single and double-incision technique, and various fixation methods are described.

Materials and methods. In the present retrospective study we report the results in a series of 22 patients surgically treated using tension-slide technique (Biceps Button – Arthrex, Inc, Naples, Florida) in association with an interference screw. Nineteen were males and 3 females, with a mean age of 48 years.

Results. One patient had PIN palsy with complete recovery in 3 months and 4 had transient LABCN neuroapraxia. At follow-up range of elbow motion and muscle strength were evaluated in comparison to the contralateral side. Clinical results were also assessed using DASH and MEPS scores. Tensiomyography was also performed to evaluate muscle strength. After a mean follow-up of 30 months, 8 patients had an excellent result and 14 a good result. No patient had a tendon re-rupture, peripheral neurological deficit or symptomatic heterotopic ossifications. Six patients had a mild deficit of elbow motion and 8 patients a mild deficit of forearm pronosupination. At tensiomyography evaluation, 7 patients showed a mild deficit of flexion and supination strength. All patients returned to their previous daily and sports activities.

Conclusions. According to our results, in patients affected by acute distal biceps tendon rupture surgical treatment, performed in the acute phase using tension-slide technique and interference screw, is associated with satisfactory outcomes.

KEY WORDS

Acute distal biceps tendon rupture; anatomical reinsertion; tension-slide technique; biceps button; tensiomyography.

INTRODUCTION

Acute complete distal biceps brachii tendon ruptures are uncommon. The incidence of this lesion is about 2% in 100,000 patients/year (1, 2) and generally occur in middle-aged men because of eccentric contraction of the biceps muscle. Patients with an acute lesion often report a painful "pop" sensation. Typical symptoms include edema, ecchymosis in antecubital fossa and proximal retraction of the distal biceps tendon (reverse Popeye sign) (**figure 1**). A decreased strength in elbow flexion and in forearm supination is commonly present. Several clinical tests have been reported to confirm the diagnosis, but the most used maneu-



Figure 1. Clinical aspect of a 43 years-old man with acute distal biceps tendon rupture.

Edema, ecchymosis in antecubital fossa and proximal retraction of the distal biceps tendon (reverse Popeye sign) are clearly represented.

vers are the hook test (3) and the passive pronation test (4). The hook test is positive if the examiner's index finger fails to hook the distal biceps tendon; the passive pronation test is positive when is observed an inability to actively supinate the injured forearm. Both tests present a high sensibility and specificity for this lesion. In the majority of cases clinical exam is sufficient to diagnose an acute distal biceps tendon rupture. In unclear cases, overall in case of partial ruptures, MRI represents the gold standard for a final diagnosis. The majority of authors recommends early surgical repair of acute complete distal biceps tendon rupture (5-14). In fact, surgical treatment of the chronic lesions determines higher complications and worse results (15).

On the contrary, conservative treatment using a shoulder arm immobilizer may be considered in selected cases.

Surgical approach can be performed by a single or double incision, and various fixation methods have been described for the reinsertion of the distal biceps tendon. In the current literature, several surgical techniques for the fixation of the distal biceps tendon have been described with different results, although many authors agree that the reinsertion must be anatomical rather than a simple tenodesis on the anterior brachialis tendon (16). Also regarding the type of anatomical fixation on the radial tuberosity, several methods have been described, including trans osseous bone tunnels, metal or soft-tissue suture anchors, re-absorbable or not interference screws, and suspensory cortical buttons (17, 18).

In the present study we report the medium-long term results obtained in 22 patients with an acute complete distal biceps tendon rupture promptly surgically treated using tension-slide technique (Biceps Button – Arthrex, Inc, Naples, Florida) in association with an interference screw.

MATERIALS AND METHODS

We selected 22 patients with acute complete distal biceps tendon rupture surgically treated in the early stage, between February 2018 and October 2022, by an anterior approach using tension-slide technique (Biceps Button – Arthrex, Inc, Naples, Florida) and interference screw. Nineteen were males and 3 females, with a mean age of 48 years (range: 27-66 years). All patients had an appropriate clinical and instrumental documentation and were analyzed retrospectively with a mean follow-up of 30 months (range: 13-49 months). One patient had a posterior interosseous nerve (PIN) palsy with complete recovery in 3 months, and 4 patients had a transient lateral antebrachial cutaneous nerve (LABCN) neuroapraxia. In 15 cases the surgical treatment was practiced using a single anterior approach centered on radial tuberosity, while in 7 cases a second skin incision centered on biceps distal myotendinous junction was necessary to identify the retracted avulsed tendon.

Surgical technique

The operating patient position is supine with the elbow extended and the forearm is rested on a table in complete supination, in order to protect the posterior interosseous nerve (PIN). A longitudinal incision of approximately 3 cm is performed distal to the antecubital fossa between brachioradialis and pronator teres. After subcutaneous dissection the brachioradialis muscle is spread laterally to protect the motor branch of the radial nerve and flexor tendons are retracted medially. During the deep dissection, a series of veins are coagulated (Henry's reticulum) and, after identifying the avulsed insertion, the radial tuberosity is exposed. The biceps tendon usually is identified in the proximal part of the surgical incision and through a gentle traction

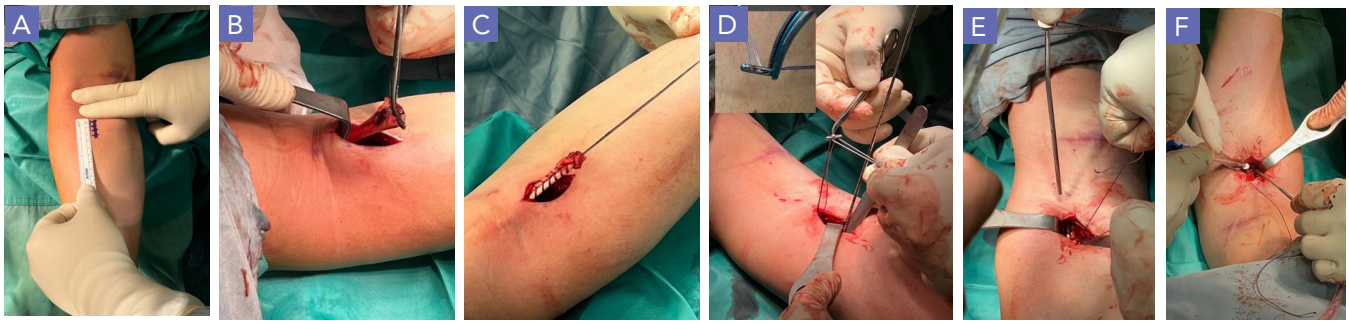


Figure 2. Longitudinal incision of approximately 3 cm just distal to the antecubital fossa centered on radial tuberosity (**a**); Biceps tendon is isolated and pulled externally (**b**); Biceps tendon is anchored using a Fiber-Loop suture and its edge is debrided to remove any degenerative tissue (**c**); Both limbs of suture are passed through the holes of the BicepsButton in opposite directions (**d**); BicepsButton is inserted, into the bone tunnel previously drilled, until it crosses the posterior cortex of the radius. The tendon is pulled into the radial tuberosity hole by tractioning the threads, which are then tied (**e**); An 8mm interferential screw is inserted into the bone tunnel to ensure better fixation of the tendon in the radial tuberosity hole (**f**).

is isolated proximally up to the myotendinous junction. The biceps tendon is then anchored using a Fiber-Loop suture and its edge is debrided to remove any degenerative tissue, until to obtain a 6-7 mm final diameter. Both limbs of suture are passed through the holes of the BicepsButton in opposite directions. The bicipital tuberosity of the radius is then prepared through a careful curettage and drilled initially with a 3.2 mm bi-cortical tunnel and subsequently with a 8 mm uni-cortical tunnel over the 3.2 mm guide pin. The elbow is moderately flexed and completely supinated to obtain an adequate tendon tension. The BicepsButton is then inserted into the bone tunnel until it crosses the posterior cortex of the radius. Through the traction threads of the suture, the tendon is pulled into the bone tunnel until a perfect adhesion of the button is obtained on the posterior cortex of the radius. After checking the correct tendon tension, the traction threads are knotted. Finally, an 8 mm interferential screw is inserted into the bone tunnel to ensure better fixation of the tendon in the tunnel (**figure 2**). After the surgical procedure, the correct positioning of the button on the bicipital tuberosity of the radius is radiographically verified (**figure 3**).

Post-surgical rehabilitation phase

The upper limb was initially immobilized with a brace that locked the elbow at 90° of flexion and 45° of supination. After two weeks the patients began the rehabilitation phase starting with active movements of pronation and supination of the forearm, while extension and active flexion of the elbow were permitted as tolerated, without lifting even light weights. After six weeks from surgery, the patients usually had full range of motion of the elbow and progressively began strength muscular exercises to return to their previous activities at the end of the third month.

At final follow-up, all patients were clinically evaluated by measuring range of motion of elbow and of forearm compared to the contralateral side. A neurological evaluation was also performed to exclude symptoms related to damage of the lateral antebrachial cutaneous nerve (LABCN) and of the posterior interosseous nerve (PIN). Clinical results were assessed using the Disabilities of Arm, Shoulder and Hand Score (DASH) (19) and Majo Elbow Performance Score (MEPS) (20). The results were considered excellent if DASH score ranged from 1 to 9 points, if MEPS score ranged from 90 to 100 points and if at clinical examination the range of elbow motion and flexion and

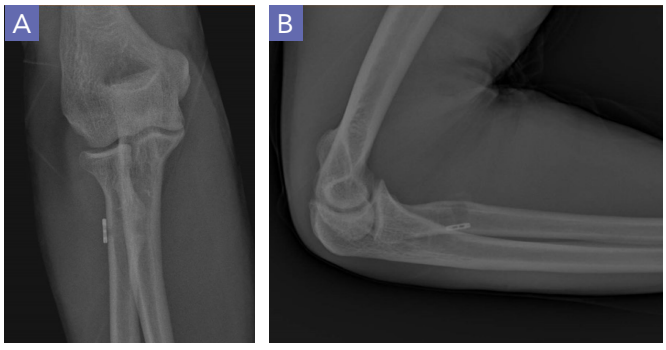


Figure 3. Radiographical examination of the right elbow in anteroposterior (**a**) and lateral (**b**) view of 53 years-old man surgically treated for acute distal biceps tendon rupture by cortical button and interference screw.

At 32 months follow-up the exam showed the correct positioning of the button on the bicipital tuberosity and excluded heterotopic ossifications.



Figure 4. Tensiomyography performed at 38 months follow-up in a 31 years-old man surgically treated for acute distal biceps tendon rupture by cortical button and interference screw.
The exam did not show muscular strength asymmetries.

supination strength were similar to the contralateral side. The results were considered good if DASH score ranged from 10 to 24 points, if MEPS score ranged from 75 to 89 points and if the range of elbow motion and flexion and supination strength were mild limited in comparison to the contralateral side (about -15° of pronosupination and -15% of muscular strength). The results were considered poor if DASH score was more than 24 points, if MEPS score ranged from 60 to 74 points and if the range of elbow motion and muscular strength were limited more than 30° and more than 15%, respectively, in comparison to the contralateral side.
Radiographic examination of the elbow was also performed to exclude radio-ulnar synostosis or heterotopic ossifications. Furthermore, the patients were analyzed using tensiomiography (TMG-BMC Ltd – Slovenia) to evaluate the muscle strength (**figure 4**) especially considering the contraction time (Tc) and maximal radial displacement (Dm) that are the two most commonly used parameters to assess the skeletal muscle contractile properties.
All study procedures were conducted in accordance with the ethical principles outlined in the 1964 Helsinki Declaration and its subsequent amendments. Informed consent for the scientific use of anonymized clinical data was obtained from all patients, in accordance with institutional regulations and the guidelines of the Italian Data Protection Authority. In compliance with Italian Legislative Decree No. 196/2003, as amended by Legislative Decree No. 101/2018, and Regulation (EU) 2016/679 (GDPR), the use of fully anonymized clinical data for research purposes does not require prior Institutional Review Board approval. Considering that the data were collected anonymously and that the study had a retrospective design, after extensive consultation with our internal committee, formal approval from the regional ethics committee was deemed unnecessary.

RESULTS

Demographics, clinical and instrumental results of our patients were reported in **table I**. According to our classification criteria, 8 patients had an excellent result and 14 a good result. No patient had a fair or poor result. We did not observe major post-operative complications like tendon re-rupture, peripheral neurological deficit related to posterior interosseous nerve (PIN) lesion, or to lateral antebrachial cutaneous nerve (LABCN) lesion. Six patients had a mild deficit of elbow motion compared to the contralateral side ranged from -10° to -15° and 8 patients had a mild deficit of forearm pronosupination ranged from -10° to -30°. DASH score ranged from 5 to 18 points (mean value 13 points) and MEPS score ranged from 82 to 94 points (mean value 88 points). At radiographic evaluation, no patient had symptomatic heterotopic ossifications or radio-ulnar synostosis. At instrumental evaluation, using the tensiomiography, 7 patients had a mild deficit of flexion and supination strength, ranged from -10% to -15%, compared to the contralateral elbow.
All patients were satisfied with the final result and returned to their previous daily and sports activities.

DISCUSSION

Distal biceps brachii tendon ruptures are relatively uncommon lesions, often diagnosed in middle-aged males as a result of eccentric biceps muscle contraction. Demographics data (**table I**) of our cohort of 22 patients are similar to those reported in current literature (1, 2, 14): 19 were males and 3 females, the mean age was 48 years and the dominant arm was involved in 19 cases. Smoking and obesity are the more common risk factors reported in the literature (14), but we did not observe specific risk factors for tendon ruptures in

Table I. Demographics, clinical and instrumental results of 22 patients with acute distal biceps tendon rupture surgical treated by anatomical reinsertion using Tension Slide Technique combined with interferential screw.

Case	Sex	Age	Side	Follow-up (months)	Elbow ROM compared to other side	Forearm ROM compared to other side	Tensiomyography muscular strength asymmetries	Dash score	MEPS score	Results
1	F	42	R	45	No differences	No differences	No differences	10	88	Good
2	M	49	R	49	No differences	-20° supination -10° pronation	No differences	17	84	Good
3	M	50	R	27	No differences	-15° supination -10° pronation	No differences	13	88	Good
4	F	52	R	29	-15° extension	-15° supination -10° pronation	-15 %	15	82	Good
5	M	44	L	47	No differences	No differences	No differences	6	92	Excellent
6	M	45	R	23	No differences	No differences	No differences	7	92	Excellent
7	M	48	R	38	No differences	No differences	No differences	16	88	Good
8	M	57	R	40	-15° extension	-25° supination -15° pronation	-10 %	14	88	Good
9	F	43	R	32	No differences	No differences	No differences	10	82	Good
10	M	58	R	37	-10° flexion	-20° supination -15° pronation	-15 %	15	92	Good
11	M	50	R	28	-10° extension	No differences	No differences	10	90	Excellent
12	M	52	R	25	No differences	No differences	-10 %	8	90	Excellent
13	M	53	R	14	No differences	-15° supination -10° pronation	-15 %	14	84	Good
14	M	66	R	15	No differences	-30° supination -20° pronation	-15 %	18	82	Good
15	M	53	R	32	-10° extension	No differences	No differences	16	88	Good
16	M	44	R	24	No differences	No differences	No differences	14	92	Excellent
17	M	66	L	29	-10° flexion	-25° supination -25° pronation	-15 %	16	86	Good
18	M	49	L	13	No differences	No differences	No differences	15	90	Excellent
19	M	31	L	38	No differences	No differences	No differences	16	92	Excellent
20	M	27	R	41	No differences	No differences	No differences	5	94	Excellent
21	M	43	R	18	No differences	No differences	No differences	15	88	Good
22	M	43	R	16	No differences	No differences	No differences	18	84	Good

our patients. Primary surgical repair of acute complete distal biceps tendon rupture, performed in the early stage, is the treatment of choice suggested by many authors, that reported satisfactory results in most patients (5-14).

In a retrospective study, De Carli *et al.* compared clinical and functional results in two groups of patients, treated for biceps distal tendon tears. Sixteen patients were treated with an anatomical reinsertion technique using trans osseous bone tunnels and in 20 cases was performed a no-anatomical repair by tenodesis on brachialis. They concluded that no-anatomical reinsertion ended up in satisfactory results, although the anatomical technique reduces the residual functional deficits often present after surgical treatment (16).

The results of a recent systematic review and meta-analy-

sis (21) documented the superiority of surgical management over conservative treatment for distal biceps tendon ruptures with satisfactory functional recovery, especially if surgical treatment is performed in the earlier stages. In fact, in chronic ruptures, scarring and proximally retracted tendon causes difficulties in anatomical tendon reinsertion and graft augmentation is often necessary using autografts or allografts (22, 23).

Conservative treatment is reserved for elderly patients with low functional demands or those that have various comorbidities with high risk of failure or perioperative complications (14, 18, 24, 25). In a systematic review, Quereshi *et al.* compared the outcomes of both operative and non-operative management of distal biceps brachii tendon rupture for adult patients. The highlights of this review are that the current evidence for surgical management of these lesions is weak, concluding that patients with a modest physical demand may have satisfactory results with non-operative treatment (18).

The surgical treatment is usually practiced using a single anterior approach centered on radial tuberosity, but sometimes is necessary to use a second anterior skin incision centered on biceps distal myotendinous junction to identify the retracted avulsed tendon. We used a single anterior incision in 15 cases while in 7 cases it was necessary to use a second anterior incision.

Also the surgical anatomical reinsertion of the distal biceps tendon rupture can be performed by a single anterior approach (26) or by a double approach, anterior and posterior (27). In single incision technique, a 2-3 cm incision is performed just distal to antecubital fossa between the brachioradialis and pronator teres; in double incision technique, a second incision is performed posterolaterally the elbow joint.

Numerous fixation methods have been reported. Options include bone tunnels, suture anchors, intraosseous screws, interference screws and bicortical buttons (14, 17, 23, 28-30). In our cases we performed a single longitudinal anterior incision with the elbow extended and forearm in maximum supination to avoid PIN lesions. The distal biceps tendon was anatomically reinserted on the radial tuberosity by a combination of bicortical button and interference screw.

Some authors reported that the use of the single incision technique has a higher risk of nerve palsy, especially of the posterior interosseous nerve (PIN) and of the lateral antebrachial cutaneous nerve (LABCN) (13, 14, 26, 31). Other authors reported that the fixation method by a cortical button increases the risk of PIN palsy as a result of bicortical drilling (7, 32). In our series only one patient had a PIN palsy with complete recovery in 3 months, and 4 patients had a transient LABCN neuroapraxia. These data are in agreement with the conclusions of Castioni *et al.* (33). In a meta-analysis including 13 studies, they compared single and double approach in surgical reinsertion of the distal biceps tendon ruptures and did not observe differences in PIN injuries. These conclusions confirm that in single approach technique maximum supination of the forearm mobilizes the posterior interosseous nerve out of the surgical site and avoids lesions of this nerve, especially during the bicortical drilling (34).

Many biomechanical and clinical studies of the various fixation methods of distal biceps tendon repair reported an excellent fixation strength using cortical button-interference screw combination technique (13, 29, 30, 35-38). In our series we did not observe recurrence of tendon rupture and these data confirm the results of biomechanical and clinical reports.

Watson *et al.* – in a systematic review – reported a complication rate of 26.4% (75 of 284) for suture anchors, 20.4% (34 of 167) for bone tunnels, 44.8% (13 of 29) for intraosseous screws, and 0% (0 of 18) for bicortical button fixation (30). Micheloni *et al.* analyzed the results of 14 cases surgically treated for distal biceps tendon ruptures using tension-slide technique and interference screw. The authors reported excellent clinical and functional results in all patients. One patient had PIN palsy, with complete recovery in 8 months, but surgery was performed 45 days after the tendon rupture (38).

In some biomechanical studies, the double-incision technique permits a more precise anatomical reinsertion of the biceps tendon into the radial tuberosity (10, 39). However, it is still debated if the anatomical reinsertion allows a significantly better result, and a higher risk of heterotopic ossifications in the double incision technique is reported (30, 31, 37, 40). In our series, all patients were surgically treated by the single incision technique and no patient had radio-ulnar synostosis or symptomatic ossifications.

We believe that even the anatomical variability and the type of tendon rupture can influence the outcome after surgical treatment. Kumar *et al.* in a cadaveric study of 50 limbs reported a detailed morphometric profile of the distal biceps tendon. The mean length of the tendon was 8 cm, the proximal thickness varied from 2 to 4 cm, and distal thickness from 1 to 3 cm. Furthermore, the morphology of the radial tuberosity is another variable element, and all these individual characteristics can influence the final result (41).

Other authors reported at follow-up some limitations of the elbow range of motion and of muscular strength (14, 38, 42). Calderazzi *et al*. used an isotonic muscle strength evaluation in 15 patients surgically treated by anatomical reinsertion with suture anchor repair through a single incision approach. The authors concluded that the dominant side is not important in the choice of treatment, but patients should be informed in advance about the possibility of a residual loss of flexion strength and limited supination range of motion (17). We used tensiomiography to evaluate the muscle strength that is a non-invasive device for monitoring muscle contractile and mechanical characteristics, analyzing some parameters such as maximal radial displacement (Dm), contraction time (Tc), delay time (Td) and velocity of contraction (Vc). In recent years, tensiomiography has been used in many applications such as muscle-tendinous damage and recovery, and bilateral muscle asymmetries (43-45). In our cases, we especially analyzed the contraction time (Tc) and maximal radial displacement (Dm), that are the two most commonly used parameters to assess the skeletal muscle contractile properties. Tc value was obtained considering the reference values indicated by the tensiomiography software according to the age of the patients, while Dm value was obtained by comparing the values of both limbs. At final follow up, in our patients we did not observe significant loss in range of motion, and, regarding the strength, in some cases we observed a slight weakness in elbow flexion and forearm supination. The limitations of our study are the relatively limited patient cohort and the absence of a control group.

CONCLUSIONS

In conclusion, according to our study, surgical treatment of acute distal biceps tendon rupture using a single anterior approach, performed by combination of tension-slide technique and interference screw, allows satisfactory clinical and functional results. Tensiomiography is a useful tool for evaluating the final results regarding the recovery of muscle strength. However, to support our preliminary outcomes, further studies are necessary.

FUNDINGS

None.

DATA AVAILABILITY

Data are available under reasonable request to the corresponding author.

CONTRIBUTIONS

PF, FDM: conceptualization, supervision, validation. VDL: data curation. FL, GR. Methodology. VDL, FL: project administration. FDM, AC: writing - original draft; GR, VDL: writing - review & editing.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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