ORIGINAL ARTICLE

Distal biceps tendon repair and posterior interosseous nerve injury: clinical results and a systematic review of the literature

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ABSTRACT

Aim To report clinical, functional and radiographic results of one-incision distal biceps tendon repair with Toggle Loc (Zimmer-Biomet, Warsaw, Indiana, USA) at an average 4-year follow-up and to assess posterior interosseous nerve injury complications after reconstruction.

Methods We conducted a retrospective review of 58 consecutive distal biceps tendon repairs performed at our department between 2010 and 2018. Disabilities of Arm, Shoulder and Hand (DASH) score, Visual Analogue Scale (VAS) scale and elbow range of motion (ROM) were recorded at each follow-up and an ultrasound examination was also performed to assess the repaired biceps brachii tendon.

Results Clinical evaluation showed good and excellent results at medium- and long-term follow-up. A temporary posterior interosseous nerve (PIN) palsy developed in four (6.81%) patients and always resolved in 8 weeks. PIN palsy prevalence is in accordance with the results of the previous studies.

Conclusion Distal biceps tendon repair with Toggle Loc is an effective surgical procedure. PIN injury is a relatively rare complication after one-incision anterior repair. Our complication rate did not differ significantly from other studies that have used cortical button fixation, reported in current literature. Our results confirm that accidental injury of PIN may also happen to experienced surgeons and suggest extreme care and an appropriate surgical technique to reduce this iatrogenic risk.

Key words: radial nerve lesion, surgical repair, sport trauma, tendon avulsion

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INTRODUCTION

Rupture of distal biceps tendon is a relatively rare injury with an incidence of 1.2 per 100,000 patients per year; injuries are most commonly seen in the dominant elbow of males (86%) with an average age of 47 years. Smoke, steroids and statins are associated to an increased risk of lesion (1,2).

Non-operative treatment leads to a functional loss of supination and flexion strength and endurance; this is reserved for older and sedentary patients with elevated surgical risks (3,4).

There are multiple options regarding the surgical technique of biceps tendon repair (one or two-incision techniques) and fixation devices (suture anchors, interference screws, cortical buttons, bone tunnels) (5,6). Complications accompany both approaches and involve a spectrum of nerve injuries, as well as heterotopic ossification, radioulnar synostosis, loss of forearm rotation and wound infection (7,8). Fixation with cortical button provided the highest load to failure (584 N) compared to suture anchors (253 N) and bone tunnels (173 N) (9).

Injury to the radial nerve is well-known and frequently described publication after distal biceps tendon repair (7,8). Historically, repair of the distal biceps tendon was complicated by injury to the posterior interosseous nerve (PIN) in 10% to 15% of patients. More recent literature has suggested that injury to the PIN has decreased to less than 10%, with rates as low as 1% (10).

The aim of the present study was to report clinical, functional and radiographic results of distal biceps tendon repair with Toggle Loc (Zimmer-Biomet, Warsaw, Indiana, USA) at 4-year mean follow-up, PIN injury complications and to evaluate the current literature to better quantify this complication in a larger population of patients. Such data could be potentially useful in preventing these lesions.

PATIENTS AND METHODS

Patients and study design

We performed a retrospective analysis of 58 consecutive patients who underwent a surgical repair of the distal biceps tendon due to a traumatic (i.e. non spontaneous) tendon rupture at the Department of Orthopaedics and Traumatology of the San Camillo-Forlanini Hospital (Rome) between January 2010 and December 2018.

The diagnosis was based on clinical history and patient physical examination. X-ray and ultrasound examination of the affected elbow were obtained before surgery. A Magnetic Resonance Imaging study (MRI) was done in 35 out of 58 (60%) patients. An ultrasound examination was performed after the surgical procedure in each patient.

The injury mechanism was recorded: the most common mechanism was a forceful eccentric extension of a flexed elbow as in lifting heavy objects.

Surgical procedures were all performed with Toggle Loc repair (Zimmer-Biomet, Warsaw, Indiana, USA) by the senior and experienced elbow surgeon. Distal biceps tendon repair was always performed within 10 days from the injury. Patients with previous surgical procedures on the affected elbow, systemic disease (diabetes, rheumatoid arthritis) and previous local corticosteroid injections were excluded from this study. Controls were performed at 6 and 12 months for the first year, and then yearly. Evaluation consisted of patient's physical examination with an assessment of elbow range of motion (ROM), pain, quantified using the Visual Analogue Scale (VAS) (0 indicating absence of pain and 10 maximum pain); standard radiographs in antero-posterior (AP) and lateral (LL) views; Disabilities of Arm, Shoulder and Hand (DASH score) questionnaires were also obtained, with 0 reflecting no disability and 100 reflecting major disability.

Ultrasound records were performed at the final follow-up.

According to the current law of our country, no ethical review board was required due to the retrospective nature of the study and it was conducted in accordance with the principles of the Declaration of Helsinki and its amendments. We fully informed all the patients about the characteristics of the study and they gave their consents.

Methods

Surgical technique. The surgical procedure consisted in a single anterior incision 1 cm distal to the elbow skin crease extended longitudinally for 3-4 cm, in correspondence with the radial tuberosity. The retracted distal biceps tendon was identified and secured with a # 2 Orthocord (DePuy-Mitek, Raynham, MA, USA), placed in a whip stitch

fashion. The dissection was carried down toward the radial tuberosity between the brachioradialis laterally and the pronator-teres muscles medially. During this exposure the lateral antebrachial cutaneous nerve and the deeper recurrent branches of the radial artery were identified and protected. With the elbow in full extension and supination the radial bicipital tuberosity was exposed. With the forearm in a maximally supinated position, a guide wire was inserted through the bicipital tuberosity in an anterior to posterior direction, aiming just slightly distal and ulnarly. Straight-cannulated drill bits were then advanced over the guide wire: a 4,5 mm for the far, posterior cortex and usually 8 mm, based on the size of the tendon, for the anterior cortex. A Biomet Toggle Loc (Zimmer-Biomet, Warsaw, Indiana, USA) was secured to the distal biceps; the cortical button was pulled through the radius using a pin to pass the suture and engaged to the opposite radial cortex. The biceps tendon was then mobilized and brought into the prepared drill hole on the radial tuberosity by shortening the Zip loop. The fixation was tested and intraoperative fluoroscopy was used to confirm the correct position of cortical button. The passing suture was removed.

Rehabilitation protocol. The arm was immobilized at 90° flexion with a sling for 2 weeks; passive movements were started immediately postoperatively with restricted extension that was sequentially increased with a full extension at 6 weeks. Active ROM was allowed at 6 weeks and gradual loading was applied to the arm until the fifth month from surgery. Patients performing sports, returned to full athletic activity 10 months postoperatively.

Statistical analysis

Continuous variables were compared using the Student t-test. Results were analysed and the study groups were compared with each other. Continuous variable was described using the mean±SD. The level of significance was set at p=0.05.

RESULTS

In the considered study period, 69 potentially eligible patients who underwent an acute surgical repair of the distal biceps tendon lesion were found. Eleven patients were excluded from the study: three because of an age <18 years, seven did not give their informed consent to the study and one was lost to follow up, leaving 58 patients eligible for the present study.

The mean age at the time of injury was 39 (range 18-55) years. The surgical repair was performed, on average, at 5 days from the trauma. The mean follow-up was 49 months.

At clinical examination none of the patients lost more than 5° in the flexion-extension or pronation-supination arc respect to the non-operated limb; five patients had a slight loss of extension (4°), pronation (3°) and supination (5°) respect to the non-operated limb; at clinical examination ROM measurements were comparable in the operated limbs in all patients (p>0.05).

The 6-month follow up mean DASH score was 21.5 (±10.6) with 75% of excellent results and 25% of good results; at 12-month follow up 18.0 (±9.9) with 78% of excellent results and 22% of good results; at the final follow up it was 16 (±10.3) with 80% of excellent results and 20% of good results. The statistical analysis showed no statistical difference (p>0.05) between the clinical scores at 6, 12 months and the final follow up. The mean VAS score was 2.1(±2) at 6-month follow up, 1.8 (±1.2) at 12-month follow up; 1.6 (±0.9) at the final follow up; no statistically significant differences were found between the VAS score results at each follow-up (p>0.05) (Table 1).

Table 1. Mean DASH and VAS clinical scores

Variable (mean±SD)	6-month follow-up	12-month follow-up	Last follow-up	p
DASH	21.5 (±10.6)	18 (±9.9)	16 (±10.3)	>0.05
VAS	2.1 (±2)	1.8 (±1.2)	1.6 (±0.9)	>0.05

DASH, Disabilities of the Arm, Shoulder and Hand; VAS, Visual Analogical Scale

Ultrasound and radiological examination did not reveal patients of biceps tendon re-rupture or signs of heterotopic ossification or synostosis. No postoperative wound problems or infectious complications were observed. One patient reported mild pain during maximal biceps brachii contraction and three patients described sensory problems like paraesthesia long the surgical incision. One patient reported complaints (tenderness) in the soft tissue of the surgical site. The most frequent complication was a transient palsy of the posterior interosseous nerve: four patients presented during their postoperative visit with

inability to extend the wrist, thumb and fingers and were placed in a dynamic digital extension splint, starting early active flexion hand exercises. At 4 weeks postoperatively, the patients had a slight improvement of extensor functions and at 8 weeks they regained PIN function (Table 2).

Table 2. Postoperative complications

Complication	N (%) of patients
Sensory disturbances	1 (1.7)
Flexion tenderness	1 (1.7)
Transient posterior interosseous nerve palsy	4 (6.9)

DISCUSSION

Injury to the radial nerve is a well-known and frequently described complication after distal biceps tendon repair. The original incision technique of repair described by Dobbie resulted in a high rate of radial nerve injury (11). Two incision techniques were later developed by Boyd and Anderson in order to decrease the high rate of nerve injury; however, this repair technique required two large incisions and was complicated by heterotopic ossification and/or radioulnar synostosis (12). The introduction of suture anchors, cortical buttons, including Endobutton and interference screws, allowed repair of the distal biceps through a smaller single anterior incision but also seemed to carry an increased risk of injury to the superficial radial nerve, the lateral antebrachial cutaneous nerve and the posterior interosseous nerve (13-15). Therefore, injury to the PIN can occur both with one- incision and two-incision approach techniques. In a systematic review, Amin et al. (16) reported a complication rate of PIN palsy of 2.7% (13/785) in the single incision procedure versus 0.2% (1/498) in the double incision procedure: this finding was most likely related to the need for more extensive anterior dissection to obtain an anatomic repair.

In a retrospective cohort study of distal biceps tendon repair, Dunphy et al. (17) reported that single incision repair undergoes lower rates of reoperation, PIN palsy and heterotopic ossification (HO), but a significantly higher rates of transient sensory nerve palsy compared to the double incision technique. The overall rate of PIN palsy reported by this study was 1.3%. This value was lower than that previously reported by other studies (17-22) ranging from 2% to 14.8%.

Indeed, several studies reported no cases of PIN palsy when a single anterior surgical approach with cortical button repair was used (9, 22-26) although one retrospective study (27) on 280 patients found an incidence of transient PIN palsy of 3.2% (nine patients) when suture anchors (3 cases) and cortical button (6 cases) were used as a fixation technique in a single surgical approach technique. In a recent systematic review of the literature regarding fixation methods and complications Chavan et al. (28) found that end button repairs exhibited the best performance in comparative biomechanical studies and reported that both transient and permanent nerve palsies were the most common complication in a single incision group in 13%. Di Raimo et al. (29) was the first to investigate the use of Toggle Loc Zip Loop and reported only one transient superficial sensory radial nerve palsy on a series of 4 patients. Kodde et al. (30) reported a dysfunction of PIN in 2 patients of 22 (9%), which was transient in both patients; in this study Toggle Loc fixation was used in 14 elbows: guide wire was drilled aiming just slightly distal and ulnarly.

These studies show that PIN palsy is a relatively rare but serious complication after biceps repair using cortical button fixation and may occur during dissection along the proximal radius, drill bit placement or entrapment under a cortical button (31,32). The drill bit trajectory across the radius can be influenced by the skin incision used to expose the biceps tuberosity of the radius; a longitudinal incision placed over the biceps tuberosity of the radius results in the drill passing the radius perpendicular to its longitudinal axis with an exit dorsal to the biceps tuberosity of the radius. Two studies on fresh frozen cadavers showed that the mean distance of the button from the PIN was 9.3 mm (9) and 11.6 mm (33).

Bain et al. (23) found that drilling anterior to posterior is safer than drilling radially: the distance from the tip of the Steinman pin advanced through the bicipital tuberosity where it exited the posterior cortex ranged from 10 to 18 mm with 0 angulation and from 0 to 13 mm with 45° posterolateral angulation. Lo et al. (34) observed an average distance of 11.2 mm from the PIN in the anterior to posterior trajectory from the radial tuberosity, compared with 4.2 mm in the radial trajectory; aiming the guide pin 30° ulnarly resulted in the greatest distance from the PIN (16.7 mm), but such an ulnar angulation risks an impinge-

ment of the cortical button on the ulna in supination. A distal drill trajectory across the radius resulted in the greatest risk of iatrogenic injury of the PIN (2.0 mm average distance between the drill bit and the PIN).

Such data were confirmed by two further studies (31,35), reporting that drilling 30° ulnarly with the forearm in maximum supination results in the greatest distance from the PIN, compared with drilling anterior to posterior, with no decrease in the bony tunnel length available for implants.

A recent study of Becker (36) showed that the PIN travels from an anterior position on the radius when measuring 1 cm proximal on the bicipital tuberosity to a lateral position on the radius at the level of the bicipital tuberosity prominence on the contralateral cortex to a slightly more posterior position on the radius 1 cm distal to the bicipital tuberosity; typically the PIN sits directly opposite the biceps tuberosity on the cortex of the radius in full supination and, therefore, perpendicular drilling starting at the bicipital tuberosity should be avoided for the risk of iatrogenic PIN injury; a more proximal and ulnar drilling angle is recommended; defining a safe zone for an anterior approach seems to be clinically unhelpful for the high anatomical variability that exists for the position of the PIN around the proximal radius.

In the current study we inserted a guide wire through the bicipital tuberosity in an anterior to posterior direction, aiming just slightly distally and ulnarly: this distal drilling could potentially explain our cases of PIN neuroapraxia. Our experience confirms that accidental lesion of the PIN may also happen to experienced surgeons; therefore, we advise extreme care and suggest an appropriate surgical technique to reduce the risk of iatrogenic injury. When an anterior approach is chosen, the arm should be supinated to protect the posterior interosseous nerve and when passing pins or drilling; oscillation or tapping of the slotted passing pin is recommended to prevent entrapment of the posterior soft tissues. In some cases, a small posterior-lateral incision could be made to ensure that the PIN is not under the cortical button. Intraoperative imaging may be used to confirm an appropriate position of the button on the radial tuberosity; the cortical button should be deployed just as it exits the posterior cortex, to avoid soft tissue interposition (20).

Identification of the radial nerve and its branches can be important in protecting it from injury: if the radial nerve and its PIN branches are isolated intraoperatively, the incidence of injury to these important structures can theoretically be minimized (37). We also advise extreme care in the exposition of the radial tuberosity and recommend the use of hand-held right-angle retractors (skin hooks) instead of Hohmann retractors at both sides of the radius, that may lead to neurovascular complications caused by their increased force.

In conclusion, this study showed that "single-incision" Toggle loop repair (Zimmer-Biomet, Warsaw, Indiana, USA) of distal biceps tendon ruptures is a "reproducible" operation with good clinical/functional results and a relatively rare incidence of PIN palsy: this complication can be reduced with appropriate surgical technique.

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TRANSPARENCY DECLARATION

Conflict of interest: None to declare.

REFERENCES

1. Safran MR, Graham SM. Distal biceps tendon ruptures: incidence, demographics, and the effect of smoking. Clin Orthop Relat Res 2002; 404:275-83.
2. Kelly MP, Perkinson SG, Ablove RH, Tueting JL. Distal biceps tendon ruptures: an epidemiological analysis using a large population database. Am J Sports Med 2015; 43:2012-7.
3. Chillemi C, Marinelli M, De Cupis V. Rupture of the distal biceps brachii tendon: conservative treatment versus anatomic reinsertion-clinical and radiological evaluation after 2 years. Arch Orthop Trauma Surg 2007; 127:705-8.
4. Quach T, Jazayeri R, Sherman OH, Rosen JE. Distal biceps tendon injuries-current treatment options. Bull NYU Hosp Jt Dis 2010; 68:103-11.
5. Lang NW, Bukaty A, Sturz GD, Platzer P, Joestl J. Treatment of primary total distal biceps tendon rupture using cortical button, transosseus fixation and suture anchor: a single center experience. Orthop Traumatol Surg Res 2018; 104:859-63.
6. Tjoumakaris FP, Bradley JP. Distal Biceps Injuries. Clin Sports Med 2020; 39:661-672.
7. Stoll LE, Huang JI. Surgical treatment of distal biceps ruptures. Orthop Clin North Am 2016; 47:189-205.

8. Ford SE, Andersen JS, Macknet DM, Connor PM, Loeffler BJ, Gaston RG. Major complications after distal biceps tendon repairs: retrospective cohort analysis of 970 cases. J Shoulder Elbow Surg 2018; 27:1898-906.
9. Greenberg JA, Fernandez JJ, Wang T, Turner C. EndoButton-assisted repair of distal biceps tendon ruptures. J Shoulder Elbow Surg 2003; 12:484-90.
10. Garon MT, Greenberg JA. Complications of distal biceps repair. Orthop Clin N Am 2016; 47: 435-444.
11. Dobbie RP. Avulsion of the lower biceps brachii tendon. Am J Surg 1941; 51: 662-83.
12. Boyd HB, Anderson LD. A method for reinsertion of the distal biceps brachii tendon. J Bone Joint Surg 1961; 43:1041-3.
13. Kelly EW, Morrey BF, O'Driscoll SW. Complications of repair of the distal biceps tendon with the modified two-incision technique. J Bone Joint Surg Am 2000; 82:1575-81.
14. Miyamoto RG, Elser F, Millett PJ. Distal biceps tendon injuries. J Bone Joint Surg Am 2010; 92:2128-38.
15. Grewal R, Athwal GS, MacDermid JC, Faber KJ, Drosdowech DS, El-Hawary R, King GJ. Single versus double-incision technique for the repair of acute distal biceps tendon ruptures: a randomized clinical trial. J Bone Joint Surg Am 2012; 94:1166-74.
16. Amin NH, Volpi A, Lynch TS, Patel RM, Cerynik DL, Schickendantz MS, Jones MH. Complications of distal biceps tendon repair: a meta-analysis of single-incision versus double-incision surgical technique. Orthop J Sports Med 2016; 4:2325967116668137.
17. Dunphy TR, Hudson J, Batech M, Acevedo DC, Mirzayan R. Surgical treatment of distal biceps tendon ruptures: an analysis of complications in 784 surgical repairs. Am J Sports Med 2017; 45:3020-9.
18. Cain RA, Nydick JA, Stein MI, Williams BD, Polikandriotis JA, Hess AV. Complications following distal biceps repair. J Hand Surg Am 2012; 37:2112-7.
19. Carroll MJ, DaCambra MP, Hildebrand KA. Neurologic complications of distal biceps tendon repair with 1-incision endobutton fixation. Am J Orthop (Belle Mead NJ) 2014; 43:E159-62.
20. Garon MT, Greenberg JA. Complications of distal biceps repair. Orthop Clin N Am 2016; 47: 435-44.
21. McKee MD, Hirji R, Schemitsch EH, Wild LM, Waddell JP. Patient-oriented functional outcome after repair of distal biceps tendon ruptures using a single-incision technique. J Shoulder Elbow Surg 2005; 14:302-6.
22. Banerjee M, Shafizadeh S, Bouillon B, Tjardes T, Wafaisade A, Balke M. High complication rate following distal biceps refixation with cortical button. Arch Orthop Trauma Surg 2013; 133:1361-6.
23. Bain GI, Prem H, Heptinstall RJ, Verhellen R, Paix D. Repair of distal biceps tendon rupture: a new technique using the Endobutton. J Shoulder Elbow Surg 2000; 9:120-6.
24. Spencer EE Jr, Tisdale A, Kostka K, Ivy RE. Is therapy necessary after distal biceps tendon repair? Hand (NY) 2008; 3:316-9.
25. Peeters T, Ching-Soon NG, Jansen N, Sneyers C, Declercq G, Verstreken F. Functional outcome after repair of distal biceps tendon ruptures using the endobutton technique. J Shoulder Elbow Surg 2009; 18:283-7.
26. Dillon MT, Bollier MJ, King JC. Repair of acute and chronic distal biceps tendon ruptures using the EndoButton. Hand (NY) 2011; 6:39-46.
27. Nigro PT, Cain R, Mighell MA. Prognosis for recovery of posterior interosseous nerve palsy after distal biceps repair. J Shoulder Elbow Surg 2013; 22:70-3.
28. Chavan PR, Duquin TR, Bisson LJ. Repair of the ruptured distal biceps tendon: a systematic review. Am J Sports Med 2008; 36:1618-24.
29. DiRaimo MJ Jr, Maney MD, Deitch JR. Distal biceps tendon repair using the toggle loc with zip loop. Orthopedics 2008; 31.
30. Kodde IF, van den Bekerom MP, Eygendaal D. Reconstruction of distal biceps tendon ruptures with a cortical button. Knee Surg Sports Traumatol Arthrosc 2015; 23:919-25
31. Thumm N, Hutchinson D, Zhang C, Drago S, Tyser AR. Proximity of the posterior interosseous nerve during cortical button guidewire placement for distal biceps tendon reattachment. J Hand Surg Am 2015; 40:534-6.
32. Lo EY, Li CS, Van den Bogaerde JM. The effect of drill trajectory on proximity to the posterior interosseous nerve during cortical button distal biceps repair. Arthroscopy 2011; 27:1048-54.
33. Tat J, Hart A, Cota A, Alsheikh K, Behrends D, Martineau PA. Distal biceps repair with flexible instrumentation and risk of posterior interosseous nerve injury: a cadaveric analysis. Orthop J Sports Med 2018; 6 :2325967118810523.
34. Lo EY, Li CS, Van den Bogaerde JM. The effect of drill trajectory on proximity to the posterior interosseous nerve during cortical button distal biceps repair. Arthroscopy 2011; 27:1048-54.
35. Saldua N, Carney J, Dewing C, Thompson M. The effect of drilling angle on posterior interosseous nerve safety during open and endoscopic anterior single-incision repair of the distal biceps tendon. Arthroscopy 2008; 24:305-10.
36. Becker D, Lopez Marambio FA. How to avoid posterior interosseous nerve injury durino single-incision distal biceps repair drilling. Clin Orthop Relat Res 2019; 477: 424-31.
37. Mokhtee DB, Brown JM, Mackinnon SE, Tung TH. Reconstruction of posterior interosseous nerve injury following biceps tendon repair: case report and cadaveric study. Hand (NY) 2009; 4:134-9.