In-Vivo Glenohumeral Joint Mechanics In Young, Healthy Subjects: Dominant Vs. Non-Dominant Shoulders

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INTRODUCTION:
Rotator cuff tears are a common injury that have a major impact on function, comfort, and medical care costs. Treatment procedures rely implicitly on the belief that restoring normal glenohumeral joint (GHJ) mechanics is necessary to obtain a satisfactory clinical result. Previous research has demonstrated that there are significant differences in in-vivo GHJ contact patterns between the repaired and contralateral shoulders of patients who have undergone rotator cuff repair [1]. However, the extent to which these findings may be influenced by shoulder dominance is unknown. Thus, the objective of this study was to compare in-vivo GHJ contact patterns between the dominant (DOM) and non-dominant (N-DOM) shoulders of asymptomatic subjects with no history of shoulder injury. We hypothesized that there would be no significant effect of shoulder dominance on GHJ contact patterns.

METHODS:
Testing Procedures: Following IRB approval and informed consent, 10 subjects (age: 28.5 ± 5.8) enrolled in this study. All subjects denied any history of prior injury, symptoms, or surgery in both shoulders. Subjects were positioned with their shoulder centered within a biplane x-ray system [2]. Biplane x-ray images were acquired for each shoulder during coronal-plane abduction from full adduction to 120° while holding a 3-pound weight. Three trials were acquired for each subject. Following testing, bilateral CT scans of the humerus and scapula were acquired and reconstructed into subject-specific 3D bone models.

Data Analysis: The 3D positions of the humerus and scapula were tracked from the biplane x-ray images using an accurate (±0.4 mm, ±0.5°) model-based tracking technique [3]. GHJ contact patterns were calculated by combining joint motion measured from the biplane x-ray images with the subject-specific bone models [4]. The GHJ contact center was determined by calculating the centroid of the minimum distance between humerus and glenoid surfaces for each frame of data. The contact center position was calculated over the entire trial and then normalized with respect to anterior/posterior (A/P) and superior-inferior (S/I) glenoid dimensions. To characterize differences between shoulders in the average position of the humerus on the glenoid, we calculated the average contact center position from 15° to 60° of glenohumeral abduction in both the A/P and S/I directions. To assess differences in dynamic GHJ stability between the DOM and N-DOM shoulders, we calculated: 1) the standard deviation of the contact center position in A/P and S/I directions, 2) the A/P and S/I contact center ranges, and 3) the total contact center path length.

Statistical Analysis: The effect of shoulder dominance (dominant vs. non-dominant) on the joint contact outcome measures was assessed with a paired t-test. Significance was set at p<0.05.

RESULTS:
Contrary to our hypothesis, there were significant differences in in-vivo GHJ contact patterns between the DOM and N-DOM shoulders of healthy, asymptomatic subjects. For example, there were significant differences in terms of the average position of the humerus on the glenoid. Specifically, the average contact center of the N-DOM shoulder was significantly more anterior than the DOM shoulder (p=0.03, Fig.1). However, no difference was detected between shoulders in the average S/I contact center (p=0.56, Fig. 1).

There were also statistically significant differences in estimates of dynamic GHJ stability between the DOM and N-DOM shoulders. Specifically, the standard deviation of the contact center position in the S/I direction was significantly greater in the N-DOM shoulder than in the DOM shoulder (p=0.04, Fig. 2). Similarly, the S/I contact center range was also significantly greater in the N-DOM shoulder (9.8±5.4% glenoid height) than the DOM shoulder (3.5±1.8% glenoid height, p=0.04, Fig. 2). However, significant differences between DOM and N-DOM shoulders were not detected for the A/P contact center range (p=0.86, Fig. 2), the A/P standard deviation of contact center (p=0.79, Fig. 2), or the contact center path length (p=0.17, Fig. 2).

DISCUSSION:
The results suggest that there are subtle yet significant differences in GHJ mechanics between the DOM and N-DOM shoulders of young, healthy, asymptomatic subjects. The finding that the humerus in the N-DOM shoulder is positioned more anteriorly on the glenoid than the DOM shoulder was surprising, and may reflect differences between shoulders in rotator cuff strength and/or other neuromuscular factors. The results also suggest that there are differences in dynamic GHJ stability between DOM and N-DOM shoulders. This particular finding may have implications for the development of rotator cuff tears. Specifically, age-related decreases in dynamic glenohumeral joint stability, coupled with overuse, could render the DOM shoulder susceptible to subacromial impingement and the development of a rotator cuff tear. Going forward, evaluation will explore GHJ mechanics in a larger population of normal, healthy subjects.

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REFERENCES: