INTRODUCTION: Posterior shoulder instability is a significant clinical problem whose etiology is not well understood. Although posterior instability is assumed to be due to the thin and weak nature of the posterior capsule, the mechanical integrity of this tissue has not been reported. Thus, the purpose of this study was to quantify regional variations in posterior capsule material properties, and to compare these data to the more substantial anterior region of the inferior glenohumeral ligament (AB-IGHL). Based on its thin nature and poorly organized fiber structure [1], we hypothesized that the material properties of the posterior capsule would be significantly inferior to those of the AB-IGHL.

METHODS: Seven healthy human cadaver shoulders (avg. age 82, range 69-100) were dissected, with all soft tissue removed except the capsuloligamentous complex. The AB-IGHL was sharply incised along its palpable borders to isolate it from the entire inferior glenohumeral ligament. The posterior capsule was isolated at its superior and inferior borders, and then divided equally into superior (SUP-PC), middle (MID-PC), and inferior (INF-PC) bone-ligament-bone (BLB) specimens. The glenoid was bisected into anterior and posterior halves and cut in line with the capsular incisions. The humeral insertions were left intact. The thickness and width of each BLB specimen were measured at four points using a light force micrometer (Mitutoyo ID-C1012CE) and micro-caliper (Manostat, resolution: 0.1 mm). Cross-sectional area of each BLB specimen was determined as the product of the average tissue thickness and average tissue width measurements at each location.

Specimens were mounted in custom mechanical grips in a physiologic PBS bath at 37°C. The BLB specimen’s long axis was aligned with the materials testing system actuator (Instron 8501). Specimens were preconditioned with a 1.5 N constant load for five minutes [2], and then tested to failure at a strain rate of 10% of the specimen’s initial length per second. Force and displacement data were normalized by initial thickness and width of each BLB specimen were measured at four points along its palpable borders to isolate it from the entire inferior glenohumeral ligament. The posterior capsule was isolated at its superior and inferior borders, and then divided equally into superior (SUP-PC), middle (MID-PC), and inferior (INF-PC) bone-ligament-bone (BLB) specimens. The glenoid was bisected into anterior and posterior halves and cut in line with the capsular incisions. The humeral insertions were left intact. The thickness and width of each BLB specimen were measured at four points using a light force micrometer (Mitutoyo ID-C1012CE) and micro-caliper (Manostat, resolution: 0.1 mm). Cross-sectional area of each BLB specimen was determined as the product of the average tissue thickness and average tissue width measurements at each location.

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RESULTS: Significant differences in tissue thickness were found among the three regions of the posterior capsule and the AB-IGHL (Fig. 1). The AB-IGHL was thicker than the MID-PC (p=0.03) and INF-PC (p=0.01), and the SUP-PC was thicker than the INF-PC (p=0.02). Except for significant differences in failure strains (Fig. 2), material properties were not significantly different among the four tissue regions. Specifically, there were no significant differences between the tissue bands in modulus (p=0.2, Fig. 3), maximum stress (p=0.46) or strain energy density (p=0.62). Specimens failed primarily near the glenoid insertion (75%), with four specimens failing at the humeral insertion and two others failing in the tissue’s midsubstance.

DISCUSSION: Our hypothesis that material properties of the posterior capsule would be significantly inferior to those of the AB-IGHL was not supported. Although the AB-IGHL is believed to have a higher degree of orientation than the posterior capsule [1], differences in fiber orientation were not manifested by significant differences in modulus, suggesting that tissue orientation alone may not be an adequate predictor of modulus. It was also surprising to find no statistically significant differences in thickness between the AB-IGHL and the SUP-PC (p=0.53), suggesting that the SUP-PC may play a more important role in joint stability than previously believed. Perhaps the most striking finding from this study was that the failure strain of the AB-IGHL greatly exceeded failure strains of all three posterior capsule bands. The AB-IGHL is an important restraint for external rotation [3] and anterior translation [4] with the arm in an abducted position. The ability for this particular region of the capsule to undergo large deformation prior to failure suggests that the anterior capsule is well designed to resist these particular loading regimes. This is the first study whose primary focus was to characterize the structure and material properties of the posterior capsule. Future research efforts will focus on determining structure-function relationships for the entire capsule and developing an approach to characterize the function of the entire capsuloligamentous complex as an intact structure.

REFERENCES:

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