Anatomic repair of the distal biceps tendon cannot be consistently performed through a classic single-incision suture anchor technique

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Background: Distal biceps tendon ruptures commonly occur in active men, and surgical repair through a single-incision technique using suture anchors has become common. The current study assessed whether an anatomic repair of the biceps to the radial tuberosity can be consistently achieved through a single-incision technique.

Methods: Acute distal biceps tendon repairs using the single-incision technique were retrospectively reviewed. Computed tomography (CT) scans were obtained to investigate tuberosity dimensions and the position of the suture anchors. An isokinetic dynamometer was used to obtain flexion and supination strength. Disabilities of the Arm, Shoulder and Hand (DASH) scores were collected.

Results: CT scans were performed in 27 patients, of which, 21 underwent strength testing. The suture anchor placement averaged 50/14 radial to the apex of the tuberosity. Strength testing showed flexion strength of the repaired side was equal (97%-106%) to the normal side. Supination strength (80%-86%) and work (66%-75%) performed were both weaker on the repaired side (66%-75%; P < .05). The average DASH score was 10.7.

Conclusions: Ideal suture anchor placement, in the ulnar aspect of the tuberosity, could not be reliably achieved through this single-incision technique. This could have clinical importance because supination strength was not fully restored in this group of patients.

Level of evidence: Level IV, Case Series, Treatment Study.

Keywords: Distal biceps repair; suture anchor; single incision; CT scan; biceps strength
Multiple studies have shown better functional outcomes with operative reattachment of the distal biceps tendon to the radial tuberosity compared with nonoperative treatment.\textsuperscript{3,8,17,26} Nonoperative treatment leaves patients with decreased flexion strength of 10\% to 40\% and a supination deficit of 37\% to 44\%.\textsuperscript{14,27} Such functional deficits may be tolerated by some sedentary patients\textsuperscript{17} but may not be acceptable to active patients and those with physically demanding occupations. In these more active patients, surgical repair has become the standard of care.

Several different approaches have been described for operative repair of the distal biceps tendon.\textsuperscript{5,11,12,24} The most current procedures involve the 2-incision or single-incision techniques. Recently the single-incision technique with repair of the distal biceps tendon using suture anchors or cortical button fixation with a limited anterior incision has grown in popularity. With the assistance of these implants, the technique is safer and may limit the complication of heterotopic ossification associated with the 2-incision technique.\textsuperscript{2,4,21-23,25,33,35}

However, the ability to achieve an anatomic repair of the distal biceps tendon onto the radial tuberosity using this technique has been questioned.\textsuperscript{16,30} Several detailed anatomic studies have shown that the radial tuberosity is 7 mm by 21 mm and is located on the inner, medial aspect of the proximal radius. This ulnar-sided location allows the biceps, which normally attaches on the apex and ulnar side of the tuberosity, to act as a more effective supinator.\textsuperscript{1,13,18} In this study, the authors showed that the biceps tendon inserts with extension over the top and to the ulnar border of the radial tuberosity.\textsuperscript{13} These authors also felt that obtaining an anatomic repair might be difficult due to this anatomy. To fully restore supination strength, it is logical to try to achieve an anatomic repair of the biceps tendon to the ulnar border of the radial tuberosity.

The purpose of this study was to determine the position of the distal biceps tendon repair using a single anterior incision and suture anchor technique. We hypothesized that the repair would not reliably restore the biceps tendon to an anatomic position on the apex and ulnar side of the radial tuberosity. Secondarily, we also studied the amount of postoperative flexion and supination strength recovery.

**Materials and methods**

**Patients**

A retrospective review of acute distal biceps tendon repairs was performed at our institution during a 3-year period (2007-2010), selecting those patients whose surgical repair was performed by 1 of 3 upper extremity fellowship-trained surgeons. Patient lists were acquired through the surgeons’ office records. Inclusion criteria were patients with a complete distal biceps tendon rupture who underwent a biceps repair through a single anterior incision using suture anchors and at least 1 year of postoperatively. Patients were excluded if they had inadequate follow-up, had undergone a revision repair, or a different surgical technique was used.

**Surgical technique**

All 3 surgeons used a limited, single anterior incision using 2 UltraFix 2.3 mm suture anchors (ConMed Linvatec, Largo, FL, USA) placed approximately 1 cm apart (proximal to distal). A transverse anterior incision was made approximately 2 fingerbreadths distal to the volar elbow crease, centered over the proximal radius. After subcutaneous dissection and protection of the lateral antebrachial cutaneous nerve, mini-Hohmann retractors were placed on either side of the radial tuberosity to protect deeper neurovascular structures. After palpatory palpation of the radial tuberosity, all surgeons attempted to place the drill bit for the anchor insertion as ulnar as possible on the tuberosity while an assistant provided maximal supination of the forearm. A sliding core, whip stitch suture technique was used to secure the distal tendon stump to the lightly decorticated radial tuberosity.

**Tuberosity and anchor position**

All patients underwent computed tomography (CT) imaging (Aquilion ONE; Toshiba Medical Systems, Tochigi, Japan) of their operative elbow and wrist in a standard position with the forearm in full supination. Axial images of 0.5-mm thickness were acquired with 1-mm-thick reformations in bone and soft tissue algorithms. The CT scans were analyzed by a senior orthopedic resident and a staff orthopedic surgeon to determine the length,
location, and apex of the radial tuberosity, as well as the position of the suture anchors relative to the radial tuberosity.

The middle point of the radial tuberosity length was defined and then used as the reference point to determine the angular position of the radial tuberosity apex. The angular position of the radial tuberosity was defined as the position of the tuberosity apex measured from a sagittal reference made on the picture archiving and communication system. The center of the medullary canal was determined as the center of a circle of best fit.

Axial CT images of the patient’s ipsilateral wrist were used to determine the axis of the radial tuberosity apex. The angular measurement was referenced from the vertical axis on the picture archiving and communication system, and the center of the medullary canal was determined as the center of a circle of best fit.

Strength

Voluntary maximal isokinetic force (Nm) was collected during elbow flexion and forearm supination in 21 patients using the Multijoint System 4 Pro isokinetic dynamometer (Biodex, Shirley, NY, USA). While seated, the patient’s arm was supported at 45° of shoulder flexion during elbow flexion tests and at 90° of elbow flexion during forearm supination tests. Patients were first given a warm up to acclimate to the Biodex machine and to practice maximal eccentric and concentric contractions at fixed speeds. After acclimation, participants were encouraged to perform concentric and eccentric flexion or supination cycles at angular velocities of 30° (slow) and 90° (quick) per second over an operating range of motion of 20° to 90° of flexion (0° = full extension) or 0° to 90° (0° = thumbs up) of supination. Patients performed 3 repetitions of each condition with a 30-second break between each effort. Maximal torque values were normalized to body weight (N/kg) and compared with the participant’s contralateral arm at consistent angles using paired t tests and a Bonferroni corrected α = 0.016.

Maximal total work was also calculated using the trapezoid method and analyzed using a paired t test. Disabilities of the Arm, Shoulder and Hand (DASH) scores were also collected.

Results

Tuberosity and anchor position

The average radial tuberosity measured 25 mm in length (range, 20-33 mm) and was located 20 mm (range, 14-25 mm) from the central concavity of the radial head. The average distance between suture anchors was 9 mm (range, 6-15 mm). The apex of the radial tuberosity measured 56° degrees (range, 43°-67°) ulnar from the midsagittal axis as calculated from the distal radius. The average angular position of the proximal suture anchors was 50° (range, 8°-97°) radial from the tuberosity apex. Similarly, the distal suture anchors were 50° (range, 17°-117°) radial from the apex (Fig. 4). No significant correlation was found between the spatial position of the radial tuberosity relative to the midsagittal axis and the amount of radial deviation of the proximal and distal anchors (correlation coefficient, 0.15 and 0.23, respectively). There was strong inter-rater reliability between both reviewers for all angular measurements (average Pearson coefficient \( r^2 \) = 0.96).

All suture anchors were placed radial to the tuberosity apex with a range from 9° to 117°. No anchors were placed ulnar to the apex of the tuberosity (Fig. 4).

Strength testing

Of the 27 patients with acute distal biceps tendon ruptures who received postoperative CT scans, 21 underwent a follow-up strength assessment. Two were excluded from strength assessment due to discomfort performing flexion and supination testing. The mean duration between the biceps tendon repair and functional strength testing was
27.9 ± 9.9 months. Of the remaining 19 participants, 13 had injured their dominant arm.

**Strength**
No difference in flexion strength was found between the repaired and uninjured limb. However, significant differences in strength \( (P < .016) \) were observed during quick concentric supination at joint rotation angles of 10° (85% ± 20%), 45° (80% ± 22%), and 80° (82% ± 21%) and during slow concentric supination at 45° (83% ± 21%). Trends were observed during slow concentric supination at 80° (86% ± 21%) and at 45° during quick (84% ± 25%) and slow (82% ± 25%) eccentric supination (Table II).

**Work**
No difference was found between the affected and contralateral limb during elbow flexion. The work performed by the repaired arm was 66% to 75% that of the uninjured limb \( (P < .05) \) during supination, with exception to the slow concentric condition, where only a trend was observed \( (work = 76%; \ P = .072) \).

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**Figure 2** Axial images of the ipsilateral wrist were used to determine the midsagittal axis. A line midway between the volar and dorsal tuberosities and a line bisecting the deepest portion of the sigmoid notch of the distal radioulnar joint was used. A perpendicular line to this axis represented the sagittal axis used to reference the radial tuberosity to account for anatomic variation between patients.

**Figure 3** Axial images were used to determine the position of a suture anchor. Note the similar vertical axis and center of the medullary canal used in determining the orientation of the tuberosity apex in Figure 1. This center of the cortical window where the suture anchor was placed was used to represent where the biceps tendon was repaired (red arrow).

**Figure 4** Graphic representation (angular position in degrees) of suture anchor placement relative to the tuberosity apex (shaded dashed line). Negative values are ulnar and positive values are radial to the tuberosity apex.

**Function**
All 21 participants completed the DASH questionnaire. The mean score was 10 ± 7. Of the participants who completed the DASH questionnaire, 17 (89%) reported they were able to return to work with minimal restrictions, and 2 (11%) reported that their injury prevented them from doing so. Nine participants (47%) reported some inability to return to the same level of physical activity before their injury, citing weakness (80%), fatigue, and wrist rotation difficulties.

**Discussion**
The purpose of this study was to analyze suture anchor location in patients who underwent a distal biceps tendon repair using a single-incision technique. We found that suture anchors were consistently placed radial to the apex of the radial tuberosity. In our study of 27 patients, the average placement was 50° radial to the apex.

Forthman et al.\(^\text{13}\) concluded that given the significant ulnar location of the radial tuberosity apex and that the midportion of distal biceps tendon inserted just 3-mm radial from this apex, that reapproximating the repaired tendon to
its anatomic footprint using only a single anterior incision would be difficult. In our experience, despite intraoperative efforts for ulnar positioning of the suture anchors, reapproximating the distal tendon to the native footprint was unsuccessful in all patients and with reasonable proximity in only 5 patients.

Schmidt et al. recently published their experience using the 1-incision technique and Endobutton repair. They used magnetic resonance imaging to assess and describe the healing of the tendon at the radial tuberosity. All tendons in their series of 19 patients appeared healed. The repair was not anatomic, however, with the average angle of the tendon 73° radial to the uninjured controls. They suggested that consistently achieving an anatomic repair of the distal biceps tendon is difficult using a 1-incision technique. These findings are similar to the current study. Since their series, Schmidt et al. favor a 2-incision technique because they believe this will allow the surgeon to more reliably restore the distal biceps tendon to its proper anatomic location. Modified single-incision techniques have been described that allow the biceps tendon to be reattached in a more ulnar position. When this new technique is used, the sutures are passed retrograde around the tuberosity, allowing for a more ulnar repair.

There was no observable difference in postoperative strength during elbow flexion between the repaired and uninjured limb. However, supination strength and work were both weaker in the operative limb than in the uninjured side. Depending on the testing protocol, supination work ranged from 66% to 75% of the uninjured arm.

Most studies that have compared nonoperative and operative treatment of distal biceps tendon ruptures have shown that nonoperative treatment leads to loss in flexion and supination. The average loss of flexion strength is 10% to 40%, and the average loss of supination strength is 37% to 44%.

Biomechanical testing has demonstrated that the long and short head components of the biceps tendon both contribute to flexion and supination. The short head is a stronger contributor to flexion because it attaches more distally. Interestingly, it is surprisingly a stronger supinator when the arm is in a pronated or neutral position. The authors hypothesized that the short head has a bigger surface area and attaches closer to the apex of the tuberosity, which increases its lever action compared with the long head. However, the short head loses this advantage in full supination when the cam effect of the bicapital tuberosity is gone, and then, the long head (which is attached more ulnar) becomes a stronger supinator.

The same authors showed, in a biomechanical model, that reattachment of the tendon in a nonanatomic position (radial to the tuberosity) had a minimal effect on strength with the forearm pronated. In contrast, the greatest effect of the repair was seen in full supination. In this position, with loss of the cam effect of the tuberosity, the moment arm was reduced by 97%. In other words, with a radial tendon repair, the biceps has almost no ability to generate supination force when the forearm is in full supination. Therefore, patients who have had a repair that is too radial may not notice much weakness with the forearm in pronation or neutral. However, weakness will become evident in a more supinated position where the effect of the nonanatomic repair has more influence.

Many studies investigating the 1-incision technique have reported good to excellent recovery of strength. However, testing was often only done in a neutral position. Peak strength of supination in normal individuals occurs at 12° of supination, and maximal supination strength is maintained until full supination (70°-80°). Schmidt et al. recently assessed patients undergoing a single-incision repair and found, similar to our study, that most of the repairs were not anatomic. When assessing strength in these patients, they found normal supination strength when testing in 60° of pronation and neutral; however, with the forearm in 60° of supination, these patients achieved only 67% of their supination strength.
strength. They hypothesized that the nonanatomic repair of the biceps tendon through the single-incision technique was able to restore supination when the arm was positioned in a pronated and neutral position. However, the biceps could no longer generate supination force when the forearm was in a supinated position. Other studies have supported this finding, with similar deficits in the supinated position. In the current study, we tested from 0° of forearm rotation to full supination and found that the supination strength and work were significantly diminished. The results were worse in more supinated positions compared with the normal side.

Limitations of this study include its retrospective design and the small study population. There was no comparison group to analyze potential strength differences in those patients with more ulnar positioning of the anchors (and thus repaired tendon) that may be possible using a more classic 2-incision approach.

Conclusion

To our knowledge, this is the first study to critically analyze the postoperative suture anchor position after repair of the distal biceps tendon. It emphasizes the need for maximal intraoperative supination and a focused effort to achieve suture anchor placement on the ulnar portion of the tuberosity. The ability to achieve this can be limited by patient factors such as a muscular build and variability of the biceps tuberosity. Achieving an anatomic repair could be improved by using flexible drills and suture anchor instruments that allow greater access to the anatomic footprint of the distal biceps tendon. Passing sutures in a retrograde fashion to achieve a more anatomic repair through a 1-incision technique has also been proposed. We have recently returned to a 2-incision technique to more consistently obtain an anatomic repair of the distal biceps tendon. In this current study, suture anchors placed using a classic single-incision technique were routinely placed too radial on the radial tuberosity, and therefore, we found this technique makes anatomic repair of distal biceps tendons difficult to perform.

Disclaimer

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References


