SCIENTIFIC ARTICLE

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

Amar A. Patel, MD,* Ali A. Alhandi, MBBS,* Edward Milne, BSc,† Christopher J. Dy, MD,‡ Loren L. Latta, PhD,† E. Anne Ouellette, MD§

Purpose To assess ulnocarpal joint stability after treatment of a peripheral triangular fibrocartilage complex (TFCC) injury with all-inside arthroscopic suture repair (SR), extensor retinaculum capsulorrhaphy with the Herbert sling (HS), and a combination of both (SR+HS).

Methods Twelve fresh-frozen, age-matched, upper-extremity specimens intact from the distal humerus were prepared. Nondestructive mechanical testing was performed to assess native ulnocarpal joint stability and load–displacement curves were recorded. 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 6 specimens treated with SR were then treated with HS (SR+HS), and testing was repeated. We used paired Student *t* tests for statistical analysis within cohorts.

Results For all cohorts, there was an average increase in ulnar translation after the creation of a peripheral TFCC injury and an average decrease after repair. Herbert sling decreased translation by 21%, SR decreased translation by 12%, and SR+HS decreased translation by 26%.

Conclusions Suture repair plus HS and HS reduce ulnar translation the most after a peripheral TFCC injury, followed by SR alone.

Clinical relevance Ulnocarpal joint stability should be assessed clinically in patients with peripheral TFCC injury, and consideration should be made for using extensor capsulorrhaphy in isolation or as an adjunct to SR as a treatment option. *(J Hand Surg Am. 2016;41(3):387–393.*

Key words All-arthroscopic, capsulorrhaphy, Herbert sling, triangular fibrocartilage complex.

*From the *Department of Orthopaedics, Jackson Memorial Hospital, University of Miami; the †Max Biedermann Institute of Biomechanics, Mount Sinai Medical Center; the §Ouellette Group, Miami, FL; and the ‡Department of Orthopaedics, Washington University, St. Louis, MO.*

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Corresponding author: Ali A. Alhandi, MBBS, Department of Orthopaedics, Jackson Memorial Hospital, University of Miami, 1611 NW 12th Avenue, Miami, FL 33136; e-mail: ali.alhandi@gmail.com.

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ULNAR-SIDED WRIST PAIN MANIFESTING with instability has proven to be a diagnostic and therapeutic challenge, and its management is controversial. Mismatch in the anatomy of the ulnar head and sigmoid notches provides minimal resistance to joint translation at the distal radioulnar joint (DRUJ),[1,2] and integrity of the surrounding soft tissue structures is essential to provide stability.[3] Contributions over the past 3 decades have led to a greater understanding of this complex problem, in particular the anatomy of the DRUJ and the ulnocarpal joint

(UCJ), extrinsic dynamic stabilizers of the forearm in rotation, and most important, the function of the triangular fibrocartilage complex (TFCC).[2,4,5]

Traumatic disruption to the TFCC comprises a spectrum of injury resulting in a variety of instability patterns. Peripheral detachment of the articular disk from its ulnar insertion has been described as the principal pathology that ultimately leads to dysfunction at the DRUJ and UCJ.[6] The contribution of the TFCC to the DRUJ has been well-established biomechanically and clinically,[7–10] and treatment strategies have largely focused on restoring radioulnar stability in patients with TFCC disorders. Few studies have described the contributions of the TFCC to UCJ stability, although it has been suggested in multiple anatomical and histological studies.[1,9,11,12] Nakamura et al[12] described the distal limb of the TFCC as a hammock to suspend the ulnar carpus whereas the proximal limb is the true radioulnar ligament, noting its importance in maintaining stability and mobility at the ulnar wrist. More recently, Dy et al[13] described decreased stiffness of the UCJ after the arthroscopic creation of a peripheral TFCC tear in their biomechanical model isolating the ulnocarpal articulation.

Peripheral tears of the TFCC at the ulnar insertion, classified as Palmer 1B lesions,[9] are amenable to surgical repair when conservative management fails. Analogous to the meniscus of the knee, peripheral TFCC tears of the TFCC are likely to heal because of local abundant vascularity.[14] Past attempts at open repair have been successful; however, arthroscopic guidance decreases soft tissue trauma, improves visualization, and improves final wrist motion.[15] Although several variations of arthroscopic repair have been described,[16] all-inside, all-arthroscopic techniques using the FasT-Fix device (Smith and Nephew, Andover, MA) are clinically safe and effective[17] and are stronger and faster than traditional outside-in techniques.[18]

Another approach to stabilizing the TFCC and wrist is the Herbert sling (HS).[19] Described by Stanley and Herbert[20] to restore DRUJ stability after ulnar head arthroplasty, the procedure uses an ulnar-based flap of extensor retinaculum to stabilize both the radioulnar and ulnocarpal articulations. This construct theoretically functions as a tether to both the DRUJ and UCJ throughout a normal arc of forearm rotation. In accordance with observations by Kleinman and Graham,[5] HS provides extrinsic ligamentotaxis of soft tissues that is essential for restoration of the normal biomechanics of the wrist. The purpose of this study was to compare restoration of UCJ stability using various treatment options for a peripheral TFCC injury, including all-inside arthroscopic TFCC suture repair (SR), HS, and a combination of both SR and HS (SR+HS).

MATERIALS AND METHODS

We prepared 12 fresh-frozen, age-matched upper-extremity specimens intact from the distal humerus to the fingertips. Each limb was thawed and evaluated with plain radiographs in orthogonal planes to ensure that no preexisting bony injury or joint misalignment was present. The soft tissue of each distal humerus was stripped to ensure that each humerus could be secured for mechanical testing.

Nondestructive testing of each intact specimen was performed to assess the native stability of the UCJ using a procedure identical to that of a previously validated model.[13] This model attempts to emulate and quantify a physical examination supination test maneuver implemented by the senior author (E.A.O.) (Fig. 1).[19] With the forearm pronated, the distal ulna is stabilized with one hand and the pisotriquetral unit is stabilized with the other. The pisotriquetral unit is then stressed volarly, essentially rotating it off the ulna. The presence of increased excursion compared with the contralateral extremity or a painful clunk indicates clinical ulnocarpal instability, similar to a positive Lachman maneuver for anterior cruciate ligament injuries of the knee.

A polyaxial pelvic screw was placed in the distal dorsal ulna approximately 2 cm from its distal end. The limb was secured to a Model 858 MiniBionix II Machine (MTS, Eden Prairie, MN) with the elbow in 90° flexion and the wrist in maximum pronation and in neutral flexion- extension with the polyaxial screw secured to the actuator (Fig. 2). Forearm rotation is known to affect the tension of the dorsal-volar radioulnar ligaments, and maximum dorsal translation occurs with the forearm in full pronation.[4,21,22] Moreover, repetitive testing of a specimen in different positions of forearm rotation results in profound distortion of soft tissue properties in mechanical models.[21] Therefore, mechanical testing was conducted only in pronation. A 2-cm spacer was positioned volarly against the pisiform (to allow volar excursion of the ulna without contacting the table) and a carbon fiber rod was secured dorsally over the lunate and triquetrum to create a mechanical block against which the ulna was to translate. The MTS actuator was then cycled sinusoidally in the volar-dorsal plane at 0.25 Hz and an initial amplitude of ±1 mm with respect to the triquetrum. We observed no movement of the lunate or triquetrum under direct visualization during the loading cycles.