SCIENTIFIC ARTICLE

The Effect of Triangular Fibrocartilage Complex Tear on Wrist Proprioception

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Purpose This study examined the influence of triangular fibrocartilage complex (TFCC) deep fiber tears on wrist proprioception.

Methods The study involved 48 subjects: 24 with deep fiber TFCC tears and 24 with healthy wrists. A specially created sensor measured wrist proprioception in 3 axes of movement. Absolute differences between target and subject-reproduced angles were compared in injured and healthy wrists and in injured and contralateral patient wrists. A greater difference in reproduced angles was deemed to reflect a lesser ability to approximate a target angle.

Results In wrists with TFCC injuries, 40° pronation and 60° pronation showed significantly greater differences between target and subject-reproduced angles compared with those in the control wrists. In wrists with TFCC injuries, 40° pronation demonstrated significantly greater differences between target and subject-reproduced angles than did those in patients' contralateral wrists. Proportions of outliers with absolute differences greater than 6° were significantly higher in 60° supination and 40° pronation in wrists with TFCC injuries.

Conclusions Deep TFCC fiber detachment may lead to decreased wrist proprioception in 60° and 40° forearm rotation.

Clinical relevance Deep TFCC fiber tear may contribute to decreased wrist rotational positioning sense and may have biomechanical importance in distal radioulnar joint stability. *(J Hand Surg Am. 2018;■(■):1.e1-e8. Copyright © 2018 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Joint position sense, proprioception, TFCC, wrist.

Online Exclusive

THE TRIANGULAR FIBROCARTILAGE complex (TFCC) is a 3-dimensional link that spans the radius, ulna, and carpus, serving key functions of load transmission and stabilization of the ulnar side of the radiocarpal and distal radioulnar joints (DRUJs).[1,2]

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A traumatic TFCC tear is one of the major causes of ulnar-sided wrist pain and impaired wrist function. The triangular fibrocartilage (TFC) is mainly composed of deep and superficial components. Integrity of the foveal anchoring, which is considered the deep component of the TFC, is one of the most important factors determining treatment in TFCC injury. Earlier studies showed that disruption of this structure is associated with unsatisfactory treatment outcomes, DRUJ instability, decreased grip strength, and DRUJ arthritis.[3]

Proprioception is a component of the sensorimotor system and includes awareness of afferent information arising from receptors that contribute to postural control, joint stability, and motor control.[4] This information originates from mechanoreceptors present within various tissues such as muscles, tendons,

ligaments, and skin.[5] Clarification of the proprioceptive role of a specific structure is essential to understanding the potential impact of injuries to that structure and the development of an appropriate treatment strategy.[6]

Anatomic studies have demonstrated that the wrist joint capsule and intra-articular ligaments are abundantly innervated.[7] The TFCC has also been found to have innervation from various nerves: the dorsal cutaneous branch of the ulnar nerve, medial antebrachial cutaneous nerve, volar branch of the ulnar nerve, anterior interosseous nerve, posterior interosseous nerve, and palmar branch of the median nerve.[8,9] Mechanoreceptor reflexes are transmitted through these nerves.[10] However, there is little information regarding changes in proprioception in a wrist with a TFCC injury.

The purpose of our investigation was to examine the influence of deep fiber tears of the TFCC on wrist proprioception. We measured the position sense of the wrist in the passive condition[6] and examined the accuracy of reproduction of a specific angle of wrist position. We hypothesized that the ability of a wrist with a deep TFCC fiber injury to reproduce a specific angle would be less accurate than that of an uninjured wrist.

MATERIALS AND METHODS

From April 2015 to July 2016, we performed a study to compare wrist proprioception accuracy and precision in wrists with TFCC injuries and healthy wrists. Based on previous studies examining the prominent role of TFCC deep fibers in controlling DRUJ rotation,[11,12] we conducted a pilot study to assess the accuracy of reproducing a specific angle of this arc. Twelve wrists in 6 patients and 6 healthy volunteers were tested to reproduce 60° pronation as a large angle without producing motion pain. They showed mean between-group differences of 6° (SD, 6.7°); therefore, an a priori sample size estimate was performed to detect the mean absolute differences of 6° to reproduce proprioceptive accuracy in patients and controls. An independent t test showed that a minimum of 22 wrists in each group would have 80% power with $\alpha = .05$.

Study samples

Eligible participants for the injured TFCC group were adults on a waiting list for arthroscopic TFCC repair surgery. Patients were required to have a diagnosis of an isolated tear of the deep component of the TFCC without evidence of other ligamentous injury as demonstrated by magnetic resonance arthrography or arthroscopy.

A total of 24 patients (16 men and 8 women; mean age, 31.6 years) were included in the injured TFCC group. All patients manifested a positive ulnar foveal sign[13,14] and DRUJ instability, as assessed by the ballottement test.[1] The examiner firmly grasped the radius and radial carpals with one hand and evaluated anteroposterior translation of the ulnar head on the sigmoid notch of the radius in the neutral, supinated, and pronated forearm positions. Increased passive anteroposterior or posteroanterior laxity that had no firm end point and evoked symptoms evidenced instability. All patients underwent magnetic resonance arthrography before proprioceptive measurements. After completing the measurements of proprioception, all patients underwent a scheduled arthroscopic examination by one hand surgeon. Diagnoses of TFCC tear based on magnetic resonance arthrography were confirmed arthroscopically. Patients who demonstrated a positive hook test,[1,15] which examined the competence of foveal insertions of TFCC on arthroscopy and showed no visible tears on the superficial component of TFCC, were classified as isolated, deep component tears of the TFCC. The wrist of the dominant arm was involved in 10 cases.

A control group of the same size was selected (14 men and 10 women; mean age, 29.0 years). They all denied ulnar-sided wrist pain or a history of major trauma of the wrists, when asked specifically by the recruiting physician. No control subjects showed an ulnar foveal sign or DRUJ instability upon the wrist examination. All underwent routine wrist radiographs, composed of posteroanterior, lateral, and oblique views, and none showed bony abnormality. Patients in the injured TFCC group were matched by age, sex, and hand dominance with subjects in the control group (Table 1). All subjects were of Asian race and were recruited from our institution by a single physician. The study was approved by the ethics committee of Korea University Medical Center.

Apparatus

We developed a unique inertial measurement unit (IMU) sensor with a gyroscope to measure angles accurately and minimize both tactile sensation and mechanical noise (Fig. 1). The IMU included a 9-axis microelectromechanical systems sensor (MPU-9150, Invensense, Sunnyvale, CA) and was composed of a triaxial accelerometer, a triaxial gyroscope, and a triaxial magnetometer. The dimensions of the newly