BIOMECHANICAL EVALUATION OF MULTIDIRECTIONAL GLENOHUMERAL INSTABILITY AND REPAIR

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INTRODUCTION: Multidirectional shoulder instability is generally atraumatic and is often accompanied by laxity in all three directions: anterior, posterior, and inferior. Unlike unidirectional instability, if a surgical intervention is required, the repair must focus on reducing the capsular redundancy, globally tightening the capsule, and reattaching the avulsed labrum when required. However, the effectiveness of surgical procedures to treat multidirectional instability is yet to be quantified, due to lack of an accurate cadaveric model. Therefore, the objective of this study was to use a novel cadaveric model for multidirectional instability and compare the Anterior Capsulolabral Reconstruction to the Inferior Capsular Shift with respect to their effects on glenohumeral translation and rotational range of motion.

METHODS: Ten fresh frozen glenohumeral joints (30-50 years), free from pathology, were dissected down to the capsule. Both the humerus and scapula were potted with plaster of paris and fixed into a custom testing shoulder jig. This jig has six degree-of-freedom for glenohumeral joint positioning while allowing application of glenohumeral joint compressive loads and measurement of anterior (A), posterior (P), superior (S), and inferior (I) humeral translations (Figure 1). This jig also permits predefined stretching of the glenohumeral ligaments via humeral rotation at any given shoulder position. The glenohumeral joints were tested in two positions: 0 degrees abduction at neutral rotation (Neutral) and 90 degrees abduction at 90 degrees of external rotation (Apprehension). The glenohumeral joint was vented and then preconditioned ten cycles in both internal and external rotation. The rotational range of motion was then measured using a goniometer (±0.5 degrees). For glenohumeral translation measurements, a joint compressive force of 22N was applied to center the humeral head in the glenoid. The translations in all four directions were then measured after application of 15N and 20N of anterior, posterior, superior, and inferiorly directed loads. A Microscribe 3DLX (Immersion Corp., San Jose, CA) was used for the measurement of glenohumeral translations in all four directions. In each position, the specimens were stretched equally in both internal and external rotation for 30 minutes, increasing the total rotational range of motion by 20%. This resulted in approximately a 10% increase in linear strain to the capsular ligaments in each respective position. Total rotational range of motion and glenohumeral joint translations in all four directions were again measured using the methods described above. Shoulders were then repaired using Anterior Capsulolabral Reconstruction (n = 5) or an Inferior Capsular Shift (n = 5). Anterior, posterior, inferior, and superior translations were measured along with the rotational range of motion for intact, stretched, and repaired conditions. The specimens were kept moist throughout testing with 0.9% saline. Comparisons were made using paired t-tests with a significance level of 0.05.

RESULTS: This new novel model for creating multidirectional instability demonstrated significant increases both in translation (Figure 2) and rotation, seen in both neutral and apprehension positions after stretching. All specimens showed increased translations and rotations after stretching. Both repair techniques significantly reduced anterior, posterior, and inferior translation. The Inferior Capsular Shift was more effective in reducing inferior translation in the apprehension position (Figure 3), however postoperative rotational range of motion was significantly restricted when compared with Anterior Capsulolabral Reconstruction and posterior subluxation was noted in all specimens.

DISCUSSION: The current study created a reproducible multidirectional instability cadaveric model. The Anterior Capsulolabral Reconstruction did not alter the total rotational range of motion. The Inferior Capsular Shift resulted in a significant decrease in total rotational range of motion compared with the Anterior Capsulolabral Reconstruction. Despite this, both repair techniques significantly limited anterior, posterior, and inferior translation. These results indicate that either surgical procedure may be useful in restoring glenohumeral stability. However, excessive tightening of the joint capsule in an attempt to eliminate capsular patholaxity may lead to significant loss of shoulder motion or posterior glenohumeral subluxation. The new novel model presented in this study successfully creates multidirectional glenohumeral instability in normal cadaveric shoulders. This model creates instability by stretching the capsular ligaments in rotation, producing glenohumeral joints with significant increases in both translation and rotational range of motion. Different positional stretching is required to stretch specific glenohumeral ligaments. In this study, the inferior glenohumeral ligament was stretched in the apprehension position and anterior and posterior capsular ligaments by stretching in the neutral position. Future studies will include creating specific instability models and evaluating surgical repair.

RESULTS:

**Figure 1: Photograph of the shoulder testing jig**

**Figure 2: Histograms of translational increase after stretching the glenohumeral capsule in the apprehension position for the Inferior Capsular Shift and Anterior Capsulolabral Reconstruction groups (n=10).**

**Figure 3: Histograms showing the decrease in translation after repair for the Inferior Capsular Shift (ICS) and Anterior Capsulolabral Reconstruction (ACLR) repairs.**

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