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 the 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:

Testing Procedures: Following IRB approval and informed consent, 14 patients (age: 63.8±10.8) enrolled in this study. Each patient had arthroscopic surgical repair of an isolated supraspinatus tendon tear prior to surgery. Each patient’s contralateral shoulder was asymptomatic. 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°. Isometric shoulder strength was measured during coronal-plane abduction (ABD), sagittal-plane elevation (ELEV), external rotation (ER), and internal rotation (IR). All data were collected at 3, 12, and 24 months post-surgery. Bilateral CT scans of the humerus and scapula were acquired for each patient at 3 months post-surgery, and rotator cuff integrity was assessed with ultrasound imaging at 24 months post-surgery.

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°) CT model-based tracking technique [2]. GHJ contact patterns were calculated by combining joint motion measured from the biplane x-ray images with the patient-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 and then normalized with respect to anterior/posterior (A/P) and superior/inferior (S/I) glenoid dimensions. To characterize differences in the baseline position of the humerus relative to the glenoid, we calculate the average A/P and S/I contact center position. To characterize difference in the contact center path, we calculated the A/P and S/I contact center range, and the A/P and S/I contact center standard deviation. The shoulder strength data were used to calculate normalized shoulder strength (i.e., repaired shoulder strength as a percentage of the contralateral shoulder strength) and a shoulder strength ratio, defined as (ER+IR)/ABD.

Statistical Analysis: The effects of shoulder condition and time post-surgery on the joint contact outcomes were assessed with a repeated measures 2-way ANOVA. The effect of time post-surgery on normalized shoulder strength was assessed with a 1-way ANOVA. We assessed the relationship between joint motion and the shoulder strength ratio with linear regression. Significance was set at p<0.05.

RESULTS: Changes Over Time: Ultrasound imaging indicated that all rotator cuff repairs were intact at 24 months post-surgery. Normalized shoulder strength increased over time for ABD (p=0.03) and ER (p=0.01), with a trend toward increased over time for ELEV (p=0.08) and IR (p=0.09). For both repaired and contralateral shoulders, no significant differences in joint contact patterns were detected over time in terms of A/P position, S/I position, A/P range, S/I range, A/P contact center standard deviation, or S/I contact center standard deviation (p>0.42, Fig. 1).

DISCUSSION:
The data indicated that the humerus in the repaired shoulder was positioned more superiorly on the glenoid than the contralateral shoulder. Although it remains unclear if this represents an etiologic factor contributing to the development of the pathology or a result of the surgical repair, this finding suggests that restoring normal GHJ mechanics may not be necessary to achieve a satisfactory clinical outcome. The data failed to demonstrate significant differences over time in the joint contact patterns (Fig. 1), but the variability in these data between patients was high. This high variability supports the use of an alternative approach to looking at functional relationships between shoulder strength and GHJ motion patterns (e.g., Fig. 2). Using this approach it is interesting to observe that the strength ratio was significantly associated with joint contact outcome measures in the A/P direction (Fig. 2), but not the S/I direction. This result suggests that the relationship between shoulder strength and GHJ stability under in-vivo conditions may be more complex than has been previously reported. Future efforts will include testing additional rotator cuff repair patients and testing control subjects with no history of shoulder pathology.

ACKNOWLEDGEMENTS:
This project was supported by grant AR051912 from NIH/NIAMS.

REFERENCES: