LIGAMENTOUS RESTRAINTS TO ANTERIOR AND POSTERIOR TRANSLATION OF THE STERNOCLAVICULAR JOINT

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Introduction: Instability of the sternoclavicular joint ranges from atraumatic subluxation in patients with generalized laxity to traumatic anterior or posterior dislocations, which may be associated with life-threatening complications. A number of reconstructive techniques to treat instability of the sternoclavicular joint have been described in the literature, however, there are no biomechanical studies investigating the anterior and posterior restraints for translation of the clavicle at the sternoclavicular joint. The purpose of this investigation was to determine the primary soft tissue restraints to anterior and posterior translation of the sternoclavicular joint using a reproducible biomechanical cadaver model. This information should be helpful in developing and validating reconstructive procedures for the treatment of sternoclavicular joint instability.

Materials and Methods:
Specimen Preparation: The sternum, both clavicles, and the first three ribs of twenty-four fresh human cadaver specimens (72.7 ± 8.7 years, 11 male, 13 female) were obtained from our institution’s Anatomical Donations Program. Specimens were dissected to retain the sternoclavicular joints, capsular ligaments and costoclavicular and interclavicular ligaments. The first ribs were augmented with 3/16 inch Steinman pins just below the insertion of the costoclavicular ligaments. The bottom of the first rib, second and third ribs, and the lower sternum were potted in rectangular aluminum pots using polymethylmethacrylate. The lateral portion of each clavicle was then potted with polymethylmethacrylate in a 3.8 cm polyvinylchloride cylinder to the level of the origin of the costoclavicular ligament.

A custom-testing fixture was constructed. This fixture included sliding ball-bearing plates that allowed for slight translations in the plane of the sternum, which are likely to occur during testing due to the saddle shape of the articular surfaces of the sternoclavicular joint. The potted sternum was secured to the fixture in a supine orientation on an 810 Materials Testing System (MTS Systems Corp., Eden Prairie, MN). The fixture for the potted clavicle allowed for changes in orientation so that the clavicle could be positioned anatomically and secured. The clavicle component of the fixture was secured to the actuator of the servohydraulic materials testing machine in series with a 222 N load cell (Sensotec Inc, Columbus, OH).

Pilot Data: Three specimens were loaded to failure to establish an appropriate load for testing which would not damage the specimens. Failure occurred at the clavicle-polymethylmethacrylate interface near the metaphyseal/diaphyseal junction. The average load to failure was 341 N ± 187 N. The 95% confidence intervals for the failure load were calculated (129 N, 552 N) and our load for testing (134 N) was chosen to be near the lower boundary to prevent damage to the specimens during testing.

Testing Protocol: The specimens were then randomized with regard to right and left side, initial displacement direction, and specific ligament tested. A neutral point was determined for each specimen with zero-load, which represented the anatomical resting position for each specimen. The testing sequence included preconditioning each specimen with ten cycles of anterior and posterior translation with an 18 N load. Specimens were then loaded from the neutral point in either the anterior direction or posterior direction to 134 N at a rate of 18 N/second, followed by loading in the opposite direction. Each direction was tested twice to assure reproducibility in testing. A single randomly chosen ligament (anterior capsule (AC), posterior capsule (PC), costoclavicular ligament (CC), and interclavicular ligament (IC)) was transected, and preconditioning and testing were repeated from the original neutral point. Displacement and load data was recorded using LabView software (National Instruments Corporation, Austin, TX) on a Macintosh computer.

Statistical Analysis: Anterior and posterior translation data were statistically analyzed to determine the effect of ligament sectioning on translation. A one-way ANOVA model was used to test for a significant main effect in each direction, and a least significant difference post-hoc test was used to identify pair-wise differences between ligaments while accounting for multiple comparisons.

Results: Anterior displacement was significantly affected by ligament sectioning (Figure 1). A statistically significant main effect was found (p<0.001). Post-hoc tests indicated that sectioning the posterior capsule produced a greater increase in anterior translation than sectioning any of the other three structures (p<0.05). The increase in translation produced by sectioning the anterior capsule was less than that produced by cutting the posterior capsule, but it was greater than that produced by sectioning the interclavicular and costoclavicular ligaments (p<0.001). We were unable to detect a difference in the change in translation between the interclavicular and costoclavicular ligaments (p=0.67).

Posterior displacement (Figure 2) was also significantly affected by ligament sectioning (p<0.001). The increase in posterior translation was greatest after sectioning the posterior capsule (p<0.001). No statistically significant differences in posterior translation change were found between the other three ligaments (p=0.97).

Discussion: The posterior capsule was the most important restraint for anterior and posterior translation of the sternoclavicular joint. The anterior capsule was another important restraint for anterior translation. The costoclavicular and interclavicular ligaments had little effect on anterior and posterior translation of the sternoclavicular joint. Consideration should be made toward reconstructing the posterior capsule in all patients who require surgical intervention for sternoclavicular joint instability. The anterior capsule should also be reconstructed in patients who require surgery for anterior sternoclavicular joint instability.