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Paper #100

Relationship between Deltoid and Rotator Cuff Muscles during Dynamic Shoulder Abduction: A Biomechanical Study of Rotator Cuff Tear Progression

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Summary:
Shoulders with rotator cuff tears require considerable compensatory deltoid function to prevent abduction motion loss.

Abstract:

Background

Previous biomechanical studies regarding deltoid function during glenohumeral abduction have primarily utilized static testing protocols. This study investigated the effect of rotator cuff tears on anterior, middle, and posterior deltoid forces during dynamic motion.

Hypothesis

1) Deltoid forces required for scapular plane abduction increase as simulated rotator cuff tears become larger, and 2) maximal abduction reduces despite increased deltoid forces.

Methods

Twelve fresh-frozen cadaveric shoulders with mean age 67 years (range 64-74 years) were utilized. The supraspinatus and anterior, middle, and posterior deltoid tendons were attached to individual shoulder simulator actuators. Deltoid forces and maximum abduction were recorded for the following tear patterns: intact, isolated subscapularis (SSC), isolated supraspinatus (SSP), anterosuperior (SSP + SSC), posterosuperior (Infraspinatus ISP + SSP), and massive (SSC + SSP + ISP). Optical triads tracked 3D motion during dynamic testing. Fluoroscopy and computed tomography were used to measure critical shoulder angle, acromial index, and superior humeral head migration with massive tears. Mean values for maximum glenohumeral abduction and deltoid forces were recorded. Linear mixed effects regression examined change in motion and forces over time. Pearson product-moment correlation coefficients (r) among deltoid forces, critical shoulder angles, and acromial indices were calculated.

Results

Shoulders with an intact cuff required 193.8 N (95% CI 125.5 to 262.1) total deltoid force to achieve 79.8° (95% CI

Paper #100

66.4° to 93.2°) maximum glenohumeral abduction. Compared to native shoulders, abduction decreased following simulated SSP (-27.2%, p=0.04), anterosuperior (-51.5%, p<0.01) and massive (-48.4%, p<0.01) cuff tears. Increased total deltoid forces were required for simulated anterosuperior (+108.1%, p<0.01) and massive (+57.2%, p=0.05) cuff tears. Anterior deltoid forces were significantly greater in anterosuperior (p<0.01) and massive (p=0.03) tears. Middle deltoid forces were greater with posterosuperior tears (p=0.03). Posterior deltoid forces were greater with anterosuperior (p=0.02) and posterosuperior (p=0.04) tears. Anterior deltoid force was negatively correlated (r = -0.89, p = 0.01) with critical shoulder angle. Deltoid forces had no statistical correlation with acromial index. Mean superior migration was 8.3 mm during testing of massive rotator cuff tears.

Conclusions

Shoulders with rotator cuff tears require considerable compensatory deltoid function to prevent abduction motion loss. Anterosuperior tears resulted in the largest motion loss despite the greatest increase in deltoid force.