Normalization of Humeral Force Generation Following Lower Trapezius Tendon Transfer

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Background: Irreparable rotator cuff tears are a difficult orthopedic problem that result in shoulder pain and dysfunction. Recently lower trapezius tendon (LTT) transfers have gained popularity in irreparable posterosuperior rotator cuff tears, demonstrating improvements in external rotation and forward flexion. However, there is no consensus on the optimal surgical technique regarding tendon transfer location to the humeral greater tuberosity, with studies describing insertion to the supraspinatus, infraspinatus, and teres minor native attachments.

Methods: A total of 7 human upper extremity cadaveric specimens were utilized. All skin and subcutaneous tissue was removed. The musculotendinous units of the deltoid, pectoralis major, lattisimus, subscapularis, supraspinatus, and infraspinatus/teres complex were identified and tagged to allow for loading as described by Omid et al.[1] Specimens with previous rotator cuff tears upon dissection were excluded. Cadaveric scapula was secured to a custom testing frame (Figure 1). The distal humerus secured to a robotic testing arm with 3-Dimensional motion capture. External rotation torque, forward flexion, and abduction forces at 0, 20, 40, 60, and 90 degrees of abduction were recorded. The native shoulder was tested as a control, followed by an induced massive rotator cuff tear, created by transecting cuff tendon off the footprint from the rotator interval to the insertion of the teres minor. Two LTT insertion sites were tested including a standard repair to the greater tuberosity at the supraspinatus and infraspinatus insertion sites junction (Figure 1). A second, novel "over-the-top" (OTT) method was tested, which involved securing graft to the superior aspect of the lesser tuberosity the leading edge of the supraspinatus insertion and two lateral fixation points at the infra/supra junction (Figure 1).

Results: External rotation torque was decreased in the massive cuff tear state compared to the native state across all abduction angles (Figure 2). Both the standard repair and the OTT repair increased external rotation force compared to the cuff tear state at all angles with significant differences detected at 0, 60, and 90 degrees of abduction. The OTT method resulted in greater flexion force at 0 degrees of abduction when compared to the standard repair (8.0 vs 4.2 N; $p = 0.026$)(Figure 3). The standard repair resulted in greater abduction force at 60 degrees of abduction when compared to the over-the-top repair (21.6 vs 16.6 N; $p = 0.037$)(Figure 4). The standard repair resulted in even greater abduction force than the native cuff intact state (21.6 vs 16.2 N; $p < 0.001$).

Conclusion: Both lower trapezius tendon transfer models normalize humeral external rotation torque when compared to a massive rotator cuff tear state. A standard repair to the greater tuberosity generally resulted in more abduction force at the expense of forward flexion force. However, the abduction force exceeded that of the native intact cuff state. The OTT repair improved both abduction and forward flexion with forces more similar to the native cuff intact state.

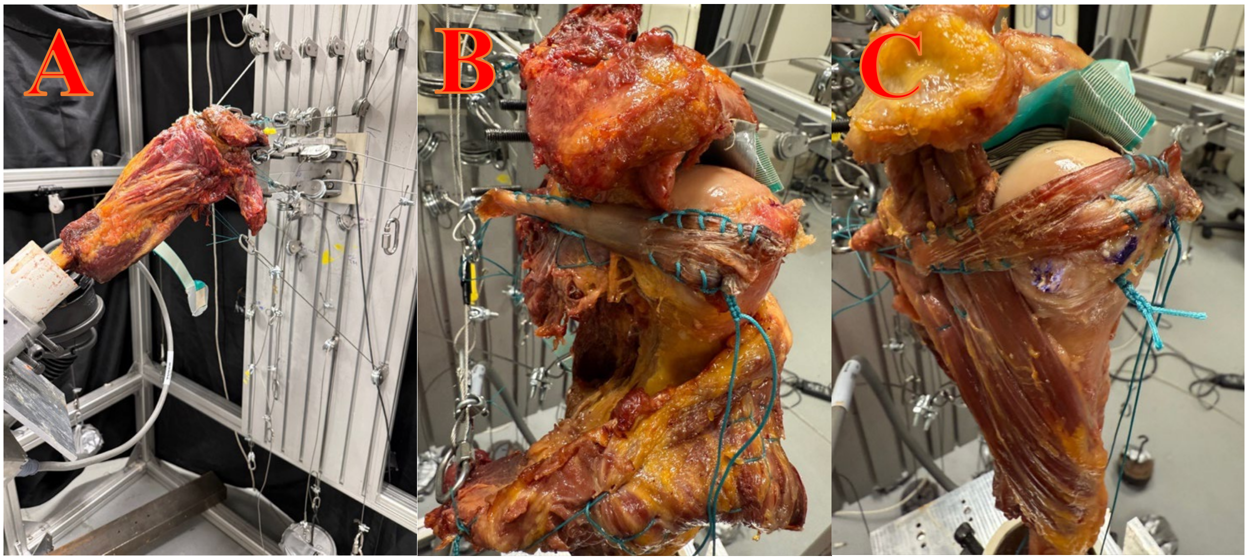

Figure 1; A: Scapula secured to custom testing frame with loadable pulley system and humerus potted and secured to Kuka robotic testing arm. B: demonstration of standard achilles graft repair to tuberosity with deltoid reflected for visualization. Fixation points were placed 1 and 2 cm anterior to the teres minor insertion. C: demonstration of "over-the-top" achilles graft repair with leading edge of graft secured to superior most aspect of lesser tuberosity and the anterior edge of greater tuberosity, with 2 additional lateral based fixation points at the supraspinatus insertion

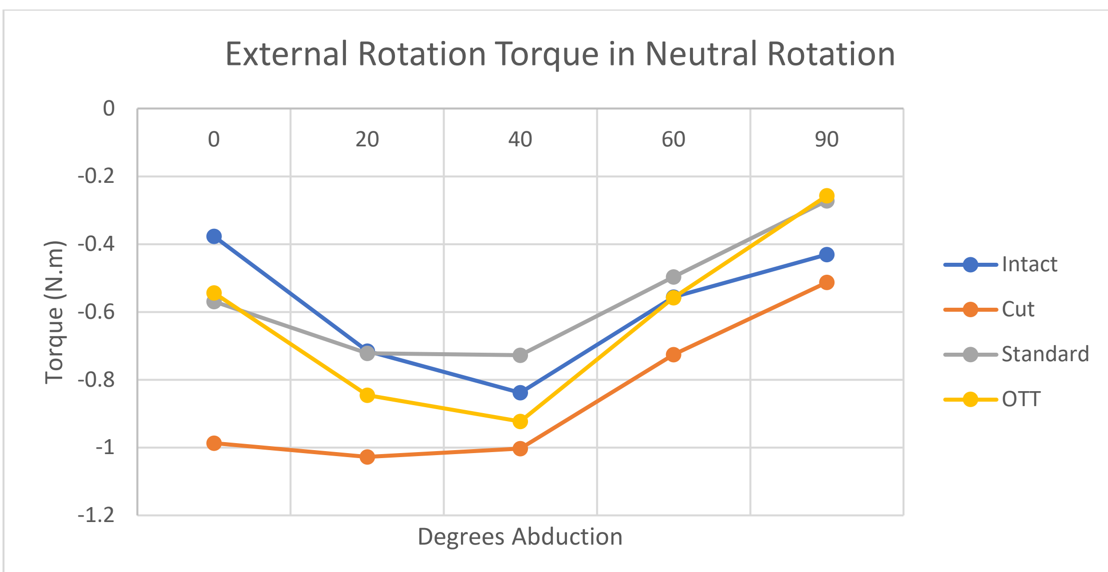

Figure 2: External rotation torques throughout degrees of abduction

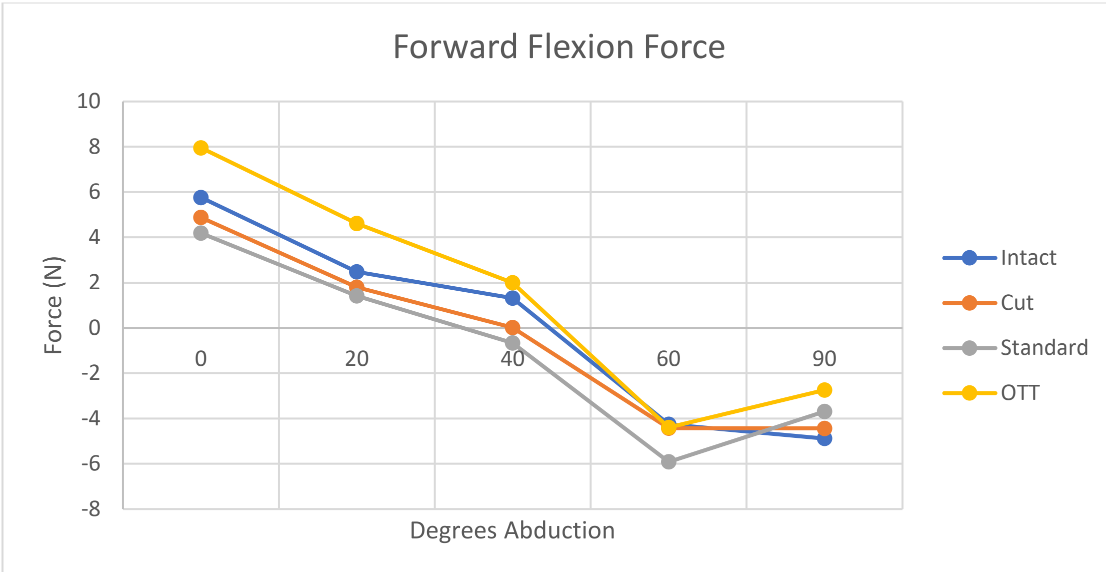

Figure 3: Forward Flexion forces throughout degrees of abduction

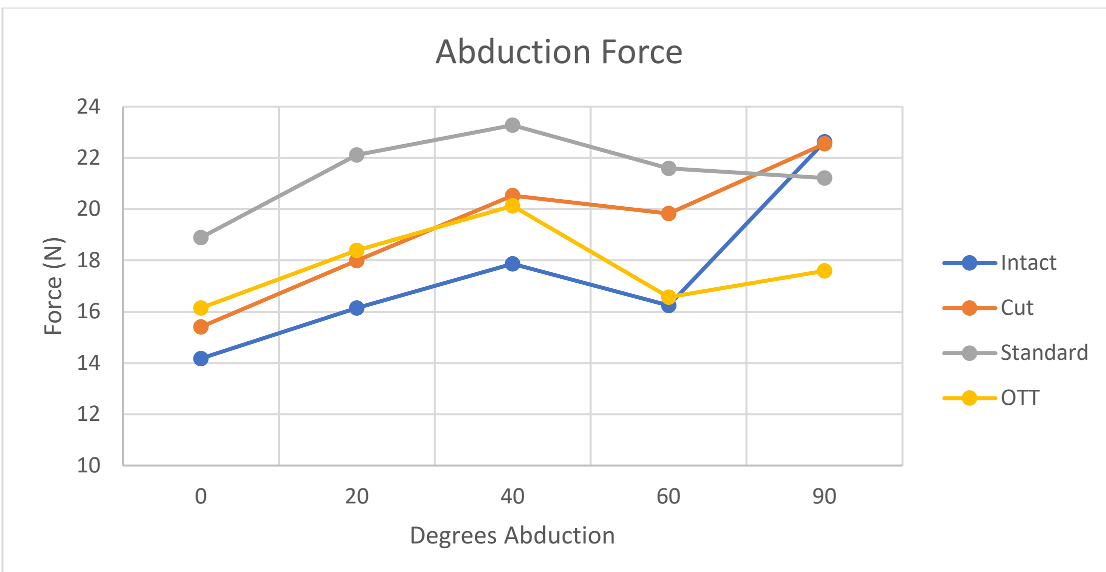

Figure 4: Abduction forces throughout degrees of abduction