BIOMECHANICAL STRENGTH COMPARISON OF FIVE DIFFERENT REPAIR TECHNIQUES FOR Rupture of the Distal Tendon of Biceps Brachii

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Introduction: The purpose of this cadaver study was to compare pullout strengths of four different techniques currently available for the repair of distal biceps tendon ruptures including two newer, less invasive techniques which have not previously been reported. Avulsions of the distal tendon of the biceps brachii are relatively uncommon but occur more frequently in muscular males who perform heavy labor. This inevitably leads to a symptomatic loss of both forearm flexion and supination power. Distal tendon avulsions most often consist of a clean avulsion of the end of the tendon from the radial tuberosity. There is immediate weakness and short lived pain as a result.

Morrey et al. found that immediate surgical reinsertion of the biceps tendon into the radial tuberosity restores the greatest strength of flexion and supination. If the biceps is not attached to the tubercle of the radius, weakening is not only to be expected in supination of the forearm but also in flexion of the elbow. Thus, not only is surgery necessary, but should be performed soon after rupture.

Methods: Twenty five fresh frozen arms were used to conduct a strength comparison of the chosen repair technique with the individual normal pullout strength. Institutional Review Board approval was obtained before working with the cadaveric specimens. Pullout strengths were measured using a servohydraulic materials testing machine (MTS 858 Mini-Bionix, MTS Corp., Eden Prairie, Minnesota). The data obtained was analyzed using Student’s t test, with a significance level of p = 0.05.

The five techniques tested were: bone-tunnel repair with number two Ethibond suture (Ethicon Inc., Somerville, New Jersey); Mitek GII suture anchor (Mitek Surgical Products Inc., Norwood, Massachusetts) repair using two suture anchors; Endobutton (Smith & Nephew Inc., Andover, Massachusetts) repair with two number two Ethibond sutures; Endobutton repair with a single number two Fiberwire suture (Arthrex Inc., Naples, Florida), and repair using Arthrex distal biceps bioabsorbable tenodesis screw (Arthrex Inc., Naples, Florida) with number two Fiberwire suture. Each technique was performed on five cadaveric specimens. All repairs were performed by one surgeon using a running-locking suture technique for tendon fixation. Normal pullout strengths were measured at 45 degrees and 90 degrees flexion with ten paired cadaveric specimens in order to compare normal pullout strengths at different elbow positions. Each of the repair techniques were loaded at 90 degrees to tensile failure and compared to normal.

Results: The average normal pullout strength measured at 90 degrees flexion was 459 ± 142.2 Newtons (N). The average normal pullout strength measured at 45 degrees flexion was 312 ± 89.1 N. The average pullout strength for bone tunnel, Mitek, Endobutton, Endobutton with Fiberwire, and Arthrex repair techniques were 127 ± 64.1 N, 172 ± 40.1 N, 258 ± 39.2 N, 269 ± 52.9 N, 197 ± 80.4 N respectively (p < 0.05). All repair techniques were significantly less than the normal pullout strength, but the Endobutton technique was statistically stronger than the Arthrex, Mitek, and bone tunnel techniques (p < 0.05).

Discussion: The normal distal biceps tendon pullout strength was statistically lower in 45 degrees versus 90 degrees flexion. This was an interesting finding which correlates well with the fact that distal biceps tendon rupture occurs clinically more often with the arm closer to full extension. This occurrence is explained by the fact that in 45 degrees flexion the posterior fibers of the tendon are lax. As seen with the mechanical testing, the posterior fibers were offering no support at 45 degrees and the anterior fibers would inevitably tear at a lower tensile strength. The tear would then propagate through the tendon to the posterior fibers.

The limiting factor for the bone tunnel, Mitek, and Endobutton repair techniques was the strength of the suture. The reason we did not find similar repair strengths even though the suture failed in all repairs, was the fact that the different techniques manipulated the suture in different ways. In the bone tunnel technique, we saw the suture breaking since it was pulled against cortical bone. The bone was very sharp and lead to the suture breaking earlier. In the Mitek suture anchor technique, the suture was pulled against the suture anchors, which have sharp metal edges. However, in the Endobutton technique which was found to be significantly stronger, the suture is pulled against rounded edges. We feel this is one major reason why the Endobutton technique allowed for greater return of strength. Furthermore, the use of the stronger Fiberwire suture in place of Ethibond suture allowed for the return of an additional 11 N of strength on average.

Based on our study, the use of easier, less invasive techniques like Endobutton and Arthrex screw fixation, as well as stronger suture material provides stronger repairs which could possibly lead to earlier mobilization and quicker return to function. The difference in strength is clinically relevant especially since 52 N is required to maintain the weight of the forearm alone in 90 degrees of elbow flexion (Pereira et al).

References:

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50th Annual Meeting of the Orthopaedic Research Society
Poster No: 1203

Figure 1: Average pullout strength for each technique tested and the normal tendon strength.