Mechanical Testing of Distal Radioulnar Instability Repair: Ligament Reconstruction vs Capsulorraphy

Christopher Dy¹, Anne Ouelette¹, Anna-Lena Makowski¹, Dena Mohnani¹,², Ali Malik¹,², Loren Latta¹,²,³
¹Orthopaedics and Rehabilitation, University of Miami, Miami, FL; ²Max Biedermann Institute for Biomechanics, Mount Sinai Medical Center, Miami Beach, FL; ³Biomedical Engineering, University of Miami, Coral Gables, FL
llatta@miami.edu

Introduction: Instability of the distal radioulnar joint (DRUJ) presents both a diagnostic and therapeutic challenge to the physician. Restoration of the structural support provided by the TFCC is imperative to relieve symptomatology and to improve the biomechanical environment of the joint. Numerous soft tissue operations targeted towards reconstruction of the DRUJ have been described, but the mechanical stability following the majority of these procedures has been disappointing. The initial clinical results provided by Adams and Berger are promising, but laboratory-based biomechanical evaluations and long-term surgical follow-up are not yet available. The purpose of this study is to compare the ability of the Adams ligament reconstruction and Herbert Sling to restore stability of the DRUJ following the creation of a standardized tear in the TFCC.

Materials and Methods: Six matched pairs of cadaveric upper extremity specimens were prepared with the proximal humerus stripped of soft tissue. The physical properties of each specimen were thoroughly evaluated with a series of non-destructive testing, including clinical examination with simultaneous fluoroscopy, arthroscopic evaluation, and tissue stiffness testing.

The upper extremity specimens were fixed to a Model 858 MiniBionix II machine (MTS, Eden Prairie, MN) with the elbows and wrists placed in 90-degrees of flexion and pronation, respectively. The MTS actuator was then cycled vertically in displacement control and the displacement envelope increased until a recognizable neutral zone was displayed (approximately +/- 1.0mm). Load-displacement curves for each examination were evaluated and neutral-zone analysis of the load-displacement curve, as initially described by Panjabi, was used as a measure of laxity prior to support from the soft tissues to better assess the TFCC’s contribution to ulnocarpal and radioulnar stability.

Following the completion of non-destructive testing, a standardized 2-3mm lesion of the ulnar-sided peripheral TFCC was created, to emulate the injury pattern similar to that for which an Adams ligament reconstruction is indicated. Following the creation of the tear, the series of non-destructive tests was repeated for each specimen.

One specimen in each pair was assigned for repair with the Herbert Sling and the other specimen in the pair assigned for repair with anatomic ligament reconstruction.

The series of non-destructive tests was repeated following surgical repair. Statistical analysis of the testing results was performed using SPSS 15.0 (SPSS Inc, Chicago, IL).

Results: Initially described by Panjabi as a measure of spinal range of motion, the neutral zone is derived from the load-displacement curve created during mechanical testing and is measured as the distance between the tension and compression portions of the curve. The neutral zone correlates with the range of motion at which joint motion is produced with minimal resistance, and length of the neutral zone is inversely related to stiffness of the joint. We decided to use neutral zone analysis as a measure of joint stiffness to more accurately evaluate the stabilizing role of the TFCC in a controlled manner.

Radioulnar and ulnocarpal NZ lengths for the two groups in each stage of testing are presented in Figures 1 and 2, respectively. Radioulnar and ulnocarpal laxity increased following the creation of the TFCC tear, and decreased following either type of surgical repair. Both the mean radioulnar NZ length and the mean ulnocarpal NZ length increased 30% after the creation of the TFCC tear when compared to its initial state and decreased 8% after either surgical repair when compared to its torn state. The mean radioulnar NZ length was increased 20% and the mean ulnocarpal NZ length increased 26.7% after either surgical repair when compared to the intact pre-experimental state. Movement of the pisiform relative to the triquetrium increased 10% after the TFCC tear, then decreased 67% following surgical repair using either technique.

The Adams ligament reconstruction provided a better restoration of radioulnar stability than the Herbert Sling, but this difference was not statistically significant (p=0.06). However, there was a significant difference in ulnocarpal stability between the two repair techniques (p=0.038), with the ulnocarpal joints in the Adams specimens significantly more lax than the Herbert specimens.

Discussion: The findings of the current study further support the use of extrinsic soft tissue repairs, such as the Herbert Sling, as effective alternatives to more invasive reconstructive procedures. The design of the Herbert Sling, a less invasive and relatively easier procedure for which satisfactory clinical results have also been reported, addresses both radioulnar and ulnocarpal stability by including a similarly short, strong, and direct link of the radius and ulna, while also stabilizing the ulnar carpus through ligamentotaxis.

Discussion: The results of the current study show the ability of the Herbert Sling to provide significantly more ulnocarpal stability when compared to the Adams anatomic ligament reconstruction. The current study’s finding that the Herbert sling provides significantly greater ulnocarpal stability than the Adams reconstruction is not surprising, as ulnocarpal stability is not specifically addressed in the anatomic ligament reconstruction. Aside from its biomechanical advantages, the Herbert Sling provides pragmatic benefits, such as less operative time, a less intrusive approach, and less equipment needed, in the interest of both the surgeon and the patient.

The findings of the current study suggest that radioulnar and ulnocarpal stability of the distal radioulnar joint can be achieved using the Herbert Sling, a relatively simple and less time consuming procedure, with biomechanical results equivalent to those following a more invasive and complex surgical reconstructive procedure.

Acknowledgements: The authors would like to gratefully acknowledge Eli Herndon, Veronica Diaz and Edward Milne for their assistance and Smith&Nephew Endoscopy for lending arthroscopic equipment for use in this project.