Effect of Long Head Biceps Tenodesis on In Vivo Glenohumeral Translations During Loaded Forward Flexion Using Biplane Fluoroscopy

INTRODUCTION:
The function of the long head of the biceps (LHB) tendon and its role in glenohumeral kinematics remain poorly understood due to the paucity and difficulty of in vivo studies. Biomechanical studies in cadaveric models have demonstrated stabilizing effects of the LHB on the glenohumeral joint. Clinically, however, biceps tenodesis has been performed with mixed outcomes and low complication rates.

In vivo, superior translation after open biceps tenodesis was found in abduction in the scapular plane. In this study, however, static postures were measured during an activity that requires relatively little biceps activation. A motion that significantly activates the biceps and that includes arm elevation is more likely to show the active stabilizing effect of the biceps on the glenohumeral joint. The biceps is active during elbow flexion with forearm supination, which combined with forward flexion is similar to lifting objects overhead. This motion is relevant for activities of daily living, work and overhead athletic activities.

Therefore, the purpose of this in vivo study was to determine the 3D glenohumeral kinematics in shoulders that had been treated by isolated sub-pectoral tenodesis compared with the intact opposite shoulder during a loaded forward flexion task. It was hypothesized that there are no glenohumeral position differences greater than 5mm (no clinically meaningful differences) between the tenodesed and healthy shoulders.

METHODS:
A biplane fluoroscopy system was used to measure the 3D pose of the scapula and humerus of both shoulders of 5 subjects (3M; 2F; age: 41±14 yrs; height: 1.77±0.09m; weight: 87±23kg) with isolated, unilateral biceps tendonitis who underwent open sub-pectoral LHB tenodesis. Each subject performed forward flexion with forearm supination, which combined with elbow flexion is similar to lifting objects overhead. This motion is relevant for activities of daily living, work and overhead athletic activities.

The 3D geometries of the scapula and humerus were extracted from the CT data (Mimics, Materialize, Ann Arbor, MI). For each frame the 3D bone poses were estimated using a contour matching algorithm (Model-Based RSA, Medis Specials BV, Leiden, the Netherlands). The glenohumeral (GH) positions were determined by measuring the position of the center of the humeral head relative to the glenoid coordinate system. The glenoid coordinate system was created based on the most superior, inferior and anterior points of the glenoid rim. The glenoid center was assumed to be midway between the superior and inferior glenoid rim points. The humeral head center was determined by fitting a sphere to the articular portion of the humeral head only. The position data were filtered at 2Hz.

The position data were then resampled from 40 deg of arm elevation to 130 deg in 10 deg increments. A 2-way repeated-measures ANOVA was performed on the anterior-posterior (AP) and superior-inferior (SI) positions with independent measures of shoulder (Tenodesed vs Healthy) and arm elevation angle (40-130deg). A t-test was used to compare average and peak EMG activation during the motion.

RESULTS:
Figure 1 shows the SI and AP positions found in this study. No significant differences were found in either direction (SI: p > 0.10; AP: p > 0.26). For the SI direction, on average the tenodesed side was positioned 0.5mm (critical difference: 0.6mm) more superior than the healthy side with a maximum average position difference of 1.0mm at 70deg of arm elevation. For the AP direction, on average the tenodesed side was positioned 0.1mm (critical difference: 0.5mm) anterior of the healthy side with maximum average position difference of 1.2 mm at 130 deg of arm elevation. Relative to the origin, both shoulders were positioned superiorly and posteriorly. EMG activation was confirmed to be high (tenodesed vs. healthy; peak: 126 ± 40% vs.115 ± 42%; average: 61 ± 17% vs. 46 ± 14%) and not significantly different between shoulders (p > 0.44).

DISCUSSION:
Our results indicate that the biceps was highly activated during the forward flexion motion. However, no statistically significant differences between the tenodesed and healthy shoulders were found. Moreover, the differences that were found were far below what is considered clinically relevant (5mm) whether looking at the average difference (±0.5mm) or at the maximum difference at any particular angle (± 1.2mm) in any direction. While the number of subjects is a limitation of this study, the study was adequately powered to detect what is clinically considered a relevant difference of 5.0mm.

Our findings are particularly relevant to the clinical management of LHB pathology. The findings support sub-pectoral tenodesis as a surgical treatment for failed conservative management of LHB pathology.

REFERENCES:

Figure 1. Superior-inferior and anterior-posterior glenohumeral position as a function of arm elevation angle during forward flexion.