INTRODUCTION:

The stability of the glenohumeral joint (GHJ) is dependent upon passive stabilizing mechanisms such as the glenoid labrum and long head of the biceps (LHB) tendon. The labrum improves GHJ stability by increasing the glenoid concavity, and the contiguous structure of the labrum and LHB tendon may increase tension on the labrum during superior humeral translations which may contribute to superior labral lesions. The purpose of this study was to determine the effect of superior humeral head translation, with and without loading of the LHB, on the displacement of the superior glenoid labrum.

MATERIALS AND METHODS:

Six shoulder specimens (age range: 47-55 yrs) were harvested and soft tissues (except for the LHB tendon, transverse humeral ligament, glenoid labrum, and articular cartilage) as well as the coracoid and acromion processes were removed. The scapula was sectioned 6 cm medial to the face of the glenoid and was potted in polymethylmethacrylate (PMMA). The humerus was sectioned at mid-shaft, and a bolt was secured in the intramedullary canal.

The long axis of the glenoid was defined as the greatest distance between the superior and inferior borders of the glenoid fossa. The anatomical zero axis was defined as the axis which was 20° posterior to the long axis of the glenoid. One millimeter alloy steel beads were affixed to each specimen on the superior labrum and in the glenoid bone at locations as shown in Figure 1. These beads were used to measure labrum displacement. The LHB tendon was sutured to solid-braided nylon rope to allow for loading of the LHB.

Figure 1: Bead placement on the glenoid and labrum and the anatomical zero axis (AZA), the long-axis (LA), and LHB

Testing was conducted on a custom fixture which permitted movement of the glenoid (relative to the fixed humerus) in the anterior-posterior (AP), medial-lateral (ML), and superior-inferior (SI) directions (directionality with respect to the glenoid being normally anatomically aligned). AP positioning of the glenoid was fixed at the start of testing, and movement of the humerus in the ML direction was recorded using a 25 mm-calibrated linear variable displacement transducer (LVDT). An electric stepper motor and 50 mm-calibrated LVDT controlled displacement of the glenoid in the SI direction in a displacement-controlled paradigm at 1 mm/sec.

The potted specimen was placed into the testing fixture, and the abduction angle of the humerus was fixed at 30° relative to the glenoid. A constant compressive load of 50 N was applied to the humerus in the ML direction and was used for all trials. The zero position of the humeral head in the SI direction was defined as the position at which there was no SI reaction force on the glenoid. This position was the reference position for each humeral translation trial.

The displacement of the labrum was examined over a range of humeral translations from 0 mm to 6 mm both with and without LHB loading. Humeral translations were directed superiorly along the AZA. At each increment of translation (including 0 mm, which served as a reference), glenoid-plane radiographs were obtained. For tests with LHB loading, a 22 N load was applied to the nylon rope of the LHB tendon.

Radiographs were scanned at 1200 dpi in 16-bit grayscale and ImageJ was used to segment beads from the image. The inter-user reliability of bead segmentation was found to be robust (ICC>0.99). Beads in the glenoid bone remained fixed and were used as reference positions between radiographs. Each radiograph was compared to the reference radiograph. Lead pair displacements were calculated for the labrum-glenoid bead pairs (PB and AB beads were paired with 0° glenoid bead). All measurements were scaled by a factor of 24.227 mm/inch (based on a prior calibration experiment) to obtain real bead displacements.

A three-way repeated measures ANOVA model was used to test for main effects and interactions. Main effects were humeral translation, bead position, and biceps loading. All statistical calculations were performed in STATA with the significance set at the 0.05 level.

RESULTS:

Displacement of the labrum was significantly affected by superior translation of the humeral head (p<0.0001), position along the labrum (p<0.0001), and biceps loading (p=0.0002). Peak mean labral displacement (1.88 mm) in the absence of a biceps loading occurred anterior to the biceps attachment. However, peak mean labral displacement shifted to the posterior biceps attachment with an applied biceps loading (3.23 mm). Additionally, there was a position-by-biceps loading interaction (p=0.0012).

DISCUSSION:

This study characterizes labral displacement due to superior humeral migration in conjunction with long head of biceps loading. It demonstrates significant independent relationships between the labral displacement and both biceps loading and superior humeral head translation. Furthermore, the posterior labrum was found to be more mobile than the anterior labrum when the biceps was loaded, which may provide further insight on the mechanism of injury in certain patterns of superior labral lesions. Patients with severe rotator cuff tears have been shown to exhibit increased humeral head translation [1,2], and less severe rotator cuff injuries may, therefore, exhibit respective increases in humeral head translations. Similarly, the incidence of labral tears in patients with rotator cuff pathology is well documented [3], and such translations may be instrumental in the relationship between rotator cuff and labral pathologies.

REFERENCES: