9-2014

A Novel Approach to Estimation of Patient-Specific Muscle Strength

David Walker
University of Florida

Allison Kinney
University of Dayton, akinney2@udayton.edu

Benjamin J. Fregly
University of Florida

Thomas Wright
University of Florida

Scott Banks
University of Florida

Poster: #3323

A Novel Approach to Estimation of Patient-Specific Muscle Strength

*David Walker - University of Florida - Gainesville, USA
Allison Kinney - University of Florida - gainesville, USA
B.J. Fregly
Thomas Wright - UFL - USA
Scott Banks - University of Florida - Gainesville, USA

*Email: drew208@ufl.edu

Current modeling techniques have been used to model the Reverse Total Shoulder Arthroplasty (RTSA) to account for the geometric changes implemented after RTSA. Though these models have provided insight into the effects of geometric changes from RTSA these is still a limitation of understanding muscle function after RTSA on a patient-specific basis. The goal of this study sought to overcome this limitation by developing an approach to calibrate patient-specific muscle strength for an RTSA subject.

The approach was performed for both isometric 0° abduction and dynamic abduction. A 12 degree of freedom (DOF) model developed in our previous work was used in conjunction with our clinical data to create a set of patient-specific data (3 dimensional kinematics, muscle activations, muscle moment arms, joint moments, muscle length, muscle velocity, tendon slack length, optimal fiber length, peak isometric force)) that was used in a novel optimization scheme to estimate muscle parameters that correspond to the patient's muscle strength[4]. The optimization varied to minimize the difference between measured("in vivo") and predicted joint moments and measured ("in vivo") and predicted muscle activations . The predicted joint moments were constructed as a summation of muscle moments. The nested optimization was implemented within matlab (Mathworks). The optimization yields a set of muscle parameters that correspond to the subject's muscle strength. The abduction activity was optimized.

The maximum activation for the muscles within the model ranged between .03-2.4 (Figure 1). The maximum joint moment produced was 11 newton-meters. The joint moments were reproduced to an value of 1. Muscle parameters were calculated for both isometric and dynamic abduction (Figure 2). The muscle parameters produced provided a feasible solution to reproduce the joint moments seen "in vivo" (Figure 3).

Current modeling techniques of the upper extremity focus primarily on geometry. In efforts to create patient-specific models we have developed a framework to predict subject-specific strength characteristics. In order to fully understand muscle function we need muscle parameters that correspond to the subject's strength. This effort in conjunction with patient-specific models that incorporate the patient's joint configurations, kinematics and bone anatomy hopes to provide a framework to gain insight into muscle tensioning effects after RTSA. With this framework improvements can be made to the surgical implementation and design of RTSA to improve surgical outcomes.

Figures

Table 1: Optimized Max Activations from Tracked EMG (phase 1 outer loop result)

Muscle	Initial	Experimental	Optimized
Anterior Deltoid	.03	.73	0.78
Lateral Deltoid	.22	.96	0.89
Posterior Deltoid	.24	.32	0
Upper Trapezius	.18	.82	0.97

Figure 1

Table 2: Muscle Parameters Estimated by Optimization

Muscle	F_O^M(Nm)	L_O^M(m)	L_S^T(m)
Anterior Deltoid	1142.6	0.1398	0.0768
Lateral Deltoid	3427.8	0.1544	0.0726
Posterior Deltoid	779.7	0.2137	0.0274
Teres Major	3427.8	0.0929	0.0529
Teres Minor	1276.2	0.1109	0.0223
Upper Trapezius	3427.8	0.0718	0.0390

Figure 2

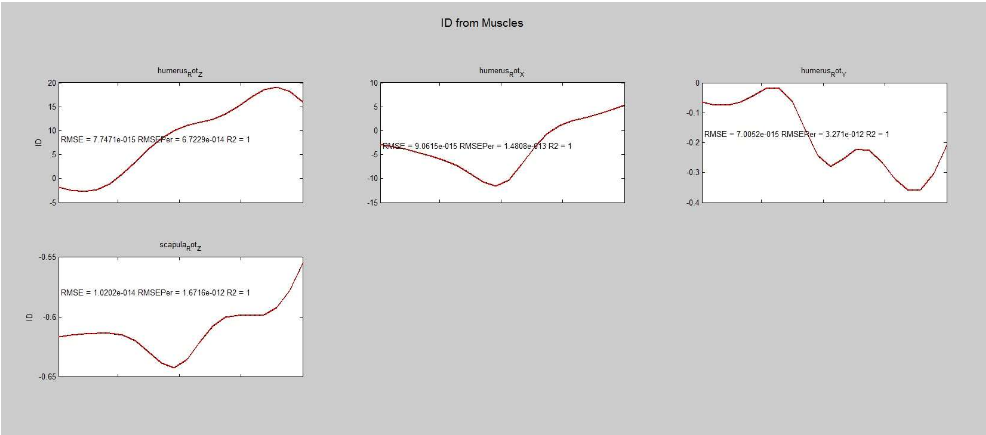

Figure 3