Tensile Characteristics of Isolated Ligaments of the Acromioclavicular Joint

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INTRODUCTION:

Two distinct bundles of the acromioclavicular (AC) joint have been identified that contribute to the joint's stability. A detailed biomechanical characterization of the different bundles of the AC ligaments is important to surgically address the needs of the AC joint. While the AC joint is involved in 40% of injuries to the shoulder, there is a lack of a gold standard treatment. The purpose of this study was to compare the ligament insertion areas and tensile strength of the superior-posterior (SP), anterior-inferior (AI), and isolated anterior (A) and posterior (P) AC joint bundles. Our hypothesis was that the SP bundle and isolated P bundle would demonstrate a greater load to failure and other tensile characteristics than the less stabilizing AI bundle and A bundle, respectively.

METHODS:

20 matched pairs, 40 shoulders total, with an average age of 69.8 ± 10.9 years were used. After soft tissue dissection, 10 of the matched pairs were transected to isolate the SP or AI bundle while the other 10 matched pairs were transected to isolate only the P or A bundle. Each bundle was loaded to failure on an Instron material testing machine at 60mm/min. Then the ligament bundles were dissected from the bony surfaces to record the insertions areas with a 3-dimensional digitizing device (Microscribe). Rhinoceros 7 was used to create 3-dimensional images and measure ligament insertion area (Figure 1). A paired t-test with significance set at $p<0.05$ was used.

RESULTS:

The SP ligament insertion on the clavicle accounted for 63.2 ±10.5% and was significantly greater than the AI ligament insertion of 36.8 ±10.5%. Similarly, the percentage of SP insertion on the acromion was significantly greater than the AI insertion, 61.0 ±7.6%and 39.0 ±7.6% respectively. The percentage of P ligament insertion on the clavicle accounted for 9.8 ±4.4% and was significantly less than the A bundle insertion which measured 15.3 ±3.6%. The P insertion on the acromion was significantly greater than the A insertion, 21.2 ±5.2% and 12.8 ±3.8% respectively. The SP bundle ultimate failure and displacement at ultimate load were significantly greater than the AI bundle, 572.9 ±168.8 N and 17.8 ±2.9 mm versus 215.4 ±136.8 N and 8.3 ±3.3 mm, respectively. Linear stiffness, yield displacement, yield load, and total energy absorbed were also significantly greater for the SP bundle compared to the AI bundle. The P bundle ultimate failure and displacement at ultimate load were not significantly different than the A bundle, 159.1 ± 70.4 N and 8.0 ±2.5 mm versus 142.2 ±85.6 N and 8.7 ±3.1 mm. There was no significant difference between the linear stiffness, yield displacement, yield load, and total energy absorbed between the isolated P and A bundles.

DISCUSSION AND CONCLUSION: The tensile characteristics and the ligament insertion areas demonstrate that both the SP and AI bundles of the AC ligaments are significant anatomic structures with the SP bundle demonstrating greater structural integrity compared to the AI bundle. While other studies in the literature have grouped the superior with the posterior and anterior with the inferior bundle due to the qualitative observation of ligament bands, the second part of this study isolating the P and A bundles show they have unique characteristics. The P and A bundles did not show different tensile characteristics; however, they were not uniformly inserted on the acromion and clavicle. Therefore, when reconstructing the AC joint, each ligament's contribution should be considered.