Dynamic in vivo Glenohumeral Kinematics during Scapular Plane Abduction in Healthy Shoulders
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INTRODUCTION: A variety of factors, including rotator cuff pathology, muscle malfunction and muscle imbalance, can alter glenohumeral kinematics, and this may cause secondary disorders such as impingement syndrome. Although many studies have analyzed glenohumeral kinematics with various methods, there have been a few articles that assessed dynamic in vivo glenohumeral motion. The purpose of this study was to evaluate glenohumeral kinematics during dynamic scapular plane abduction using 3D–2D registration techniques.

METHODS: Twelve healthy males with a mean age of 32 years (range, 27 – 36) were enrolled in this IRB approved study. All subjects were right-handed.

Fluoroscopic images of scapular plane abduction were recorded at 30 Hz for both shoulders in each subject. Bilateral CT scans of the shoulders were acquired, and the 3D models of the humerus and the scapula were created (ITK-snap, Penn Image Computing and Science Laboratory, Philadelphia, PA). Anatomic coordinate systems were embedded in each model according to reported conventions (Geomagic studio, Raindrop Geomagic, Research Triangle Park, NC) (1). In brief, the humeral origin was placed at the centroid of the humeral head. Y axis was parallel to the humeral shaft, and Z axis was defined as a line through interteruncular bony groove from the origin. The scapular origin was defined as the midpoint of the line connecting the most superior and inferior bony edges of the glenoid, and Y and Z axis were pointed superiorly and anteriorly, respectively.

The 3D position and orientation of the humerus and the scapula were determined using model–image registration techniques (Figure 1) (2). The kinematics of the humerus relative to the x-ray coordinate system and to the scapula were decomposed into rotations about each of three axes in a specific order to describe 3D motion, and alteration of the rotation order can affect the rotational values (5).

RESULTS: There were no side-to-side differences in both external/internal rotation and superior/inferior translation (P<0.05) (PASW17.0, SPSS Inc., Chicago, IL).

The humerus was superiorly translated 2.0 mm from the starting position to 90º of the humeral elevation. Then, the humerus was inferiorly translated 0.9 mm by maximum elevation (Figure 3 A). This change was statistically significant (P<0.001). Post-hoc test revealed that there were significant differences between the starting position and all of the other points of elevation (P<0.01 at each point). Maximum elevation had significant differences in the translational values compared with every point between 75º and 120º (P<0.05 at each point).

The humerus was externally rotated approximately 15º from the starting position to 60º of the humeral elevation. Then, the humerus was internally rotated approximately 5º by maximum elevation (Figure 3 B). This change was statistically significant (P<0.001). Post-hoc test revealed that there were significant differences in the rotational value between the starting position and all of the other points of elevation (P<0.001 at each point). Maximum elevation had significant differences compared with 60º, 75º and 90º of elevation (P<0.05 at each point).

DISCUSSION: The results of this study revealed that the humeral head translated superiorly in the early phase of elevation and then translated inferiorly. This movement seems to follow the characteristics of the glenohumeral joint and the principle of joint movement. In the early phase of elevation (the setting phase), stability of the glenohumeral joint would not be achieved, and the humeral head was translated superiorly by the deltoid. After the setting phase, the glenohumeral joint would be stabilized and should act according to the rule of convexity and concavity; i.e. when convex moving surface rotates on concave surface, glide occurs in opposite direction as bone movement. Thus, the humeral head would glide in inferior direction with humeral elevation.

Some authors reported approximately 30º of external rotation during scapular plane abduction through 3D analysis (3, 4). The results of this study revealed that the humerus was rotated 15º externally from the starting position to 60º of humeral elevation. This difference might be because of the differences in measurement method or the activity. We speculate that the calculation process of 3D motion might be also responsible for the difference. Rotational movement of a subject is decomposed into rotations about each of three axes in a specific order to describe 3D motion, and alteration of the rotation order can affect the rotational values (5).

The findings in this study will contribute understanding of normal and pathological glenohumeral kinematics.

REFERENCES: