METHODS
Six fresh frozen shoulders sectioned at the mid humerus were utilized for this study. The shoulders were dissected free of musculature and tendons, preserving the glenohumeral joint capsule. A capsulotomy was made in the rotator interval. The humerus and scapula were potted in plaster of Paris and mounted on a custom shoulder testing system which allowed six-degrees of freedom for glenohumeral positioning. The shoulder was fixed at 60 degrees of glenohumeral abduction and the humerus was positioned in both the scapular plane and coronal plane for testing. A 60 N joint compressive force was applied throughout the testing process.

Specimens were tested intact, after capsular stretching (instability model) and after anterior plication. To create the anterior instability model, the anterior-inferior capsule was stretched by increasing external rotation 20% beyond the external rotation measured in the intact capsule. Arthroscopic plication was performed through the rotator interval with two 3mm glenoid anchors placed between the 3 and 6 o’clock positions, plicating one centimeter of joint capsule. Capsulorraphy was performed in an inferior to superior direction in line with the fibers of the anterior band of the IGHL.

Rotational range of motion of the shoulders was measured, with a 1.7 N-m torque determining the endpoint of internal and external rotation. The relative positions of the glenoid and humerus through the range of motion, at thirty degree increments, were measured using the Microscribe 3DLX positional sensor. At the conclusion of the testing process the shoulders were disarticulated and the articular surfaces were mapped with the positional sensor. The humeral head apex could then be calculated and tracked through range of motion. Translations of the gleno-humeral joint with 20 and 25 Newton forces directed in the anterior and posterior directions were also determined with the Microscribe 3DLX digitizing system. Glenohumeral contact pressures were recorded using the Tekscan pressure mapping system by placing the transducer through the rotator interval without disrupting the joint capsule. Repeated measures ANOVA with a p value of 0.05 was used for statistical analyses.

RESULTS
Range of Motion
In the scapular plane, external rotation significantly increased after capsular stretching from 139.8 ± 7.4 degrees to 148.0 ± 8.3 degrees (p < 0.05) and significantly decreased to 140.3 ± 7.5 (p < 0.05) degrees after plication. In the coronal plane, external rotation of the intact shoulders also increased significantly from 128.3 ± 10.6 degrees to 140.5 ± 10.5 degrees (p < 0.05) after stretching and significantly decreased to 129 ± 9.8 degrees after plication (p < 0.05).

Translation
Anterior translations of the humeral head on the glenoid increased after capsular stretching and decreased after plication with both twenty and twenty-five Newtons of anterior force. Significant differences in translational data were found between the stretched (4.1 ± 1.5 mm) and plicated (2.2±0.8 mm) conditions with 20 Newtons of anterior force in the coronal plane p < 0.05. In the scapular plane significant differences were between the stretched (10.6± 1.8mm) and plicated (6.0 ± 1.8mm) conditions with an anterior force of 25 Newtons p < 0.05.

Path of Motion
Humeral head apex position varied significantly in maximum external rotation in the coronal plane. In the stretched condition the position of the humeral apex with maximal external rotation was 2.2 ± 0.3mm more superior than the intact shoulders (p < 0.05). Plication resulted in depression of the humeral head apex 2.0 ± 0.4mm compared to the stretched condition (p < 0.05). In the scapular plane with maximal external rotation, the position of the humeral head apex increased 1.8 ± 0.6mm superiorly after stretching (p< 0.05). There were also significant changes in humeral apex position at 30° in the coronal plane and at 60° and 90° in the scapular plane, however the magnitude of these positional changes were less than 1mm. (Figure 1)

No significant increases in contact pressures were found between the intact, stretched and plicated conditions in either the scapular or coronal plane (Figure 2). However, the contact areas appear to decrease with stretching and also with subsequent arthroscopic plication in both the scapular and coronal plane.

DISCUSSION
The instability model created for this study stretched the anterior capsule in external rotation simulating anterior instability. Arthroscopic plication in the superior-inferior direction restored the increased external rotation achieved in the instability model without excessively restricting range of motion. The increase in anterior translation in the instability model was also reduced with plication. Humeral head apex positional changes were significantly different at maximal external rotation as this was the position in which external rotation increased in the instability model. Glenohumeral position was not largely affected by capsular stretching or plication throughout the mid range of motion, as it is mainly dependent on glenohumeral congruency. When differences in humeral apex position were significant in the mid range of motion, these differences were small, less than one millimeter. Arthroscopic capsulorraphy was able to reliably restore excessive external rotation and translation without large alterations in glenohumeral position or increasing contact pressure.

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