INTRODUCTION

Advocates for the non-operative treatment of distal biceps ruptures emphasize the limited functional loss. Isometric supination strength loss of 26% - 40% has been reported in a neutral forearm position and supination strength loss after biceps tendon reconstruction differs with forearm position. Biomechanical studies have also demonstrated that the native biceps moment arm changes significantly with forearm position. The purpose of this study was to quantify the effects of a complete distal biceps rupture. We hypothesized that supination strength loss would be significant, vary with forearm position, and be independent of arm dominance. Furthermore, strength loss would positively correlate with time from injury and negatively correlate with pain and disability.

METHODS

Individuals with complete avulsion of the distal biceps tendon were recruited to participate. Inclusion criteria consisted of individuals presenting in clinic seeking repair of the ruptured tendon and no other upper extremity injury. Subjects performed isometric supination strength testing using a custom-made torque-measuring device (Figure 1) and a previously published protocol. Peak torque was recorded for each arm at three forearm positions; 60° of supination, (0°) neutral and 60° of pronation.

Supination strength loss was expressed as the ratio of the injured side to the contralateral side. Pain was assessed using a numeric visual analog pain scale (VAPS), ranging from 0-10 and functional outcomes were measured using the DASH questionnaire. Strength data were compared as a function of arm dominance, test angle, and biceps injury using a 3-way ANOVA, while relationships to strength were analyzed using linear regression (significance set at p=0.05). Outliers in the data were found by calculating the Mahalanobis distance, a metric gauging similarity in the dataset, accounting for Euclidean distance and correlations.

RESULTS

Twenty three adult males with an average age of 49 ± 10 years suffered a complete distal biceps avulsion. There were 12 dominant and 11 non-dominant arm injuries. One individual was detected as an outlier, as his injury to evaluation was 10,951 days. The Mahalanobis distance for this data point was 4.58 where the threshold for the data set was 2.64. This data point was not used in the subsequent analyses, but will be discussed later as a relevant single case.

The average time of injury to evaluation was 25 days, ranging from 4 to 71 days. The supination strength loss was significant compared to the uninjured side (Figure 2): 59% in supination (p<0.001), 60% in neutral (p<0.001), and 52% in pronation (p<0.001). The strength values also showed the uninjured arm was significantly stronger in 60° of pronation and neutral compared to 60° of supination.
supination (p<0.001 and p= 0.012 respectively). The injured arm was also stronger in 60° of pronation compared to 60° of supination (p= 0.043).

**Figure 2:** Supination torque values for all subjects; the data is divided into injured and uninjured arms regardless of arm dominance and highlights significant findings.

Analysis detected no differences in supination strength loss between the 3 forearm test positions (p=0.094) (Figure 3). Analysis revealed that arm dominance had no effect on strength loss (p=0.76). Strength loss, at any test angle, did not relate to the time from injury to evaluation (p > 0.65), VAPS score (p > 0.06), or DASH assessment (p > 0.22). The average VAPS score was 5 ± 2 and DASH score was 40 ± 21. Furthermore, time from injury did not correlate to the VAPS score (p=0.10) or to the DASH (p=0.17). The VAPS and DASH assessments positively correlated (p=0.004).

The outlying case with a lengthy time from injury to evaluation of 10,951 days (30 years), showed full recovery of strength in the pronated position (115%), partial recovery in neutral (72%), and less recovery in the supinated position (61%). (Figure 3)

**DISCUSSION**

The study shows that an individual loses 52% to 60% of their supination strength following distal biceps rupture. Pairing the literature on conservative treatment\(^1\),\(^2\) with the current data involving no treatment demonstrates that significant deficits occur without surgical repair. Surgical intervention has been shown to restore biceps strength to 90% of normal.\(^6\)

Supination strength loss was significant regardless of forearm position hinting at a dynamic interaction in the contribution of force between supinator muscles in the forearm. Forearm position showed variation in the amount of torque an individual could apply, even in the biceps deficient arm. This finding may be due to the co-contraction of the brachioradialis muscle, which acts as a supinator of the pronated forearm and then switches function to act as a pronator in the supinated forearm.

Reported disability and pain associated with the injury were not indicative of reduced strength, hinting that true weakness is independent of perception. Similarly, strength loss was not dependent on the time from injury to the evaluation. This suggests there is no immediate ability for the body to compensate for biceps rupture. The single case of an individual with a chronic biceps injury suggests that strength can be recovered at certain forearm positions. Long term data is needed to truly determine if supination strength, pain, and disability can improve without an attached distal biceps. We speculate that supination strength from pronation to neutral can improve as one strengthens the brachioradialis, but that strength deficits from neutral to supination will be difficult to overcome.

**REFERENCES**