Biomechanical Analysis of All-Inside, Arthroscopic Suture Repair versus Extensor Retinaculum Capsulorrhaphy for Triangular Fibrocartilage Complex Tears with Instability

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Introduction

Ulnar-sided wrist pain manifesting with wrist instability is a therapeutic and diagnostic challenge. The complex anatomy at both the radioulnar and ulnocarpal joints makes injuries to this area particularly difficult to treat, and current treatments have proven to be heterogeneous in results. Peripheral detachment of the triangular fibrocartilage complex (TFCC) from its ulnar insertion has been described as the principal pathology that ultimately leads to dysfunction at the distal radioulnar joint (DRUJ) and ulnocarpal joint (UCJ). Treatment strategies, however, have largely focused on restoring DRUJ integrity. Few studies have described the contributions of the TFCC to UCJ stability, though it has been suggested in multiple anatomical and histological studies.

Currently, peripheral TFCC injuries are treated with anatomic repair using sutures through either open or arthroscopic means. Refractory cases may be amenable to reconstruction of the DRUJ instead, though these procedures have proven to be invasive with poor results biomechanically. Extensor retinaculum capsulorrhaphy with the Herbert Sling (HS) is simple and non-invasive alternative that may be used in isolation or as an adjunct procedure for restoring UCJ stability. The purpose of this study is to compare the restoration of UCJ stability using various treatment options for a peripheral TFCC injury, including all-inside arthroscopic TFCC suture repair (SR), the Herbert sling (HS), and a combination of both arthroscopic TFCC repair and the Herbert sling (SR+HS).

Methods

Twelve fresh-frozen, age-matched specimens intact from the distal humerus were used for this study. Non-destructive mechanical testing was performed to assess native UCJ stability, and load displacement curves were recorded. Non-destructive testing of each intact specimen was performed to assess the native stability of the UCJ using identical procedure to a previously-validated model (Dy CJ, 2009) This model attempts to emulate and quantify a physical examination “supination test” maneuver implemented by the senior author (EAO) **(Fig. 1)**

A polyaxial pelvic screw was placed in the distal dorsal, and each arm was secured to a Model 858 MiniBionix II Machine (MTS, Eden Prairie, MN) with the elbow in 90 degrees of flexion and the wrist in maximum pronation. A carbon fiber rod was secured dorsally over the lunate and triquetrum to create a mechanical block for the ulna to translate against **(Fig 2)**. The MTS actuator was then cycled sinusoidally in the volar-dorsal plane at 0.25 Hz and initial amplitude of ± 1 mm with respect to the pisiform. The amplitude was gradually increased while carefully monitoring the load-displacement curve until firm endpoints were reached and then continued for several cycles until a steady state was met. Panjabi et al originally described a similar concept as the “neutral zone” in a study of spine biomechanics (Panjabi M, 1989). In our model, the distance between points of maximal volar and dorsal excursion on the load-displacement curve was defined as “translation”. A statistically significant increase in translation from the intact specimen was defined as “instability”.

A peripheral, ulnar-sided TFCC injury was created with arthroscopic assistance, and mechanical testing was performed. Each specimen was treated with SR or HS, and testing was repeated. The six specimens treated with SR were then treated with HS (SR+HS), and testing was repeated. The Herbert sling procedure was performed according to a previously described surgical technique **(Fig. 3)**. Statistics were described with means and standard error within cohorts. Paired Student’s t-test were implemented to evaluate the difference between the initial examination and the post-TFCC tear evaluation and the difference between the post-TFCC tear evaluation and the post- repair evaluation for each group.

Figure 1: Diagram demonstrating the supination test. (A) Standard PA radiograph recreation with the wrist in neutral. (B) With the distal radius/ulna stabilized, the carpus is maximally sup
inated. In cases without ulnocarpal instability, the TFCC restrains the carpus from rotating excessively. (C) In cases of ulnocarpal instability, there is excessive rotation of the carpus as the TFCC does not restrain motion. This is represented in particular with more rotation of the triquetrum when compared to stable wrists.

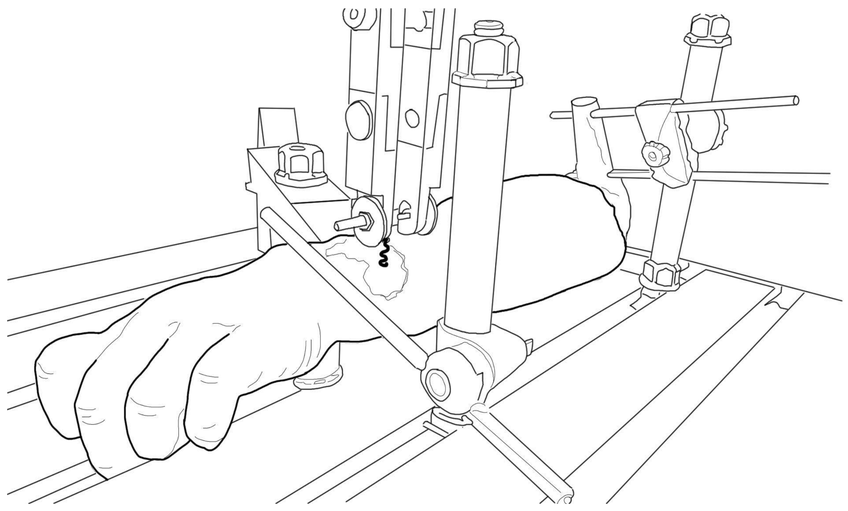
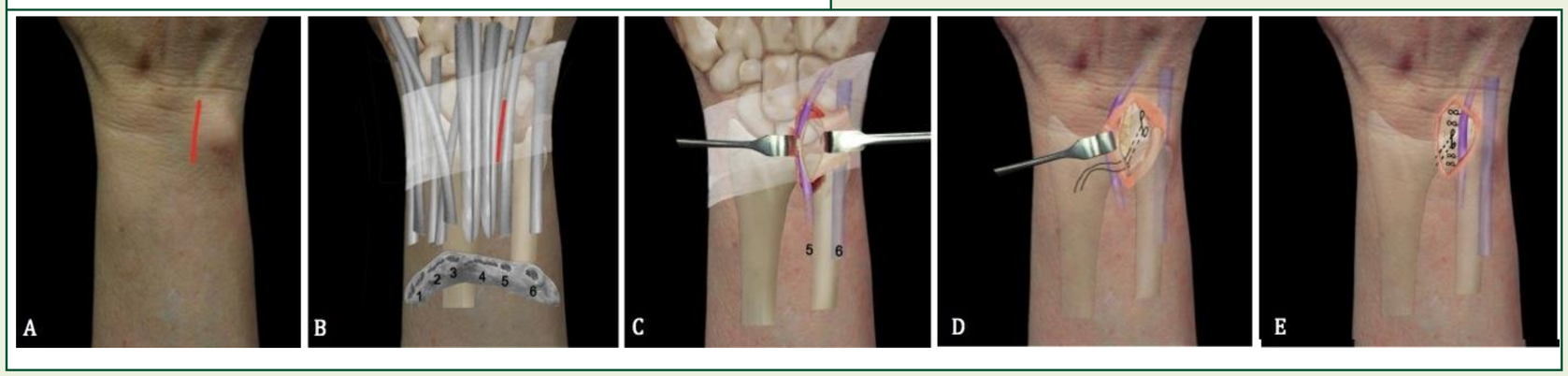


Figure 2: Mechanical testing apparatus showing distal humerus transfixed to the MTS machine. A carbon fiber rod has been secured over the proximal row of the carpus. A polyaxial screw has been placed in the dorsal aspect of the distal ulna and is connected to an actuator.

Figure 3: Diagram of the operative technique for extensor retinaculum using the Herbert sling. **(A, B)** An incision is made over the fifth dorsal compartment. **(C)** The EDQ is identified and retracted radially. The extensor retinaculum is exposed. **(D)** The retinaculum is then incised and raised as an ulnar-based flap, which is transposed proximally and laterally at a 30° oblique angle. **(E)** The flap is repaired to the periosteum of the radius with 2-0 suture, and the EDQ is transposed.



Results

There was a significant increase in average ulnar translation (p=0.01) after the creation of the peripheral TFCC injury. Regardless of technique, repair resulted in an average decrease in ulnar translation (p<0.001). Individual analysis of cohorts demonstrated varied changes in translation after repair when compared to the disrupted specimen **(Fig. 4)**. HS decreased translation by 21% (p=0.01), SR decreased translation by 12% (p=0.08), and SR+HS decreased translation by 26% (p=0.05).

Discussion

Instability of the wrist after injury to the TFCC is a challenging problem to diagnose and treat. Many current treatments are available; however, there is no consensus on what is mechanically the most stable or clinically the most effective method. UCJ is a unique component of wrist instability that is not normally evaluated nor addressed. The results of our limited cadaveric study demonstrate that SR in isolation may not fully address the anatomy of the TFCC as it provides the least resistance to ulnocarpal motion. HS in isolation or with SR provided the most stability and significantly reduced translation.

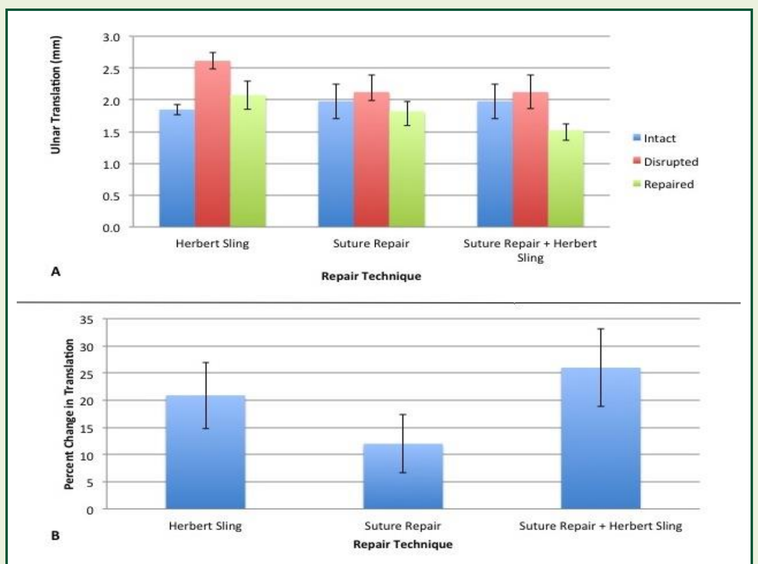


Figure 4: (A) Comparison of ulnar translation by procedure. (B) Percentage change in ulnar translation when comparing disrupted to repaired specimen.

Significance

UCJ stability should be clinically assessed in patients with peripheral TFCC injury, and consideration should be made for utilizing extensor capsulorrhaphy in isolation or as an adjunct to suture repair as a treatment option.