Anatomical evaluation of a cortical button for distal biceps tendon repairs

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Abstract

Background The posterior interosseous nerve (PIN) is at risk for injury during one-incision distal biceps tendon repair using a cortical button. The purpose of this study was to evaluate the proximity of a cortical button to the PIN during one-incision repairs of the distal biceps tendon using human cadaveric models.

Methods In ten cadaveric elbows the biceps tendon was identified, traced to its insertion, and transected. With the forearm supinated, a guide pin was drilled through the radial tuberosity at a 0°, perpendicular to the table. A dorsal incision was used to identify the PIN. The tendon was repaired with a cortical button, ensuring the device lay in line with the radial shaft. The distance from the device to the PIN was measured using digital calipers. This process was repeated with the guide pin aimed at 20° proximal toward the radiocapitellar joint (RCJ) and 30° distal toward the wrist. The data were compared using a Student's paired *t*-test.

Results The average distance from the device to the PIN with the straight posterior insertion was 8.94 mm, 11.86 mm with 20° proximal, and 0.55 mm with 30° distal angles. The distance between the button and the PIN was significantly greater when aiming the device 20° toward the RCJ compared to the straight insertion technique ($p=0.0061$).

Conclusions The distance between the PIN and cortical button can be significantly increased by aiming the guide pin between 0° and 20° proximal toward the RCJ and placing the device in line with the radial shaft.

Keywords Distal biceps · Anatomical study · Elbow surgery · Tendon repair · Posterior interosseous nerve

Background

Rupture of the distal tendon of the biceps brachii most often occurs in active, middle aged men [5]. Although distal biceps tendon rupture has been reported to represent between 3 % and 10 % of all biceps ruptures with an incidence of 1.2 of 100,000, this injury has financial and functional implications for those affected [12, 13]. Non-surgical management is a treatment option for these injuries, however, reports have shown that non-operative management leads to a significant decrease in supination and flexion strength and can result in continued discomfort and functional impairment [1].

Anatomic repair of the distal biceps brachii tendon to its insertion on the radial tuberosity has been shown to restore function and strength and has excellent functional outcomes [1, 14]. Multiple surgical and fixation techniques have been reported for repairing the distal biceps brachii tendon to its insertion [9, 14]. The two incision technique was first described by Boyd and Anderson and later modified by Morrey et al. [2, 11]. This technique can cause heterotopic ossification which may result in radioulnar synostosis. In an

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effort to reduce post-operative complications, a single incision technique was developed [4]. The single incision technique reduces the risk of heterotopic ossification but is associated with a higher incidence of nerve injuries, especially to the posterior interosseous nerve (PIN) [9]. The PIN winds around the neck of the radius in the substance of the supinator muscle into the dorsal compartment of the forearm where it continues close to the interosseous membrane. During the single incision technique, the PIN is at risk of injury when the drill exits the posterior cortex of the radius and during placement of the device [10].

The purpose of this study was to determine if variations in drill angle would increase the distance between the cortical button device and the PIN. We hypothesized that aiming the drill 20° directly proximal toward the radiocapitellar joint (RCJ) would provide the greatest margin of safety between the PIN and the cortical button.

Materials and Methods

Ten formalin-preserved, cadaveric arms from six donors were used for this study. With the forearm fully supinated, a transverse incision was made 3 cm distal and parallel to the crease at the antecubital fossa. Dissection was carried down toward the radial tuberosity. Care was taken to avoid the lateral antebrachial cutaneous sensory nerve and median nerve. The tendon of biceps brachii was identified and transected at its insertion to represent an acute rupture. A dorsal incision was made in order to identify the PIN as it winds through the supinator muscle to facilitate accurate measurement.

With the arm fully supinated, a 2.4-mm guide pin (Biomet, Inc., Warsaw, IN) (Fig. 1), was drilled in each of two positions as follows. The first pin was driven with the drill in the perpendicular position. The starting point was engaging the radial tuberosity in as ulnar a position as possible. The guide pin was drilled straight. A simulated repair of the biceps tendon was performed with the cortical

button (ToggleLoc™, Biomet, Inc.). The suture components that make up the loops of the ToggleLoc device were pulled to expand the length of the loops. These two loops were pulled and cut evenly in the center making four strands. A free needle was used to sew the actual device suture into the biceps tendon in a Krakow fashion and tied to each other after suturing. The tip of the wire, and subsequently the device itself, was then measured in proximity to the closest point to the PIN, ensuring that the device lay in line with the radial shaft with the longer end closest to the PIN (Fig. 2). All measurements were performed with digital calipers.

The guide pin was drilled into the bicipital tuberosity the same manner as described above but aimed 20° directly proximal toward the RCJ (Fig. 1). The cortical button was placed and the distance from the device to the closest point of the PIN was measured. Twenty degrees proximal was chosen because we found it to be the most distal the surgeon could bring their drill hand while trying to point the guide pin tip proximally toward the RCJ.

The guide pin was drilled in aimed at 30° distal, pointing toward the hand (Fig. 1). The cortical button was placed in the same manner as described above and measurements were obtained. Thirty degrees distal was chosen because it is the angle from the antecubital fossa to the biceps tubercle and is something that is relatively easy to accomplish clinically.

Data from each technique were compared using a two-tailed, paired Student's *t*-test and were considered significant if $p < 0.05$.

Results

Five right arms and five left arms from six donors were used for this study. The age range for the specimens was 79–89 years with an average of 83.6 years. Seven of the ten arms were from female donors. The average length and width of the bicipital tuberosities were 17.4 (± 4.31) and 12.7 (± 3.84) mm, respectively.

Fig. 1 Pictorial representation of the three drill angles. **a** Drill aimed directly posterior; **b** drill angled 20° toward the radiocapitellar joint; **c** drill angled 30° toward the hand

Fig. 2 Picture of the posterior aspect of the forearm showing the cortical button placed in line with the shaft of the radius

The average distance from the PIN to the cortical button was 8.9 mm (standard error=0.969) for the perpendicular insertion, 11.9 mm (standard error=0.950) when aimed toward the RCJ, and 0.6 mm (standard error=0.296) when aimed toward the hand (Table 1). There was a significant difference between the perpendicular insertion and inserting the device at 20° toward the RCJ ($p=0.0061$). The distance between the device and the PIN was significantly less using the 30° distal insertion compared to the perpendicular insertion ($p<0.0001$).

Discussion

The incidence of diagnosed distal biceps tendon ruptures may have increased from 3 % of all tendon injuries to approximately 10 % in the past few decades [12, 13]. Patients affected are most often males in their third through

Table 1 Distance from the cortical button to the posterior interosseous nerve (PIN)

Distance from the PIN to the device			
Specimen	20° Proximal	Perpendicular Insertion	30° Distal
1	11.3	12.0	1.3
2	11.1	11.8	0.0
3	13.0	8.8	0.0
4	12.2	7.0	0.0
5	9.5	4.2	0.0
6	14.7	8.4	0.0
7	11.4	8.6	0.0
8	5.2	5.2	1.3
9	17.2	14.8	0.0
10	12.9	8.7	2.9
Avg	11.9	8.9	0.6
Std error	1.0	1.0	0.3

sixth decades of life [5, 12]. The mechanism of injury in most cases is an eccentric contraction while carrying a heavy load or after a fall onto an outstretched arm [12]. Degenerative tendon changes as well as use of anabolic steroid or smoking likely increase the risk of tendon rupture [12]. Current literature supports surgical repair of distal biceps tendon ruptures in a population of patients requiring restoration of elbow flexion and supination strength [1, 14].

The use of a cortical button for distal biceps tendon repair continues to gain popularity due to superior initial repair strength which allows for more aggressive postoperative rehabilitation [4, 6, 8]. In addition, the single incision technique may decrease operative time and reduce the risk of radioulnar synostosis [3]. This technique has been associated with iatrogenic injury to the PIN from the drill exiting the posterior cortex of the radius and while placing the device [13]. Most surgeons use a transverse incision across the antecubital crease, making it necessary to aim the drill distally to access the bicipital tuberosity.

Intermedullary fixations either through tunnel [8] or trough [4] are also favorable and popular fixation techniques. Intermedullary fixation may have a better healing rate and there is no hardware and a minor risk of nerve injury. One disadvantage of intermedullary fixation is an increase in the occurrence of heterotrophic ossification, one event that is unlikely to occur with our repair. Baker et al. performed intermedullary fixation through a two incision technique using a trough. He found in a small patient group that loss of flexion strength and decrease in supination were common [4]. Within 9 months of surgery heterotrophic ossification was also found in one of the patients [4].

Other reports have studied the effect of drill angle on distance to the PIN and have shown similar results [7, 13]. Lo et al. [7] published a recent report which evaluated the distance between the pin used to drill through the radius and the PIN using four different drill angles (anterior to posterior, 45° distal, ulnar and radial) in ten fresh-frozen, unmatched human cadavers. They showed a significantly greater distance when the pin was drilled perpendicularly through the radius as opposed to when it was drilled in a 45° distal direction [7]. These findings are similar to our study. Lo et al. [7] also evaluated the distance between the guide pin and the PIN when the drill was aimed ulnarly and radially. They found that aiming the pin ulnarly provided the greatest margin of safety to the PIN but also resulted in drilling into the ulna in 30 % of their specimens, making this an impractical option [7]. This study did not examine aiming the drill in the proximal direction which we found to have the greatest distance from the PIN.

We demonstrated that there was a significant difference between the drill tip pointing perpendicular to the radius and subsequent straight insertion of the cortical button and the drilling with the drill tip pointed toward the RCJ with subsequent insertion of the device angled at 20° toward

the RCJ. In addition, the distance between the device and the PIN was significantly smaller when the drill tip was pointed distally toward the wrist at a 30° angle and thus inserting the device 30° distal towards the hand could increase the chance of damaging the PIN.

We recognize several limitations to this cadaveric study. A goniometer was used to measure the angle of the guide pin with respect to the bicipital tuberosity for each evaluation point; however, there was likely some variation in the actual angle at which the pin entered the bone. In addition, of the ten cadaveric arms used for this study, seven were from female donors. It is possible that specimen size may have some effect on proximity of the PIN to the cortical button when using this technique for repair. This study found that the greatest distance between the PIN and the cortical button existed when the button was placed in line with the radius, which may be difficult to achieve surgically. Finally, other anatomic structures such as the lateral antebrachial cutaneous nerve and radial recurrent artery may also be at risk for injury during this procedure, this study did not evaluate the effect of drill angle on those structures. Future studies should evaluate the effect of drill angle on these structures.

In conclusion, based on the results of this study, the distance between the PIN and cortical button can be significantly increased by aiming the guide pin tip between 0° or perpendicular to the radius, and 20° proximal toward the RCJ and placing the device in line with the radial shaft.

Conflict of interest The authors declare that they have no conflict of interest.

Disclosure Biomet provided the ToggleLoc and beath pins used for this study. J.E. Michaelson is a paid consultant for Biomet, Inc, Warsaw, IN.

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