SCIENTIFIC ARTICLE

The Influence of Thumb Metacarpophalangeal Joint Rotation on the Evaluation of Ulnar Collateral Ligament Injuries: A Biomechanical Study in a Cadaver Model

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Purpose To determine whether variation in thumb metacarpophalangeal (MCP) joint pronosupination influences perceived ulnar collateral ligament (UCL) stability during clinical stress testing.

Methods Twelve fresh-frozen specimens underwent sequential evaluation for the following conditions: ligament intact (LI), proper UCL deficient (-pUCL), and proper and accessory UCL deficient (*UCL). Valgus stress testing was completed in both 0° and 30° MCP joint flexion for thumb pronation, neutral, and supination.

Results Compared with neutral MCP joint rotation, supination decreased and pronation increased stability such that established treatment guidelines could be incorrectly applied. During evaluation in supination and 0° flexion, 9/12 -pUCL had greater than 35° laxity and, similarly, the mean laxity of -pUCL was similar to the *UCL group in neutral rotation and 0° flexion, incorrectly suggesting a complete ligament tear. In comparison, mean laxity of the *UCL in pronation and 0° flexion was not different than -pUCL in neutral rotation and 0° flexion, emphasizing the stabilizing effect of pronation.

Conclusions Thumb MCP joint pronosupination significantly influenced the evaluation of joint stability, where pronation improved valgus stability in contrast to supination that tended to increase joint instability, In pronation and 0° flexion, a complete UCL injury could be misdiagnosed as a partial injury. In supination and 30° flexion, an intact UCL could be misdiagnosed as a partial UCL injury. In supination and 0°, a partial UCL injury could be misdiagnosed as a complete UCL injury.

Clinical relevance Accurate evaluation of thumb UCL stability is critical for guiding treatment. Variations in thumb MCP joint rotation during stress testing may influence clinical interpretation and, therefore, we recommend standardization of testing with the thumb MCP joint in neutral rotation. *(J Hand Surg Am. 2014;39(3):474–479. Copyright © 2014 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Gamekeeper's thumb, metacarpophalangeal joint, skier's thumb, thumb, ulnar collateral ligament.

Ulnar collateral ligament (UCL) injuries represent 60% to 90% of ligamentous injuries to the thumb metacarpophalangeal (MCP) joint and are caused by hyperextension and abduction directed forces to the thumb.[1–3] Thumb MCP joint stability relies on both dynamic and static structures; static stabilizers include the radial collateral ligament and the UCL, joint capsule, volar plate, and the inherent contour of the articular surfaces. The UCL complex consists of a proper (pUCL) and an accessory (aUCL) collateral ligament and has been

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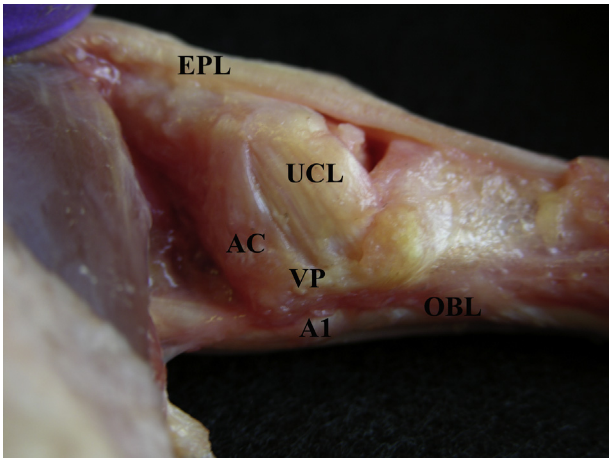

FIGURE 1: The adductor aponeurosis has been removed, revealing the ulnar aspect of the thumb MCP joint. The UCL and the accessory ulnar collateral ligament (AC) originate at the dorsal-ulnar margin of the head of the metacarpal; the UCL inserts into the ulnar base of the proximal phalanx and the AC inserts into the volar plate (VP) of the MCP joint. The extensor pollicis longus tendon (EPL) is dorsal to the MCP joint and the A1 and oblique (OBL) pulleys of the flexor sheath are noted volar to the MCP joint and the proximal phalanx. (Reprinted with permission from Leversedge FJ, Goldfarb CA, Boyer MI. *A Pocketbook Manual of Hand and Upper Extremity Anatomy—Primus Manus*. Philadelphia: Lippincott Williams & Wilkins; 2010. © Leversedge FJ, Goldfarb CA, Boyer MI, 2004.)

demonstrated to provide up to 95% of resistance to radial deviation of the proximal phalanx (Fig. 1). The volar plate and articular contour provide additional stability.[4,5] Alterations in the positioning of these static structures relative to joint orientation may alter their relative contributions to joint stability.[6]

Treatment guidelines for UCL injury are based on reproducible methods for evaluating the severity of ligamentous injury.[1,2,7–23] The incarceration of the displaced UCL insertion by the adductor aponeurosis (Stener lesion) that occurs in 64% to 87% of patients with a complete UCL avulsion has a low chance of healing properly without operative intervention.[1,2,7–22,24] Clinical assessment of the UCL involves the application of a radially directed force to the proximal phalanx while stabilizing the metacarpal. Positioning of the MCP joint in 0° flexion preferentially evaluates the aUCL, whereas evaluation of the pUCL is accomplished with the thumb MCP joint in 30° to 35° of flexion. Previous biomechanical and clinical studies have defined a complete UCL tear (*UCL) as involving 20° to 45° of absolute angulation at the MCP joint,[8,9,11,12,14,16–22] less than 10° to 15° difference in laxity flexion versus extension,[14] or a 10° to 45° difference in laxity between the injured and the uninjured thumbs during valgus stress testing.[9,10,13,15,17,19–21] It is our practice to diagnose a complete tear in the presence of at least 35° laxity without a firm end point to valgus stress testing with the MCP joint in full extension or greater than 15° more laxity compared with the uninjured side, as suggested by Heyman et al.[14,21] Although several studies advise prevention of thumb pronosupination during testing, the influence of thumb MCP joint pronosupination on the clinical evaluation of UCL integrity is not completely understood.[1,2,7–22]

The purpose of this biomechanical study was to determine whether variations in the position of thumb MCP joint rotation would influence joint stability during clinical stress testing of the thumb UCL using a human cadaver injury model and serial ligament sectioning. We hypothesized that variations in thumb MCP joint pronosupination would affect perceived UCL stability and, therefore, could influence clinical decision making based on current treatment guidelines for UCL injuries.

MATERIALS AND METHODS

Institutional review board approval was obtained. Twelve fresh-frozen transradiocarpal joint amputation specimens without visible or radiographic evidence of previous trauma and with intact MCP joint collateral ligaments were used. The skin and subcutaneous tissue were removed. Using fluoroscopic guidance, two 2.4-mm threaded Steinmann pins were drilled through the thumb metacarpal in parallel fashion, perpendicular to its long axis and at the junction of its proximal and middle and of its middle and distal thirds. The pins were clamped such that the rotational axis of the MCP joint-was parallel to the floor. A bicortical 2.8-mm Steinmann pin was drilled transversely across the proximal phalanx base 2 cm distal to its proximal articular surface. The radial end of the pin was cut 2.5 cm from the proximal phalanx and bent to a 120° angle 1.5 cm from the phalanx. A 4.5-kg mass was attached to a cable passed over a pulley system and secured to the bent end of the proximal phalanx pin. A custom circular plumb goniometer was secured to the proximal phalanx pin to monitor thumb pronosupination; it was zeroed when parallel to the floor and, therefore, when the proximal phalanx was in neutral rotation. For the purposes of this study, the term "rotation" was applied specifically to describe motion relative to the pronosupination axis (Fig. 2).

Fluoroscopic images were obtained of each specimen with a 4.5-kg mass attached to the cable in

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