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. However, it is unknown if rotator cuff repair restores and maintains normal GHJ mechanics. Furthermore, the extent to which muscle strength (a factor which is believed to be important in maintaining dynamic GHJ stability during functional activities) is related to GHJ mechanics is unknown. Thus, the objective of this study was to compare in vivo GHJ contact patterns between it's repaired and contralateral shoulders of patients who underwent rotator cuff repair. We hypothesized that GHJ contact patterns would be significantly different between repaired and contralateral shoulders. In addition, a secondary objective was to assess the relationship between shoulder strength and measures of GHJ mechanics. We hypothesized that there would be an inverse relationship between shoulder strength and GHJ contact center range.

METHODS:

Subjects: Following IRB approval and informed consent, 15 subjects (age: 63.8±10.8) enrolled in this study. Each subject had arthroscopic surgical repair of an isolated supraspinatus tendon tear prior to testing. Each subject’s contralateral shoulder was asymptomatic.

Testing Procedures: Subjects were positioned with their shoulder centered within a biplane x-ray system [1]. Biplane x-ray images were acquired for each shoulder during coronal-plane abduction from full adduction to 120°. Maximum isometric shoulder strength was measured during coronal-plane abduction (ABD), sagittal-plane elevation (ELEV), external rotation (ER), and internal rotation (IR). Conventional clinical outcomes were determined using the Western Ontario Rotator Cuff (WORC) Index. All data were collected at 3 months and 12 months post-surgery. Following testing, 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 [2]. GHJ contact patterns were calculated by combining joint motion measured from the biplane x-ray images with the subject-specific bone models [3]. 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, averaged to determine an average contact center position, and then normalized with respect to anterior/posterior (A/P) and superior/inferior (S/I) glenoid dimensions. From these data we calculated four outcome measures: A/P contact center position, S/I contact center position, A/P contact center range, and S/I contact center range.

Statistical Analysis: The effects of shoulder condition (repaired, contralateral) and time post-surgery (3 months, 12 months) on the four joint contact outcome measures were assessed with a 2-way ANOVA. The effect of time post-surgery on normalized shoulder strength and composite WORC score was assessed with a 1-way ANOVA. For both shoulders, we assessed the relationship between joint motion and shoulder strength with linear regression. Significance was set at p<0.05.

RESULTS:

Changes Over Time: From 3 to 12 months post-surgery, subjects reported a significantly higher quality of life (i.e., lower composite WORC Index, p=0.001). Repaired shoulder strength as a percentage of contralateral shoulder strength also increased from 3 to 12 months post-surgery during ABD (60.8 ± 35.8% to 82.0 ± 45.5%, p=0.07), ELEV (67.7 ± 35.7% to 88.9 ± 42.6%, p=0.04), ER (57.4 ± 33.0% to 85.5 ± 45.9%, p=0.03), and IR (79.4 ± 37.9% to 105.9 ± 17.5%, p=0.01). For both the repaired and contralateral shoulders, no significant difference in joint contact patterns was detected in terms of A/P position, S/I position, A/P range, or S/I range (p>0.31, Fig. 1).

Differences Between Shoulders: At 3 months post-surgery, the average S/I contact center position of the repaired shoulder was significantly higher on the glenoid than the contralateral shoulder (p=0.002, Fig. 1). This finding was also true at 12 months post-surgery, with the repaired shoulder still positioned higher on the glenoid than the contralateral (p=0.003, Fig. 1). At 3 months and 12 months post-surgery, no significant differences were detected between the repaired and contralateral shoulders in terms of A/P position (p=0.34, Fig. 1), A/P range (p=0.40, Fig. 1), or S/I range (p=0.16, Fig. 1).

Strength Vs. Shoulder Motion: There were only modest associations between shoulder strength and motion or position of the glenohumeral joint contact center. There was significant positive association between ER strength and the S/I joint contact center range in the repaired shoulder at 12 months post-surgery (r=0.56, p=0.04, Fig. 2), whereas a negative association existed between these two variables in the contralateral shoulder (r=−0.48, p=0.08, Fig. 2).

DISCUSSION:

The data indicate significant improvements over time in clinical outcomes (WORC index, shoulder strength), but no change in GHJ motion. However, the strength data and GHJ contact patterns both demonstrate considerable variability, which is consistent with the clinical observations of patients having a highly varied response to rotator cuff repair. Appreciable differences in the relationship between shoulder strength and GHJ contact patterns (e.g., Fig. 2) are beginning to lend additional insight into functional discrepancies between the repaired and contralateral shoulders after rotator cuff repair. Future efforts will include testing patients out to 24 months post-surgery and testing normal volunteers with no history of shoulder pathology.

REFERENCES: