Introduction:

Biceps tendon ruptures represent 3% of injuries involving the biceps. The mechanism of tendon injury is typically a traumatic event involving an abruptly applied extension force to a partially flexed elbow, resulting in eccentric contraction of the biceps. While much has been published regarding the technique and biomechanics of tendon repair, we know of only one study that has investigated the strength properties of an intact biceps tendon. That study reported a mean failure strength of the native biceps tendon of 222 ± 66 N [1], which seems to be relatively low compared to the potential force generated in the tendon during activities of daily living. This may be attributable to the angle in which the tendon was avulsed in that study, which may not be the same as the angle of tendon insertion in vivo. We hypothesized that distal biceps tendon rupture might require greater loads than those that have been reported, and that load to failure varies according the angle of the elbow, which creates different angles between the tendon and long axis of the radius.

Methods:

15 fresh frozen proximal radii were dissected free of all soft tissue except for the biceps tendon. They were mounted in a PMMA mold with the radial tuberosity facing medially. This allowed us to tension the biceps tendon perpendicular (vertically) to the long axis of the radius, simulating the orientation of the tendon insertion in forearm supination (Figure 1). The muscle and tendon was clamped within a customized cryogrip, leaving approximately 4.5 cm of tendon free. Cooling with carbon dioxide gas resulted in the muscle/tendon freezing to the grips, providing a more secure clamping of the soft tissue. The grip was attached to a load cell.

There were three testing conditions (5 specimens in each group) according to the bone/tendon angle: i) 90 degrees (Figure 2 B – D). Each condition was tested at a displacement rate of 4 mm/s. A differential, variable-reluctance transducer was inserted into the tendon to record the deformation/elongation of the tendon.

Results: Rupture of the distal biceps tendon occurred in 15 of 15 specimens. In 5 / 15 (33%), rupture occurred within the mid-substance of the tendon itself. In the remaining 10 samples, avulsion occurred from the bony insertion. We observed a strong trend of an increasing bone-tendon angle to increasing failure loads. The failure loads were (360 ± 120 N) (95% C.I. 80 – 640 N), (617 ± 140 N) (95% C.I 340 – 900 N), and (762 ± 130 N) (95% C.I. 480 – 1050 N) for the 90, 60, and 30 degree groups, respectively (Figure 3). The means were not significantly different from each other (p = 0.12) due to the large confidence intervals. The maximum failure load recorded in any specimen was 1230 N (30 degrees), while the minimum was 120 N (90 degrees).

Discussion:

The mean stiffness results for 13/15 specimens (DVRT malfunctioned in 2 cases), were 501 ± 176 N/mm, 763 ± N/mm, and 756 ± 179 N/mm for the 90, 60, and 30 degree groups, respectively.

Power calculations based on this data set revealed that we would need 17 specimens per group to have an 80% chance of detecting a significant difference of 1 SD, or 260 N. The mean stiffness results for 13/15 specimens (DVRT malfunctioned in 2 cases), were 501 ± 176 N/mm, 763 ± N/mm, and 756 ± 179 N/mm for the 90, 60, and 30 degree groups, respectively.

Discussion: The failure loads that we recorded are higher than those previously reported. The ability of the distal biceps tendon to withstand rupture appears to depend on the flexion angle as well. This is important as those advocating certain surgical repair methods may be using the previously-reported value as a standard for comparison. Though several studies have investigated the strength of distal biceps tendon repair methods, only one study has tested the native tendon’s failure loads. Idler et al. [1] found a mean native distal biceps maximum strength of 222 ± 77 N, with the tendon aligned 90° to the long axis of the radius. However, in that study the tuberosity faced upwards (vertically) and the tendon was pulled in the same direction (vertically), which is a non-anatomic position, past the limit of forearm supination. In our study, 12 of 15 specimens (80%) did not fail until reaching loads that exceeded the upper 95% confidence interval (351 N) of the data reported by Idler et al. Our specimens were tested with the tuberosity facing horizontally and the tendon being pulled vertically, which more accurately simulates physiologic forearm supination. This is one factor (anatomic positioning) which may account for the higher failure loads that we observed compared to that study. A second difference between our investigation and Idler’s was the testing of angles other than 90 degrees of flexion. The usual mechanism of distal biceps tendon rupture has been described as an unexpected extension force applied to the elbow during flexion from an extended position. Our clinical experience supports that the actual flexion angle at the moment of rupture is usually in the extension portion of the arc of elbow motion.

Patients with a chronic degenerative process at the radial tuberosity may be predisposed to distal biceps tendon rupture, though we did not encounter any significant tendon pathology in our samples, so cannot comment on its possible effect.

Significance: The load to failure of the distal biceps tendon that we observed may be higher than what has previously been reported. This should be taken into account during consideration of repair and rehabilitation.

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