The Effects Of Scapulohumeral Rhythm On The Moment Generating Capacity Of The Deltoid Muscles After Reverse Total Shoulder Arthroplasty

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Introduction: An upper extremity model of the shoulder was developed from the Stanford upper extremity model (Holzbaur et al 2005) in this study to assess the muscle lengthening changes that occur as a function of kinematics for reverse total shoulder arthroplasty (RTSA) subjects. An analysis of muscle moment arm changes as a function of scapulohumeral rhythm (SHR) during abduction for RTSA subjects was performed. The purpose of the study was to calculate the effect of RTSA SHR on the deltoid moment arm over the abduction arc.

Methods: 23 RTSA subjects were modeled and compared with 24 healthy shoulders. The model was parameterized as a 12 degree of freedom model in which the scapula and humeral rotational degrees of freedom were prescribed from fluoroscopy. The model had 15 muscle actuators representing the muscles that span the shoulder girdle. The model was then uniformly scaled according to reflective markers from motion capture studies. An average SHR was calculated for the normal and RTSA cohort set. The SHR averages were then used to drive the motion of the scapula and the humerus. Lastly 3-dimensional kinematics for the scapula and humerus from 3d-2d fluoroscopic image registration techniques were used to drive the motion of model. Deltoid muscle moment arm was calculated.

Results: Muscle moment arms were calculated for the anterior, lateral and posterior heads of the deltoid. Significant changes (>1mm) were only found in comparing the anterior deltoid muscle moment arm predictions between the normal and RTSA group. The anterior deltoid for RTSA had a moment arm range from -9.41 - 22.6 mm over the max abduction arc. The anterior deltoid for normal group had a moment arm range from -12.492 - 22.6 mm over the max abduction arc. There is a difference of 4mm between the normal and RTSA anterior deltoid moment arm at lower degrees of elevation during abduction.(<45°) There were no significant differences found between normal and RTSA groups for the lateral and posterior deltoid. The most significant difference between moment arm calculations for the RTSA and normal group was found in the Anterior deltoid. (Figure 1)

Discussion: It was found that the muscle moment arms in the RTSA group were significantly different than in the normal group for the anterior deltoid. No other significant differences were found. In the initial 40° of elevation there is a 2 mm difference in anterior deltoid muscle moment arm between the normal and RTSA group. This difference is also found is seen from 60°-90° of elevation. From 35° -55° there is no difference between RTSA and normal groups. SHR for the RTSA (1.8:1) is significantly lower than in the normal (2.5:1) group. Differences found in muscle moment arms over the abduction arc between RTSA and normal groups point to the significant change of the anterior deltoid after RTSA. This study primary objective was to assess the differences in muscle moment arms as a function of SHR (Kinematic differences).

Significance: Significant differences found may improve implant design, surgical technique, and rehabilitative strategies for reverse shoulder surgery.

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length, Neck-stem angle, and anteversion angle on the moment-generating capacity of the muscles.