The Effect of Biceps Reattachment Site on Moment Arm

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Introduction: Avulsion of the distal biceps tendon from the tuberosity occurs mostly in middle-aged males resulting from eccentric loading of the flexed, supinated forearm [1]. When non-operative treatment is chosen, supination strength decreases by 50% and flexion strength is reduced by 35-40% [2]. Surgical repair has been shown to be a better alternative than non-operative treatments for restoration of strength and endurance [2,3].

Current surgical methods include one and two incision repair techniques in which the tendon is reattached to the anterior or posterior aspect of the tuberosity respectively. Methods of attachment of the tendon include using sutures, suture anchors and endobuttons. Although studies have examined the fixation strength of these types of repairs, little has been done to examine the effect that attachment location has on functional outcome of the repair[4].

The objective of this project is to determine the impact that the reattachment location has on torque generating ability of the forearm described as its moment arm. The results of this study can help surgeons gain a better understanding of how to optimize the repair and thereby improve the expected outcome of patients with distal biceps injuries.

Methods: A total of 6 frozen upper extremity cadaveric specimens (5 male), with an average age of 60 (36-83) years, were used. The specimens included the full forearm from the hand to the mid-humerus proximally. Specimens with medical histories of rheumatoid arthritis, degenerative joint disease or any orthopaedic anomaly were excluded. Prior to the day of testing, each specimen was allowed to thaw overnight at room temperature and kept moist with normal saline.

An elbow simulator, that includes computer controlled actuators to exert known loads on the forearm applied through the biceps tendon, was adapted to a device capable of measuring isometric forearm torque generated by cadaveric elbows[5]. The device has an adjustable shaft that attaches to a plate mounted on the distal radius. The other end of the shaft transmits load to a torque sensor (Transducer Techniques, Temecula, CA) which is wired into a computer data acquisition system.

Each specimen was mounted in the elbow simulator with the humerus and ulna fixed firmly to the frame at 90° of flexion. The proximal end of the distal biceps tendon was attached to an actuator using 80lb test line. The adjustable shaft was attached to the distal radius plate. The forearm was then rotated and locked into three positions: 60° supination, neutral and 60° pronation. The biceps tendon was loaded to 15 lbs, and the torque was measured for the native tendon attachment. Then the biceps tendon was detached and attached at four different locations. For each forearm position, each test was replicated three times.

With the arm fully supinated, the borders of the radial tuberosity were identified, and the proximal and distal border lines were drawn (Figure 1). The borders were defined at the point where the bone geometry of the radius begins to exhibit slight concave curvature. The length of the tuberosity borders was measured and their midpoints were marked. A line connecting the two midpoints was used to define the center axis line. The highest point (apex) on the tuberosity at the tendon-bone interface was identified using calipers. A medial to lateral line, parallel to the tuberosity border lines, was drawn to define the apex diameter line.

Using these markings as a guide, three drill holes were systematically placed in the radius. Location "A" was placed on the apex diameter line at the native tendon insertion. Location "B" was drilled at the intersection of the center axis and apex diameter lines. Location "C" is the same as "B" except that the tendon wrapped around the tuberosity and attached on the posterior side of the radius. Location "D" was drilled at the most ulnar point on the proximal border line.

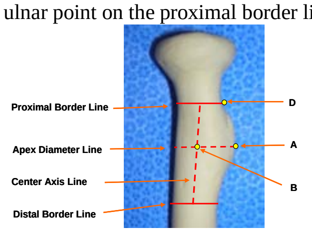

Fig.1: Tendon Reattachment Locations. (Note: Location "C" not shown)

A simple linear regression line with no intercept was fitted to the torque vs. load data for each test. The moment arm for each tendon attachment was found from slope of the regression line. The moment arm was averaged over the three replicated tests taken at each treatment level. A positive moment arm value indicated that the biceps generated a supination torque.

A two-way repeated measures analysis of variance was used to determine if tendon location and forearm position significantly affect the moment arm of the biceps (p-value <0.05). Tukey's post-hoc testing was used to compare the means of individual treatment levels with one another.

Results: Analysis showed that tendon location and forearm position significantly affected the moment arm of the biceps ($p<0.05$). The native tendon had a mean moment arm of 5.67 ±2.86 and 10.44 ±1.45 (mm) in 60° supination and neutral respectively. Reattachment to location "A" in all forearm positions respectively (6.24 ±3.30, 10.41±2.03, 8.41±1.22) showed no significant difference from the native insertion. Location "B" was significantly lower in supination (0.15 ±3.48) and neutral (7.65 ±1.95). No difference was observed between the tendon locations in pronation. Location "C" was significantly higher in supination (7.21± 3.02) compared to the native, however no differences were found in neutral and pronated positions. Location "D" (4.69 ±2.75) was significantly higher than Location "B" in supination.

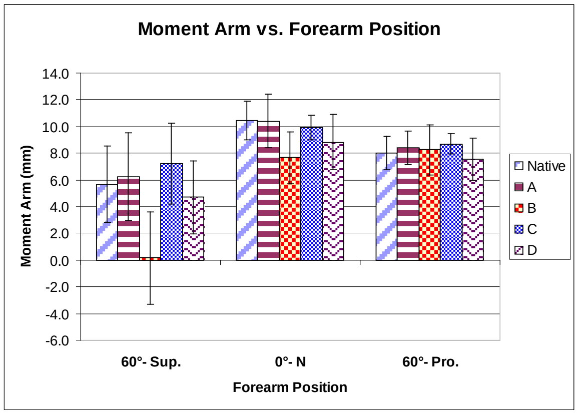

Fig. 2: Average moment arms for each tendon location. See text for statistical significance.

Discussion: Reattachment of the distal bicep tendon to its native position, Location "A", showed no difference in moment arm to its control. Radializing the attachment, Location "B", resulted in a significantly lower moment arm than its control in neutral and supinated positions. We believe this observation is due to less wrapping of the tendon around the tuberosity with an anterior position. Further, this finding is supported by an increase in moment arm at Location "C" with the arm in a supinated position.

A proximal ulnar position, Location "D", trended to have a lower moment arm than its control in all forearm positions, but was only significantly different in neutral. Clinically these findings would suggest that if the muscle was contracted and the tendon could not be inserted to its native position then a proximal ulnar position would be better than a more central anterior one.

Reference: 1. Chillemi, C., M. Marinelli, et al. (2007). Arch Orthop Trauma Surg 127(8): 705-8. 2. Hetsroni, I., R. Pilz-Burstein, et al. (2008). Injury 39(7): 753-60. 3. Baker, B. E. and D. Bierwagen (1985). J Bone Joint Surg Am 67(3): 414-7. 4. Kettler, M., et al. (2007). Am J Sports Med. 35(9): 1544-8. 5. Kuxhaus, L. (2009) ASME J Medical Devices