SCIENTIFIC ARTICLE

Cadaveric Study of Insertional Anatomy of Distal Biceps Tendon and its Relationship to the Dynamic Proximal Radioulnar Space

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Purpose To quantify and assess the relationship between the insertional dimensions of the distal biceps tendon (DBT) and radioulnar space (RUS) in 3 rotational positions. We hypothesized that in all positions RUS would be adequate for the DBT and would remain adequate even after an incremental increase (1 to 3 mm) in tendon thickness.

Methods Eleven fresh-frozen cadaveric elbows were dissected; DBT dimensions and bicipital tuberosity measurements were performed and insertional footprints were quantified using a distal biceps footprint index. The RUS was measured at 3 levels of the bicipital tuberosity and in 3 positions of forearm rotation. We performed statistical analysis to analyze differences in RUS (positional and inter-level). In addition, significant differences between DBT thickness (native and incremental) and RUS were analyzed to identify potential sites of radioulnar impingement.

Results The DBT had a mean length of 92 mm; thickness ranged from 2.9 to 6.1 mm. Three variations in DBT insertional footprint were observed and quantified. The RUS linear distance reduced significantly from a supinated to a pronated position at each of 3 bicipital tuberosity levels; the reduction was statistically significant at the lower tuberosity level (45%). Pronation RUS distance was adequate for native DBT thickness and was significantly less when DBT thickness increased by 2 and 3 mm.

Conclusions Radioulnar space reduces significantly from the supinated to the pronated position and is most evident in the lower aspect of the tuberosity. In addition, the RUS in pronation is inadequate for incremental increases in DBT thickness.

Clinical relevance Postoperative DBT impingement in the RUS may be prevented by avoiding techniques that increase the thickness of the tendon and by using a reattachment site at the proximal aspect of the tuberosity. *(J Hand Surg Am. 2017;42(1):e15–e23. Copyright © 2017 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Biceps footprint, biceps rupture, distal biceps tendon, elbow, radioulnar space.

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Distal biceps tendon (DBT) ruptures and their reattachment techniques have been described in several studies.[1–4] Anatomical and biomechanical data have been used to suggest fixation methods and devices. Clinical results suggest a rerupture rate of 1% to 5% after open surgical reattachment, and some techniques are associated with a higher rerupture rate.[5–13] Seiler et al[14] suggested that mechanical impingement on the DBT within the narrow radioulnar space (RUS) occurs during forearm rotation and could possibly contribute to attritional

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ruptures of the DBT. Kreuger et al[15] further implicated the RUS in postsurgical impingement and suggested that certain fixation techniques may predispose the repaired tendon to radioulnar impingement. Optimization of DBT repair necessitates replication of the insertional anatomy of the DBT and avoidance of excessive encroachment of the RUS to prevent postoperative dynamic wear.[14,16] A postoperative increase in DBT cross-sectional area has been demonstrated on imaging, which may result from the following factors: (1) In a surgical setting, a ruptured biceps tendon is sectioned to a healthier proximal level, and the tendon is further inserted into a bone tunnel; this results in a thicker proximal tendon region at the bone−tendon interface. (2) The tendon is whipstitched and tubularized with heavy suture material, and additional biological augmentation may be performed.[15−21] Similarly, exercise and habitual loading-induced tendon hypertrophy result in an increase in the cross-sectional area of a tendon, and an imbalance between the available RUS and tendon thickness may occur.[22−24] These physiological and postoperative increases in tendon dimensions may hypothetically predispose to dynamic impingement within the RUS during pronation and supination. Previous studies described the morphological anatomy of the distal biceps, and variable reports of the footprint types and characteristics have been mentioned.[6,9,25,26] Moreover, the anatomical RUS at the level of the bicipital tuberosity has been evaluated only radiologically, and detailed quantitative anatomical data regarding the dynamic RUS and its relationship to the DBT are lacking.

The purpose of this study was to analyze the insertional anatomy of the DBT and its relationship to the RUS at the bicipital tuberosity. The specific aims were (1) to determine the dimensions of the DBT and to quantify the attachment sites on the bicipital tuberosity footprint, and (2) to quantify the RUS available for DBT repair at 3 levels of the bicipital tuberosity in 3 rotational positions of the forearm. We hypothesized that the dynamic RUS would be adequate for a normal DBT at its reattachment level (2 cm proximal to the insertion). We also assumed that the space would be adequate even after incremental increases in tendon thickness (1 to 3 mm).

MATERIALS AND METHODS

We obtained an institutional review board waiver for the cadaveric study. A convenience sample composed of 11 fresh-frozen cadaveric elbows (6 right and 5 left; 11 males) from 6 cadavers was dissected to study the insertion of the DBT. Cadavers included young and older specimens; however, the exact age of the cadaveric specimens was not available from the records. The arm was stabilized using a clamp, in the anatomical position with the elbow in extension, the forearm in supination initially, and in neutral and pronation subsequently. The entire biceps muscle was dissected to identify the individual long and short heads in the proximal region. These heads were then traced distally to identify the distal components of the biceps tendon. The long and short heads of the DBT were identified and traced to their attachment on the bicipital tuberosity, and lacertus fibrosus (LF) was identified. Individual tendons were traced to their insertion on the bicipital tuberosity and sharply detached sequentially. The footprint of each head was carefully marked and the entire bicipital tuberosity was outlined. Next, the RUS was exposed and evaluated in 3 positions (supination, neutral, and pronation) as follows: the elbow was stabilized in 30° flexion by clamping the humerus to a post on the dissection table. We used a goniometer to measure forearm rotation. Radioulnar space distances were measured perpendicular to the long axis of the radius and ulna in (1) 90° supination, (2) neutral rotation of 0°, and (3) 80° pronation. The interosseous membrane was left undisturbed throughout these measurements. Finally, the osseous dimensions of the tuberosity were measured.

A standardized digital device (Vernier Caliper; VERTEX Tools, Staffordshire, United Kingdom) with precision to 1/100th of a millimeter (0.01 mm) was used. We documented values to 2 decimal points for ease of reporting. Each measurement was performed 3 times by 1 investigator, and the mean of the 3 values was recorded.

Distal biceps tendon dimensions

The DBT was measured in 3 regions (Fig. 1): (1) preaponeurotic region (P): the region of the DBT extending from the distal musculotendinous junction down to the proximal attachment of LF. The length (PL) of this region was measured; (2) aponeurotic region (A): the region of the DBT extending from the proximal attachment of the LF down to its distal border on the DBT. The length (AL) of this region was measured; (3) postaponeurotic (Po) region: defined as the region of the DBT extending from the distal attachment of the LF on the DBT down to the DBT footprint on the bicipital tuberosity. The surgical reattachment level (SL) was defined as a point 2 cm proximal to the bicipital tuberosity attachment.