GLENOHUMERAL CONTACT PRESSURES AND STABILITY FOLLOWING LABRAL AND OSSEOUS INJURY TO THE ANTERIOR-INFERIOR QUADRANT OF THE GLENOID

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Introduction: Due to the unique geometry of the glenohumeral joint, many fractures involving this joint are associated with anterior dislocation. These injuries may result in a variable amount of bone loss from the anterior-inferior aspect of the glenoid rim. No information is available as to how bone loss in this anterior-inferior region alters glenohumeral joint contact forces. Injury in this region may result in rim loading of the anterior glenoid and the potential for recurrent instability of the glenohumeral joint or asymmetric wear of the joint surface. Late arthritis from instability is not an infrequent problem and is likely due to abnormal joint loading.

It was the purpose of this study to determine if there is a critical amount of bony injury to the anterior-inferior glenoid rim, which results in significant changes in glenohumeral articular contact pressures seen during compressive loading of the joint. The hypothesis of this study was that injury to both the labral and bony portions of the anterior-inferior glenoid would result in increased articular cartilage contact pressures in the anterior-inferior quadrant of the glenoid, and that large bone defects would cause intrinsic joint instability.

MATERIALS AND METHODS: Specimen preparation: Eight fresh-frozen adult cadaver shoulders without evidence of arthritis or other pathology were used in this study. Specimens were kept moist with 0.9 normal saline throughout testing. The intact labrum was left in situ and the remaining peri-articular soft tissues were removed. The glenoid along with a portion of the scapular body were potted horizontally within a steel cylinder a low-melting metal alloy. The humerus was similarly. Biomechanical testing: The humerus was mounted on a multi-positional cannon mount permitting positions of 30°, 60° and 90° of abduction in a position of neutral rotation. The cannon mount was attached to an Instron 8500 materials testing machinery (Instron, Canton, MA). The potted glenoid was attached to a two degree of freedom table that allowed for both anterior-posterior and medial-lateral translation. This allowed the glenohumeral joint to center within the glenoid during testing. A Tekscan digitized pressure sensor (#5051 - Tekscan, Inc., South Boston, MA) was placed between the humerus and the glenoid. This device measured contact areas and pressures across the glenohumeral joint. I-Scan software (Tekscan, Inc., South Boston, MA) was used to analyze the data. The Instron machine produced compressive loads of 220 N and 440 N across the joint. Contact areas and pressures over the entire surface of the glenoid, as well as in four predetermined glenoid quadrants. The quadrants were established by the intersection of the superior-inferior and anterior-posterior glenoid diameters. These diameters were used calculate the total glenoid surface area of each intact specimem for comparison to the contact area measured during glenohumeral loading. The testing sequences included:

1. Intact specimen with normal labrum and no bony abnormalities.
2. Removal of the anterior-inferior labrum (i.e., simulated Bankart lesion).
3. Loss of 10% of anterior-inferior bone from the anterior-inferior quadrant of the glenoid.
4. Loss of 20% of bone from the anterior-inferior quadrant.
5. Loss of 30% of bone from the anterior-inferior quadrant.

Digitized images and data were saved for each of the testing condition.

Data Analysis: Four glenoid quadrants (anterior-superior, anterior-inferior, posterior-superior and posterior-inferior) were used to determine the affect of progressive soft tissue and bone loss on articular contact pressures, with particular focus on the anterior-inferior quadrant. Using I-Scan software, the contact area, average contact pressure, and peak contact pressure for each quadrant was determined.

Statistical Analysis: A repeated measures analysis of variance and pair T-tests were used to evaluate the data to for significant changes in contact pressures occurring with progressive anterior-inferior tissue loss. P was set at 0.05 with a power of 0.8.

Results: There was a trend towards unloading of the superior quadrants with progressive bone loss, and small increases in both peak and average contact pressures in the posterior-inferior quadrant. The average contact pressures, and the peak pressures in the anterior-inferior quadrant were most affected by labral and bone loss. An in depth evaluation of joint contact pressures in the anterior inferior quadrant demonstrated the following:

1. Contact area of the glenolabral complex was between 51.3% and 64.5% of the measure area for the intact specimens.
2. Loss of the anterior-inferior labrum decreased the contact area by 4-14%. Ten percent, 20%, and 30% bone loss from the anterior-inferior quadrant decreased the contact area by 11-21%, 33-40%, and 54-71%, respectively.
3. At both 220 N and 440 N of load the average contact pressure over the surface of anterior-inferior quadrant increased with progressive loss of the labrum and bone.
4. Contact pressures increased by 39-87% with loss of the anterior-inferior labrum. Ten percent, 20%, and 30% bone loss from the anterior-inferior quadrant increased the contact pressure by 59-113%, 88-168%, and 224-367%, respectively (p<0.01 for 6 of 6 test conditions). Peak pressures followed similar trends. [(Figure 1a,1b).

Figure 1a,1b- Trial specimen with intact glenoid contact pressure map on the left(a), and with 20 % of the anterior-inferior glenoid removed (1b) red indicates higher pressure readings.

5. At 40% bone loss, all specimens were grossly unstable and could not be loaded. Gross glenohumeral instability prevented loading of 2 specimens at the 30% defect condition.

Conclusions: Loss of the labrum in the anterior-inferior quadrant increases the average contact pressure in this quadrant approximately 50% during compressive loads of 220 N and 440 N. Bone loss of 10% and 20% results in additional increases of 17% and 44% respectively. Bone loss of 30% results in markedly higher anterior-inferior contact pressures, 280% greater than the intact specimen, and gross instability of the joint may occur with 30% and 40% defects. Peak pressures in the anterior-inferior quadrant follow similar patterns.

Poster Session - Shoulder and Elbow - Hall E