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Original Research

Risk of Posterior Interosseous Nerve Injury During Distal Biceps Tendon Repair Using a Cortical Button

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Purpose: To evaluate the possibility of posterior interosseous nerve (PIN) injury during cortical button deployment and seating associated with bicortical drilling and passage of the cortical button across the distal cortex when repairing a distal biceps rupture in a cadaveric model.

Methods: Each cadaver was placed in the supine position with the arm extended. A single 4 cm transverse incision was made in the region of the radial tuberosity, 3–4 cm distal to the antecubital fossa flexion crease, and dissected down to the radial tuberosity. A #2 looped nonabsorbable suture was used to baseball stitch the musculotendinous junction to the distal 2.5 cm end of the tendon. A 3.2 mm cannulated drill bit (Arthrex) was used to create a bicortical drill hole in the center of the radial tuberosity aiming 30° ulnar to maximize the distance from the PIN. Fluoroscopy was used to confirm drill placement in the radial tuberosity for all specimens. The posterior aspect of the elbow in all cadavers was subsequently dissected out to directly visualize how far the cannulated drill was from the PIN.

Results: Twelve cadavers, average age 57.4 years (range, 27–83 years), were dissected. During deployment, the cortical button contacted the PIN directly in 6 extremities. The cortical button came within 6 mm of the PIN in eleven extremities. In 8 specimens, the cortical button was within 2 mm of the PIN. The PIN was caught directly under the cortical button in one specimen.

Conclusions: Placement of a biceps cortical button bicortically when repairing a distal biceps tendon may increase the risk of injury to the PIN during cortical button deployment and seating.

Type of study/level of evidence: Therapeutic IV.

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Distal bicep tendon rupture represents only 3% of all injuries to the biceps and has a reported incidence of 1.2 per 100,000 per year.[1] This injury predominantly occurs in male patients between the ages of 30 and 60. Up to 86% of distal biceps tears occur in the dominant extremity secondary to eccentric loading of the muscle-tendon unit.[1] Risk factors include smoking and steroid use.[1] Reliable physical examination findings in the acute patient include pain, antecubital ecchymosis, and a positive hook test. Both nonsurgical and surgical methods have been described to manage this uncommon injury.[2–4] However, surgical treatments have demonstrated improved flexion and supination strength, as well as decreased fatigability of the biceps when compared to nonsurgical modalities.[5]

Different distal biceps repair methods have been advocated (suture, suture anchors, interference/tenodesis screws, cortical button devices). When compared to screws, bone tunnels, and anchoring devices, suture cortical button repairs show higher loads to failure.[6] However, peripheral nerve injury has been reported to both the posterior interosseous nerve (PIN) and the lateral antebrachial cutaneous nerve with the use of suture cortical buttons.[7] It is estimated that PIN palsy may occur as often as 5% of cases using a single-incision approach.[8] Novel techniques advocate placing the cortical button within the intramedullary canal to avoid major complications, including PIN injury.[9] This technique has the benefit of using a single unicortical drill hole in the radius while allowing the surgeon to manually and sequentially tighten the tendon to its desired level of tension. Furthermore, the single drill hole through the radius can reduce bone debris and allow the tendon to lay on its respective footprint more completely.

Declaration of interests: No benefits in any form have been received or will be received related directly or indirectly to the subject of this article.

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Table
Specimen Characteristics, Final Distance From PIN, and Whether There Was Contact With the PIN During Deployment

Sample Number	Side	Sex	Age (y)	Height (cm)	Weight (kg)	BMI (kg/m^2)	Contact With Cortical Button During Insertion	PIN Distance After Seating (mm)
1	Left	F	58	165.1	63.5	23.29	x	1
2	Right	F	36	165.1	83.5	30.62	x	4
3	Right	M	27	177.8	90.7	28.69	x	0
4	Left	M	55	177.8	59.0	18.65		6
5	Left	M	72	182.9	50.3	15.05		2
6	Right	M	35	172.7	72.6	24.33		8
7	Right	F	62	160	98.9	38.61		2
8	Right	M	61	190.5	96.2	26.5	x	0
9	Left	F	62	160	98.9	38.61		2
10	Right	M	68	190.5	104.8	28.87	x	1
11	Left	F	70	152.4	34.0	14.65	x	0*
12	Left	M	83	188.0	97.5	27.6		4

* Caught under cortical button.

In our review of the literature, we could not identify any studies that directly investigate the proximity of the cortical button to the PIN during deployment and seating after bicortical drilling. Past studies have examined different drill trajectories and proximity to the PIN in a cadaveric model, identifying an ideal trajectory aiming 30° ulnar to limit the contact of the drill with the nerve.[10,11] These studies did not consider the space needed for the cortical button to clear the distal cortex during deployment and seating.

The purpose of this cadaver study was to record the incidence of contact between the PIN and the cortical button during cortical button deployment and seating after bicortical drilling for distal bicep tendon avulsion repair. In addition, we intended to observe the potential for PIN entrapment under the cortical button after deployment and during seating. We hypothesized that we would come within close proximity of the nerve using the bicortical technique, with potential contact while passing the button across the distal cortex.

Materials and Methods

Twelve specimens were dissected and described (Table). Six specimens were left arms, and 6 were right arms. Five specimens were from females, and 7 were from males. One donor provided both left and right arms. The average age was 57.4 years with a range from 27 years to 83 years. The average height was 173.5 cm, with a range of 152.4–190.5 cm. The average weight was 79.15 kg with a range of 34.0–104.8 kg. The average body mass index (BMI) was 33.17 kg/m^2, with a range of 14.65–38.61 kg/m^2. Each time a single-incision technique was used to place the cortical button bicortically with the same materials and trajectory. The specimens were well distributed in regard to age, BMI, and sex.

Surgical technique

Two residents completed all the procedures under the supervision of a single board-certified shoulder and elbow surgeon. The cadaver was placed in the supine position with the arm extended. A single 4 cm transverse incision was made in the region of the radial tuberosity, approximately 3–4 cm distal to the flexion crease of the antecubital fossa (Fig. 1).

After sharp dissection through the skin, dissection scissors were used to open the fascia and develop a plane to identify the biceps tendon insertion at the radial tuberosity. Using deep skin retractors as needed, the radial tuberosity was directly visualized. The biceps tendon was subsequently released and secured with an Allis clamp.

To prepare the tendon, a #2 looped nonabsorbable suture on a straight needle (Arthrex) was used to place a standard looped baseball stitch from the musculotendinous junction to the distal 2.5

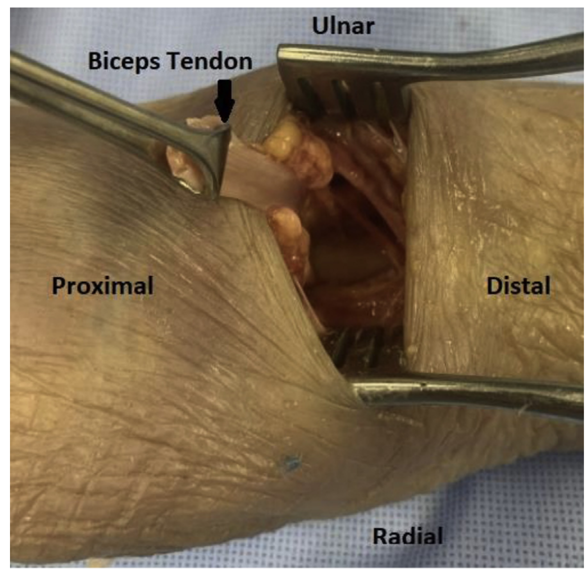

Figure 1. Image of surgical approach with the release of the distal bicep tendon. This is the anterior aspect of a right arm with the palm supinated. The left side of the image is proximal. The right is distal. The top aspect is ulnar. The bottom aspect is radial.

cm end of the tendon. The clamp was then removed and the suture cut, leaving 2 long free ends. These free ends were threaded into a 4 × 12 mm cortical suture suspension button (Arthrex) (Fig. 2). One suture was passed through one eye of the cortical button and out the other. The second suture was then passed in the opposite direction. The free ends of the suture were clamped and set aside with the tendon (Fig. 3).

Attention was then turned to the preparation of the footprint of the bicep's tendon on the radial tuberosity. With the arm maximally supinated, the radial tuberosity was brought into view. Then, under direct visualization, a 3.2 mm cannulated drill bit (Arthrex) was used to create a bicortical drill hole in the center of the radial tuberosity aiming 30° ulnar to maximize the distance from the PIN. Fluoroscopy was used to confirm drill placement in the radial tuberosity for all specimens.

For the purpose of this study, we subsequently dissected out the posterior aspect of the elbow to directly visualize how far the cannulated drill was from the PIN (Figs. 4, 5).

The cortical button was then placed directly into the proximal radius using the supplied inserter (Arthrex). At this point, we directly observed the distance between the deployed cortical button and the PIN before seating. Clearance of the distal cortex was confirmed using fluoroscopy (Fig. 6). At this point, we assessed for

Figure 2. Arthrex distal biceps cortical button is adjacent to the supplied inserter, courtesy of Arthrex in their technique guide.

Figure 3. Prepared distal biceps tendon.

potential entrapment of the nerve under the cortical button and measured the distance of the seated cortical button to the nerve using a medical ruler. We used minimal retraction to limit the distortion of natural anatomy while providing the ability to determine distance. When the cortical button was clear of the distal cortex, we observed for contact between the PIN and cortical button. We then recorded if there was contact at any point with any aspect of the cortical button. We then proceeded with cortical button seating. The sutures were sequentially tensioned, which allowed the tendon to be reduced down to the surface of the bone under direct visualization. Then, we assessed for potential entrapment of the nerve under the cortical button and recorded the final seated distance of the cortical button from the nerve using a medical ruler and minimal retraction to minimize soft tissue distortion. (Fig. 7).

Cortical button contact with the PIN at any time during its deployment, before seating, was recorded in an additional column as “x” or blank for no contact. This includes contact at any point with any aspect of the cortical button. The distance from the PIN after final seating was recorded to the nearest millimeter. If the cortical button was in direct contact with the PIN, it was recorded as 0 mm. An asterisk indicates that the nerve was under the cortical button.

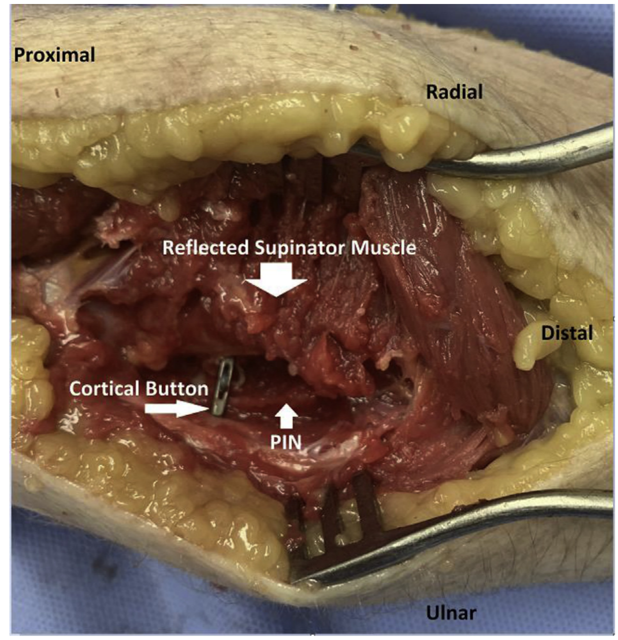

Figure 4. Posterior approach allowing visualization of the cortical button during deployment. This is the posterior aspect of a left arm supinated. The left side of the image is proximal. The right is distal. The top aspect is radial. The bottom aspect is ulnar.

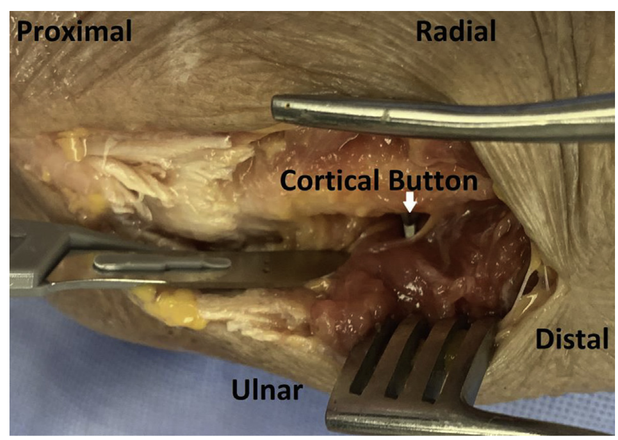

Figure 5. Image of a deployed cortical button. This is the posterolateral aspect of a right arm supinated. The left side of the image is proximal, the right is distal, the top aspect is radial, and the bottom aspect is ulnar. The scalpel is pointing toward the PIN.

Statistical analysis

The statistical analysis of the results was accomplished using IBM SPSS Statistics Version 22 and included Pearson Correlation Coefficient and Mann-Whitney U test. Statistical significance was defined as $P < .05$.

Disclosures

Arthrex supplied bicep cortical buttons, inserters, drill bit, and associated materials for investigation.

Results

Twelve cadavers were dissected and observed to determine if the cortical button came in intact with the PIN during its

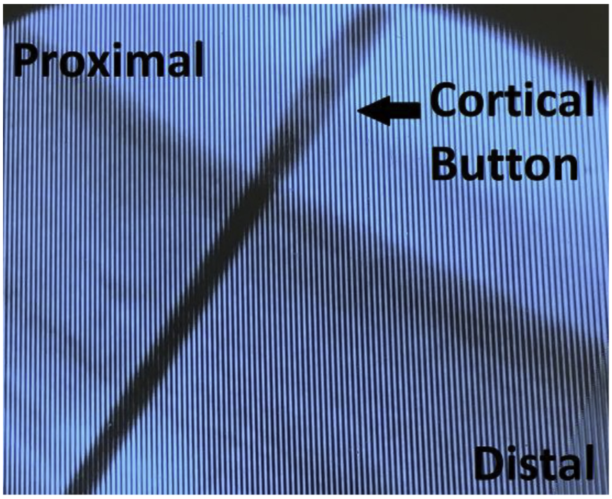

Figure 6. Fluoroscopy confirming clearance of distal cortex by the cortical button. The left side of the image is proximal. The right is distal. The cortical button is on the end of the inserter. Please note that the inserter is more radio-opaque than the cortical button.

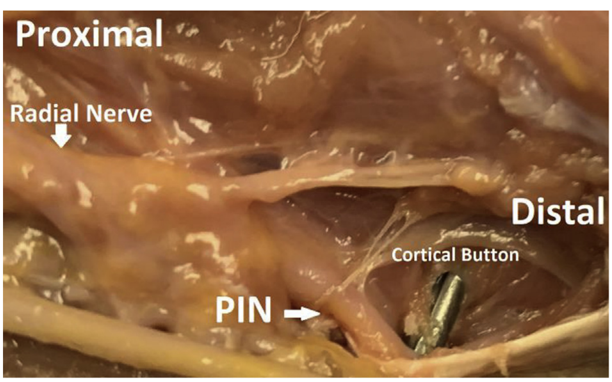

Figure 7. Extensively dissected specimen allowing better visualization of the cortical button and surrounding anatomy before deployment. This is the posterolateral aspect of a right arm. The left side of the image is proximal, and the right side is distal.

deployment or seating. The cortical button came in direct contact with the PIN in 6/12 extremities during deployment. After seating, the cortical button was within 6 mm of the PIN in 11/12 extremities. Once seated, the cortical button was within 2 mm in 8/12 specimens. The PIN was caught directly under the cortical button in 1/12 specimens.

Discussion

Twelve cadavers were dissected, and we found that the cortical button came in direct contact with the PIN in 6/12 extremities during deployment, within 6 mm of the PIN in 11/12 extremities while seating, and within 2 mm in 8/12 specimens while seated. As stated above, the PIN was caught directly under the cortical button in 1/12 specimens. The contact between the cortical button and the PIN during deployment, the proximity after seating, and the nerves entrapment in 1 specimen supported the hypothesis that PIN is at risk not only after its seating but throughout its insertion when using a bicortical construct.

A potential limitation of this study is the small number of specimens. In addition, the posterolateral incision used to directly observe the cortical button during deployment and seating could have disturbed the surrounding tissues, which would otherwise be untouched in a single-incision surgery with a live patient. The secondary dissection could potentially result in displacement of tissue away from the cortical button and thereby increase space for soft tissues to move away from the cortical button as the soft tissue envelope is further released. Despite these factors, our study still showed contact with the nerve with half the specimens and close proximity of the nerve when seated. The cortical button we used is 12 mm in length and 2.6 mm in width. Therefore, 12 mm of the cortical button in addition to the inserter tip needs to extend past the distal cortical surface. This could cause a higher potential for contact with the nerve as the cortical button is deployed and seated, given that not all commercially available cortical buttons have the same measurements. For comparison, the original endobutton study by Bain et al[9] used a Smith and Nephew button that was only 10 mm in length and 4 mm in width. While this step of the procedure is often short it could theoretically result in an iatrogenic nerve injury.

Injury to the PIN can be a major complication of distal biceps repair.[12,13] The risk of this complication has been shown to be as high as 5%.[8] More instances occur following the use of a cortical button from a volar approach.[12,14] A recent attempt to avoid this major complication has been to modify the surgical technique by placing the cortical button fixation in a unicortical fashion, directly into the medullary canal of the proximal radial tuberosity.[9,15]

Another technique previously described to avoid PIN complication involves deploying and seating the long axis of the button parallel to the shaft of the radius rather than transversely.[16] All of our buttons in this study were deployed transversely in accordance with the original Arthrex technique guide, which may account for the higher incidence of PIN capture.

We conclude that when using bicortical-button fixation to repair distal biceps tendon rupture, the incidence of direct contact during deployment between the cortical button and PIN needs to be considered. Furthermore, the seating of the cortical button may result in the cortical button being in close proximity to the PIN. Future studies comparing bicortical and unicortical (intramedullary) fixation may be of benefit.

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