Distal Biceps Repair With Flexible Instrumentation and Risk of Posterior Interosseous Nerve Injury

A Cadaveric Analysis

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Background: Current repair techniques using cortical button fixation cannot achieve anatomic reconstruction of the distal biceps when performed through a single-incision anterior approach. We recently introduced a single-incision technique that uses flexible guide pins and flexible reamers to allow for an insertion point on the tuberosity that more closely approximates the anatomic footprint of the distal biceps.

Purpose: To investigate the safety of this technique with regard to nerve injury by comparing the guide pin position relative to the posterior interosseous nerve in 16 cadaveric elbows through use of a flexible versus rigid reamer.

Study Design: Descriptive laboratory study.

Methods: A standard single-incision anterior approach was performed in all cadaveric specimens, and the biceps tendon was dissected off the tuberosity. In 8 specimens, a traditional straight guide pin was used with a cortical button repair inserted through the bicipital tuberosity as close to the anatomic tendon footprint as possible. In the remaining 8 specimens, a curved guide was used to insert a flexible guide wire through the tuberosity within the native footprint. Dissection was carried out to measure the distance from the exit point of the guide pin to the posterior interosseous nerve. The 2 groups were compared by use of non-parametric Wilcoxon rank-sum test (significance threshold, \( P < .05 \)).

Results: The mean distance of the guide wire to the posterior interosseous nerve was 11.6 mm (SD, 3.4 mm; range, 6.5-16.9 mm) in the standard rigid instrument group compared with 8.6 mm (SD, 4.2 mm; range, 1.0-13.9 mm) in the flexible instrumentation group; the difference between groups was not statistically different (\( P = .19 \); 95% CI, −1.1 to 7.1).

Conclusion: Based on our cadaveric testing, the use of flexible instrumentation in a single-incision repair of the distal biceps presents with no significant difference in risk of damage to the posterior interosseous nerve compared with standard rigid instruments. In view of the relatively small number of specimens, however, some caution should be observed when applying these results clinically.

Clinical Relevance: As contemporary techniques in sports medicine strive to re-create each patient’s native anatomic characteristics, the use of flexible instruments allows for a more anatomic repair of the distal biceps, and our study demonstrates that it is a safe option. The next step is to evaluate its safety in vivo.

Keywords: distal biceps tendon avulsion; biceps repair; single incision; Endobutton; cadaver; posterior interosseous nerve

The incidence of distal biceps tendon ruptures is 1.2 per 100,000 persons, and the injury predominantly affects men between the ages of 30 and 60 years. In earlier studies, nonoperative treatment was found to cause significant loss of bicipital forearm function, including 79% less supination endurance and 40% less supination strength. The current mainstay of management, particularly in active healthy individuals, is early surgical reattachment using either single- or double-incision techniques, each with its own set of advantages and complications.

A meta-analysis of complications from distal biceps repairs between 1950 and 2013 reported greater complication rates with the single-incision technique (28.3%, 222/785) compared with double-incision (20.9%, 104/498). In that analysis, the single-incision technique entailed more nerve-related injuries, such as a higher incidence of...
Anatomic placement of the distal biceps tendon remains a challenge for the single-incision approach. This challenge arises because a single incision using traditional, standard rigid instrumentation has a constrained angle of insertion (owing to the anterior surrounding soft tissues and noble structures) and results in guide pin placement that is often anterior to the native tendon footprint. A more posteriorly positioned tendon better reestablishes the native tendon supination biomechanics and windlass mechanism. To address this issue, our group recently proposed a modification to the single-incision technique using flexible instrumentation: flexible guide pins and flexible reamers. In this previous study, we showed that flexible instrumentation compared with a standard rigid instrument allows the tunnel to be drilled closer to the anatomic footprint and to have a more central tunnel position during insertion. To insert the pin close to the anatomic footprint and posterior on the tuberosity as the soft tissue dissection is performed, we simulated a distal biceps tendon repair with flexible guide wire and reamer (flexible instrumentation group), and the second arm in the matched pair underwent standard rigid technique (standard rigid instrument group). For all specimens, a standard anterior approach to the antecubital fossa was performed by use of an L-shaped incision with a 2-cm longitudinal limb parallel to the ulnar border of the mobile wad and a 2-cm transverse limb 2 cm distal to the antecubital flexion crease. We started by identifying and protecting the lateral antebrachial cutaneous nerve in superficial dissection. We then identified the biceps bursa and followed it down to the biceps tuberosity. Right-angle retractors were then used to aid exposure of the bicipital tuberosity for drilling the bone tunnel. For the standard rigid instrument group, a straight, rigid, 2.4-mm drill-tip passing pin (Acufex Director Set for ACL Reconstruction; Smith & Nephew) was inserted through the bicipital tuberosity by use of a scalpel, leaving a 1- to 2-mm stump of tissue attached to the bicipital tuberosity. The forearm was kept in a maximally supinated position during insertion. To insert the pin close to the anatomic footprint, the starting point was as far ulnar and posterior on the tuberosity as the soft tissue dissection would allow. Straight cannulated drill bits were then advanced over the rigid guide: 8 mm for the near cortex and 4.5 mm for the far cortex (Acufex Director). A chest tube was placed over the drill and reamer and used as a clear “see-through” soft tissue protector to prevent damage to the anterior neurovascular structures (Figure 1). The same technique was used in the second group of 8 specimens, except for the use of flexible instruments. A 2.4-mm flexible passing pin was inserted through the bicipital tuberosity by use of a 42° curved femoral guide (Clancy Anatomic Cruciate Guide Flexible Drill System; Smith & Nephew) (Figure 2), followed by a flexible...
cannulated 8-mm and 4.5-mm reamer through the near and far cortex, respectively (Clancy Anatomic Cruciate Guide/Flexible Drill System) (Figure 3). The surgical technique using flexible instrumentation is described in detail in our previous work.\textsuperscript{1,17.}

For assessment of PIN injury, the distance between the guide pin and PIN was measured by 1 examiner (K.A.), and the average was taken after 3 measurements. Dissection was carefully performed with a posterolateral incision to expose the fascia overlying the supinator muscle belly. The fascial layer was carefully incised to allow the identification of the PIN, and a digital caliper was used to measure the distance from the PIN to the exit point of the guide pin (Figure 4). The nonparametric Wilcoxon rank-sum test was used to compare the means between groups. Statistical significance was set at $P < .05$.

**RESULTS**

Patient demographics are shown in Table 1. All specimens underwent uneventful reconstruction according to their assigned group (standard rigid vs flexible reamer techniques). The mean distance of the guide pin to the PIN was 11.6 mm (SD, 3.4 mm; range, 6.5-16.9 mm) in the standard rigid instrument group versus 8.6 mm (SD 4.2 mm; range, 1.0-13.9 mm) in the flexible instrumentation group (Table 1). The difference in mean values between groups was not statistically different ($P = .19$; 95\% CI, –1.1 to 7.1). In no instance in either group did the guide pin come in direct contact with the PIN during our measurement.

**DISCUSSION**

Anatomic reconstruction of the distal biceps is challenging with current single-incision techniques that use rigid
TABLE 1

| Group                          | Age, y | Sex | Side | Distance to PIN, mm |
|-------------------------------|--------|-----|------|--------------------|
| Standard rigid instrument group | 84     | Female | Left | 11.4               |
|                               | 57     | Female | Right | 11.2               |
|                               | 22     | Female | Right | 16.9               |
|                               | 67     | Male   | Right | 13.4               |
|                               | 51     | Female | Left  | 11.5               |
|                               | 92     | Female | Right | 7.5                |
|                               | 27     | Male   | Left  | 14.4               |
|                               | 88     | Male   | Left  | 6.5                |
| Mean ± SD                     | 61 ± 27| Female | Right | 11.6 ± 3.4         |

Flexible instrumentation group

| Age, y | Sex | Side | Distance to PIN, mm |
|--------|-----|------|--------------------|
| 57     | Female | Left  | 1.0               |
| 22     | Female | Left  | 11.5               |
| 67     | Male   | Left  | 13.9               |
| 51     | Female | Right | 11.5               |
| 92     | Female | Left  | 5.1                |
| 27     | Male   | Right | 6.0                |
| 75     | Male   | Left  | 9.8                |
| Mean ± SD | 59 ± 29| Female | Right | 8.6 ± 4.2         |

reamers. We previously introduced a single-incision approach using a flexible guide pin and flexible reamers, which allowed for a more posterior and ulnar starting point that was closer to the native tendon footprint compared with rigid straight instrumentation. The goal of the present study was to further develop our technique for clinical use by assessing the risk of a PIN injury. We compared the guide pin position relative to the PIN with a single-incision biceps tendon repair using rigid and flexible reamers in 16 cadaveric elbows. While the distance of the guide pin to the PIN was less in the flexible instrumentation group, the difference was not statistically significant, with the mean distance being 8.6 ± 4.2 mm and the shortest distance being 1.0 mm. Thus, our technique does not statistically place the PIN at greater risk based on findings from our cadaveric model.

The distances measured between the rigid guide pins and PIN in the present study are in keeping with those reported by previous cadaveric studies. Greenberg et al. demonstrated that after implantation of the Endobutton through an anterior single incision, the mean distance from the button to the radial nerve was 9.3 mm, with the closest distance being measured at 7 mm. Bain et al. advanced a Steinman pin through the bicipital tuberosity with the forearm in 90° of supination. The pin was advanced from the bicipital tuberosity through the radius directed either 0° posteriorly or with 45° of posterolateral angulation. The distance from the tip of the Steinman pin 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. Saldua et al. examined whether a different drilling angle would compromise the safety of the PIN during the anterior single-incision repair. Using a cadaveric model, those investigators inserted a K-wire through the center of the bicipital tuberosity. The exit point of the wire was a mean distance of 10.9 mm from the PIN, with the closest measurement being 7.8 mm. A second K-wire was then inserted in the same hole, 30° ulnar to the plane of the first wire, and the mean distance to the PIN was found to be significantly increased at 16.3 mm.

Our study is limited by the small sample size of 16 cadaveric arms. We believed that this sample size was appropriate, given that the goal of the study was to establish safety of our technique in a cadaveric model before attempting in patients. To address our sample size, we used a nonparametric test, the Wilcoxon rank-sum test, for a more conservative comparison between groups. We also matched our specimens for each group, so that for each specimen pair, 1 arm was in the flexible instrumentation group and the second arm was in the standard rigid instrument group. Although the guide pin did not come in direct contact with the PIN in any specimen, given the small sample size it would be premature to say there is no chance of nerve injury without further testing. The clinical implications of these results should therefore be assessed with caution.

Last, we assumed that the distance from the guide pin to the PIN represented the risk of injury. It is possible that reaming could also damage the nerve, and we did not measure the distance of the reamed tunnel to the PIN. Given the size of the reamer (4.5-mm reamer vs 2.4-mm guide pin), theoretically our results may vary up to 1.05 mm. We have since modified our approach to further protect the PIN. We recommend that the surgeon, after reaming the far cortex, pass the Endobutton using a rigid guide pin and position the pin more ulnarily in the 4.5-mm tunnel. The forearm should be kept maximally supinated to maximize the distance from the PIN. Our next step will be to evaluate clinical outcomes associated with PIN injury in patients having distal biceps repair using our flexible instrumentation technique.

CONCLUSION

We previously developed a technique to enable repair of distal biceps tendon ruptures that more closely approximates the anatomic footprint using a single-incision approach and flexible instrumentation. This technique uses a curved guide and a flexible guide pin, which allows for a more posterior and ulnar starting point than a straight pin, which has a constrained angle of insertion from the anterior surrounding soft tissues and noble structures. In the current study, the guide pin did not come in direct contact with the PIN, as determined by our anatomic dissections. The study findings suggest that flexible instrumentation may not have an increased risk of nerve injury compared with standard rigid instrumentation; however, further testing in vivo is necessary. This novel approach has the theoretical advantage of restoring forearm supination mechanics through a single anterior incision while avoiding the complications associated with the double-incision approach.
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