INTRODUCTION:

Rotator cuff tears are very common, resulting in significant pain, disability, and medical expense. The etiology of rotator cuff tears is not well understood, though certain anatomical factors (e.g., a “hooked” acromion) have been associated with rotator cuff tears. Cadaveric studies have demonstrated that a higher glenoid inclination angle (i.e., a more upwardly tipped glenoid) is associated with rotator cuff tears [1] and that increased glenoid inclination may lead to greater superior translation of the humerus relative to the scapula [2]. This concept is consistent with the idea of superior translation of the humerus leading to subacromial impingement and the development of rotator cuff tears. However, the relationship between glenoid inclination and humeral translation has not been demonstrated under in-vivo conditions. Thus, the purpose of this study was to assess the relationship between glenoid inclination and superior translation of the humerus during shoulder elevation. We hypothesized that there would be a strong correlation between glenoid inclination and superior translation of the humerus during shoulder elevation. In addition, we hypothesized that patients undergoing unilateral rotator cuff repair would have greater glenoid inclination in their repaired shoulder than in their contralateral shoulder.

METHODS:

Following IRB approval and informed consent, 13 subjects (11 male, 2 female; average age: 63.2 ± 10.7) enrolled in this study. Each subject had arthroscopic surgical repair of an isolated supraspinatus tendon tear 3–4 months prior to enrolling in this study. The contralateral shoulder of each subject was asymptomatic.

Testing Setup: Subjects were positioned with their shoulder centered within a biplane x-ray system [3]. The system consists of two 100 kW pulsed x-ray generators (EMD Technologies CPX 3100CV, Quebec) and two 30 cm image intensifiers (Shimadzu AI5765HVP), optically coupled to synchronized high-speed video cameras (Phantom IV, Vision Research, Wayne, NJ). Subjects wore a lead-lined thyroid shield and protective vest during testing to minimize x-ray exposure.

Testing Procedures: Biplane x-ray images were acquired at 60 Hz while subjects elevated their shoulder in the frontal plane from full adduction to approximately 120° of humerothoracic elevation. This motion was performed with each subject holding a 3-pound hand weight, or a weight consistent with their stage of rehabilitation. Three trials were recorded and both shoulders were tested. Following testing, CT scans of the entire humerus and scapula were acquired (GE Lightspeed16, Milwaukee, WI). The humerus and scapula were manually segmented, interpolated, and reconstructed into a three-dimensional (3D) bone model whose resolution was similar to that of the biplane x-ray images. The 3D locations of major anatomical landmarks were identified and used to define standard coordinate system axes [4].

Glenohumeral Joint Motion: For five of the subjects, the 3D positions of the humerus and scapula were measured from the biplane x-ray images using an accurate (±0.4 mm, ±0.5°) model-based tracking technique [5]. Translations and rotations of the humerus were expressed relative to the scapula. These kinematic data were used to calculate the range of superior/inferior (S/I) translation of the humerus for each trial.

Glenoid Inclination: For all 13 subjects enrolled in the study, glenoid inclination was determined from the 3D CT-based bone model by measuring the angle formed between a line connecting the superior and inferior glenoid rims and a line connecting the spinoglenoid notch and intersection of the scapular spine and medial border (1) and a line connecting the spinoglenoid notch and intersection of the scapular spine and medial border (2).

RESULTS:

In the 5 subjects for whom we had measures of in-vivo joint motion, the humerus translated superiorly relative to the glenoid from the adducted position to approximately 20° of elevation, and then translated inferiorly in a consistent manner with increasing elevation angle (Fig. 2). Elevation angle had a significant effect on S/I translation (p<0.01, Fig. 2), but no difference in S/I translation was detected between repaired and contralateral shoulders (p=0.74, Fig. 2). Somewhat surprisingly, glenoid inclination was significantly less in the repaired shoulder (89.4 ± 3.7°) than in the contralateral shoulder (92.2 ± 4.4°, p=0.01). There was a strong correlation between glenoid inclination and S/I translation range for both the repaired (r=0.78) and contralateral (r=0.88) shoulders. However, the correlation direction for the contralateral shoulders – specifically, lower S/I translation range with increasing glenoid inclination angle – was also contrary to our expectations.

DISCUSSION:

Previous research has suggested that glenoid inclination may be associated with rotator cuff tears. In particular, Hughes and colleagues used 2D radiographs to measure glenoid inclination in 8 cadaver specimens with unilateral full-thickness rotator cuff tears. They reported that glenoid inclination was greater in the rotator cuff tear shoulder (98.6°) than in the contralateral shoulder with an intact cuff (91.0°) [1]. Contrary to their findings, the current study indicates that glenoid inclination of the rotator cuff tear shoulder (89.4°) is actually lower than the asymptomatic, contralateral shoulder (92.2°). It is unclear why these results are in such stark contradiction to this previous research, though inherent differences in measurement technique (i.e., 2D radiographs vs. 3D reconstructed CT model) likely contribute to this discrepancy.

REFERENCES:


Fig. 1: Glenoid inclination was measured from the CT-based bone models by calculating the angle formed between a line connecting the superior and inferior glenoid rims and a line connecting the spinoglenoid notch and intersection of the scapular spine and medial border.

Fig. 2: Average (±st dev) superior-inferior translation of the humerus relative to the glenoid during shoulder elevation. No statistically significant difference between shoulders was detected (p=0.74).