Biomechanics of Two Reconstruction Techniques for Elbow Ulnar Collateral Ligament Insufficiency

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Disclosures:

Introduction: The medial ulnar collateral ligament (UCL) of the elbow is susceptible to serious injury in high performance overhead throwing athletes. Extreme valgus stresses are generated across the elbow during the late cocking and early acceleration phases of throwing. Valgus moments on the elbow during a pitch have been estimated between 64-120 Nm and the static demand on the UCL has been estimated at 32 Nm. Within the functional range of 30-120 degrees the primary restraint against these stresses is the anterior bundle of the UCL with its anterior band being the most isometric. Repetitive stresses can lead to attenuation or disruption of stabilizing structures resulting in elbow pain, instability, and reduced athletic performance. Previous to surgical ligament reconstruction, this injury was often career ending. Surgical techniques for reconstruction of the UCL have evolved and remain controversial in their methodologies and efficacy. The purpose of this study was to compare two different surgical techniques for UCL reconstruction; the DANE TJ1, 2 uses proximal docking and distal interference screw techniques, and the TJ Hybrid3 which combines bone tunnels proximally on the humerus with Biotenodesis screw fixation distally on the ulnar side. The hypothesis was that the Hybrid TJ technique would show less valgus laxity and higher failure strength compared to the DANE TJ.

Methods: Twelve fresh-frozen cadaveric upper extremities were dissected to remove soft tissue except static elbow stabilizers and joint capsule. Reflective markers were placed near the ligament attachments of the UCL on the humerus and ulna. The humerus was transected 14 cm from joint center and rigidly fixed in polymethylmethacrylate cement. The radius and ulna were secured in neutral rotation with a 4.5 screw, cut 10 cm from joint center, and a stainless steel rod was inserted into the ulnar shaft. The specimens were mounted in a custom jig, orienting the medial epicondyle superior and the elbow flexion plane horizontal. Joint valgus laxity testing was performed for the intact UCL elbows by applying a 3 Nm moment across the joint at randomly assigned 15 degree intervals throughout the elbow flexion arc from 0-120 degrees and tracking the displacement of the ligament attachment site with 4 motion analysis cameras (Motion Analysis Corp., Santa Rosa, CA). The laxity tests were repeated after transection of the UCL and then reconstruction of the UCL with either the TJ Hybrid or DANE TJ techniques. Palmaris longus graft was used for majority of the reconstructions, FDS of the 4th digit if not present. Cyclic failure testing was then performed by mounting the extremities in a custom-made jig on an MTS 858 Mini-Bionix testing machine (MTS, Inc., Eden Prairie, MN) with the elbow at 90 degrees and applying an initial valgus load of 20 N at 0.5 Hz for 200 cycles applied 12 cm distal to the joint. The load cycle was increased by 10 N for each subsequent set until failure or ligament displacement of 5 mm was reached. Real-time motion analysis was used in all displacement measurements, and the order of reconstruction and testing were randomized. Statistical analysis of kinematic and failure displacements consisted of mixed model analysis of variance (ANOVA) with Tukey adjustment for multiple comparisons and alpha set at 0.05.

Results: As shown in Figure 1, the TJ Hybrid reconstruction closely and consistently replicated the intact condition displacement throughout the range of motion with no statistically significant differences observed. While the DANE TJ performed closer to the intact for higher flexion angles, it deviated significantly for 0 degrees (p=0.01) and 15 degrees (p=0.02) of flexion. There were no statistical differences in joint displacements between the TJ Hybrid and the DANE TJ over the flexion angle range. Failure testing of the reconstructions revealed no catastrophic failures of the graft interface, ligament or bone. The TJ Hybrid absorbed a mean of 802 ± 584 cycles before failure, compared to the DANE which sustained a mean of 575 ± 409 cycles before failure. The TJ Hybrid revealed lower ligament displacement throughout the loading range than the DANE TJ, although not statistically significant.

Discussion: This biomechanical comparison presents techniques similar to recent publications for testing ligament reconstructions in the elbow joint with the primary difference being the measurement of ligament attachment site displacements rather than elbow joint valgus angle. The results reveal that the TJ Hybrid and DANE TJ reconstructions both adequately restored valgus laxity to intact levels, with the exception of the DANE at low flexion angles. There were also no differences in failure strength or stiffness between the two techniques. Therefore, this study cannot recommend one hybrid fixation over the other from a biomechanical standpoint, as that choice would amount to surgeon preferences with the various aspects of performing each procedure.

Significance: Despite numerous developments in collateral ligament reconstruction techniques, there exist inherent advantages and limitations to each procedure and there is no clear gold standard procedure. While both the TJ Hybrid and DANE TJ
reconstructions both adequately restored valgus laxity to intact levels, the inferior strength of the reconstructions as compared with the native ligament necessitates the use of protected motion protocols in the postoperative period; restrictions that may ultimately contribute to lost motion and incomplete recovery of performance.

Acknowledgments:
