Distal Biceps Tendon Repair: A Biomechanical Investigation of the High Flexion Angle Repair

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INTRODUCTION: The biceps brachii is a frequently used muscle that contributes to elbow flexion and forearm supination. Consequently, a rupture to the distal biceps brachii tendon results in weakness of these movements[1]. These ruptures, typically seen in the dominant limb, are predominantly found in 40–60-year-old males work in manual labor or compete in sports[2]. The mechanism of injury mostly involves fast elbow flexion against resistance resulting in loss of strength and acute pain[3]. For a complete tear, operative treatment is recommended and usually associated with good patient satisfaction and functional outcomes[1]. Different surgical techniques are available that restore adequate strength[4]. These techniques can include a direct repair (DR) that fixes the tendon back to its native footprint[1], and a graft repair (GR) when direct repair is difficult to achieve, typically due to a ruptured tendon having poor quality or significant retraction[5]. To reduce the need for a graft and maintain the native tendon, a relatively recent "high flexion angle" repair (HFR) was developed, which consists of repairing the tendon to its native footprint while keeping the elbow in 60 degrees of flexion or more (up to 90 degrees). However, possible complications may exist following this operation, such as flexion contractures or possible re-ruptures[5]. Biomechanical assessments have been previously performed following a DR, showing that no significant differences in strength (i.e., peak torque) and endurance (i.e., total work and work fatigue) exist between the operated and contralateral limb[6]. However, no similar assessments have been performed following an HFR. Therefore, the purpose of this study was to compare strength and endurance outcomes of the biceps brachii following direct, graft, or high flexion angle repairs. It was hypothesized that the HFR would have no differences in peak torque, total work, and work fatigue to DRs and GRs.

METHODS: A retrospective review of medical records from 2012-2022 from the South Health Campus Bone and Joint Clinic (Calgary, AB) was performed to obtain a list of individuals who received a distal biceps brachii tendon repair. A total of 363 individuals (all males, no females) were identified and invited to participate in this study; institutionally approved by the Conjoint Health Research Ethics Board (REB21-1851). All participants provided informed consent prior to participating. Currently, 9 participants (age: 51.4 ± 10.8 years; body mass index: 29.02 ± 3.44 kg/m^2; time since operation: 1621.78 ± 3894.05 days) with a previous biceps brachii tendon repair (DR: n = 2; GR: n = 2, HFR: n = 5) have been recruited for this ongoing study. To assess biceps brachii strength and endurance, participants performed bilateral forearm supination/pronation, followed by elbow flexion/extension, fatigue tests on a Biodex dynamometer[6]. Participants were seated and strapped into the system to avoid torso movements during the trials. The protocol consisted of a 3-repetition warm-up, 1-minute rest, and finally a 50-repetition trial. Maximum effort was performed during the concentric contraction of the biceps brachii (i.e., elbow flexion or forearm supination) and no effort on the eccentric contraction (i.e., elbow extension or forearm pronation). Movements were performed at 120 deg/s, and the non-operated limb was always the first limb to perform the protocol. Strength and endurance were evaluated using measures of peak torque, total work, and work fatigue. Strength was represented by peak torque, or the maximum value of torque applied during the full 50 repetitions. Endurance was represented by total work (i.e., the total amount of work performed throughout the 50 repetitions) and work fatigue (i.e., the percent ratio of the last third of work to the first third of work throughout the 50 repetitions). For each movement, a repeated measure General Linear Model ($\alpha = 0.05$) was used to assess within-participant differences between operated and non-operated limbs. Between-participant differences for surgery type were also included in the model to determine interaction effects with the limbs. However, due to small sample sizes, the DR and GR groups were combined in the analysis and compared to the HFR group.

RESULTS: No statistically significant interactions were found between limbs and surgery type for both movements. A significant difference was found between the two surgery groups during supination ($p = 0.010$), with the DR/GR group performing 137.69 ± 108.85 J more total work than the HFR group (Table 1). No other differences were seen.

DISCUSSION: No significant interactions were found between limbs and surgery type, supporting the hypothesis that no differences would be found between HFR, DR, and GR. This is in partial agreement to a previous study that saw individuals with DR show no differences between the operated and contralateral limbs, except for work fatigue being lower in the operated limb. However, this was speculated to be a result of arm dominance, as most repairs were performed on the dominant limb. The only significant difference found in this study was the DR/GR group performing more total work than the HFR group during supination, regardless of limb. This may be a result of several factors, such as the overall fitness of the two groups and time since operation/injury. These important confounders, along with arm dominance, will be considered in future analyses to better understand these findings. Furthermore, the DR and GR groups were combined in the statistical analysis due to having small sample sizes. Acquiring a larger sample (i.e., n = 20 per group) will avoid the need to pool the two surgery types. Based on an a-priori power analysis (power = 0.80) using previously published literature[6], a sample size of 15 for each group is required to determine a significant difference.

SIGNIFICANCE: This ongoing study is the first to perform a biomechanical assessment of individuals who have received an HFR. Quantifying the biomechanical effects of a HFR can better inform surgical decision making.

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IMAGES AND TABLES:

Table 1. Group means (standard deviations) for limbs (non-operated and operated) and surgery type (DR/GR and HFR) for both movements. An asterisk indicates a significant difference.

		Limb				Surgery Type		
	Measure	**Non-operated**	**Operated**	**p-value**	**Measure**	**DR/GR**	**HFR**	**p-value**
Supination	**Peak Torque (Nm)**	8.50 (2.02)	8.15 (1.63)	0.70	**Peak Torque (Nm)**	8.85 (1.94)	7.80 (1.74)	0.27
	Total Work (J)	454.70 (83.98)	395.54 (85.56)	0.21	**Total Work (J)**	493.96 (81.13)	356.27 (72.56)	0.01*
	Work Fatigue (%)	32.35 (14.62)	13.66 (22.67)	0.09	**Work Fatigue (%)**	28.24 (18.51)	17.77 (16.56)	0.25
Flexion	**Peak Torque (Nm)**	38.75 (8.19)	37.78 (4.74)	0.66	**Peak Torque (Nm)**	41.11 (8.81)	35.42 (7.88)	0.19
	Total Work (J)	1830.31 (325.58)	1687.38 (366.25)	0.08	**Total Work (J)**	1812.34 (491.92)	1705.35 (439.99)	0.64
	Work Fatigue (%)	49.31 (24.55)	59.36 (17.61)	0.11	**Work Fatigue (%)**	51.46 (29.35)	57.21 (26.25)	0.67