SCIENTIFIC ARTICLE

Impact of Joint Position and Joint Morphology on Assessment of Thumb MCP Joint Radial Collateral Ligament Integrity

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Purpose A 2-part biomechanical study was constructed to test the hypothesis that coronal morphology of the thumb metacarpophalangeal joint impacts the assessment of instability in the context of radial collateral ligament (RCL) injury.

Methods Fourteen cadaveric thumbs were disarticulated at the carpometacarpal joint. Four observers measured the radius of curvature of the metacarpal (MC) heads. In a custom jig, a micrometer was used to measure the RCL length as each thumb was put through a flexion and/or extension arc under a 200 g ulnar deviation load. Strain was calculated at maximal hyperextension, 0°, 15°, 30°, 45°, and maximal flexion. Radial instability was measured with a goniometer under 45 N stress. The RCL was then divided and measurements were repeated. Analysis of variance and Pearson correlation metrics were used.

Results The RCL strain notably increased from 0° to 30° and 45° of flexion. With an intact RCL, the radial deviation was 15° at 0° of flexion, 18° at 15°, 17° at 30°, 16° at 45°, and 14° at maximal flexion. With a divided RCL, instability was greatest at 30° of flexion with 31° of deviation. The mean radius of curvature of the MC head was 19 ± 4 mm. Radial instability was inversely correlated with the radius of curvature to a considerable degree only in divided RCL specimens, and only at 0° and 15° of flexion.

Conclusions The RCL contributes most to the radial stability of the joint at flexion positions greater than 30°. The results suggest that flatter MC heads contribute to stability when the RCL is ruptured and the joint is tested at 0° to 15° of metacarpophalangeal flexion.

Clinical relevance The thumb MC joint should be examined for RCL instability in at least 30° of flexion. *(J Hand Surg Am. 2015;■(■):■−■. Copyright © 2015 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Cadaveric study, metacarpophalangeal joint, radial collateral ligament, radial instability, radius of curvature.

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RADIAL COLLATERAL LIGAMENT (RCL) injuries constitute 10% to 42% of collateral ligament injuries of the thumb metacarpophalangeal (MCP) joint.[1] The proper RCL, accessory collateral ligament, and volar plate all contribute to the stability of the radial side of the joint.[2] Pain and instability, impaired pinch and grip strength, and degenerative arthritis are sequelae of these injuries.[3]

Although much research has been devoted to examining ulnar collateral ligament injuries, less has

been focused on the RCL. Current tenets of examination, diagnosis, and treatment have largely been extrapolated from the studies of the ulnar collateral ligament without independently verifying the applicability to the RCL. Although manual stress testing remains the mainstay of evaluation, the position of the joint during evaluation and the amount of instability consistent with complete rupture of the RCL remain controversial. Therefore, current assumptions regarding diagnosis and treatment of such injuries may not necessarily be correct.

Previous studies have demonstrated that the normal arc of motion of this joint varies widely, from 5° to 115°.[4] This difference has been meaningfully correlated with articular geometry in the sagittal plane, with joints with rounder metacarpal (MC) heads displaying more mobility. A complete RCL rupture in a joint with a flatter MC head may cause less angular deviation of the joint compared with a joint with a rounder MC head. This may be of great importance when attempting to decide the optimal treatment method for these injuries.

We hypothesized that as MCP joint flexion increases, strain on the RCL increases. We also postulated that there would be a correlation between MC head morphology and radial instability in models with an intact RCL and with a divided, RCL. We predicted that MCP joints with flatter MC heads (larger radii of curvature) would display less radial instability with both an intact and ruptured RCL. Conversely, those with rounder MC heads (smaller radii of curvature) would display greater radial instability.

METHODS

To assess the RCL contribution and impact of MCP morphology on joint stability, we designed a 3-part cadaver study. The first consisted of directly measuring the strain of the intact RCL through a full arc of motion with the goal of identifying the MCP joint position at which the RCL provides the greatest contribution to stability. The second involved examining radial instability with both an intact and divided RCL, through a total arc of MCP joint motion. The third involved measuring the radius of curvature of each MC head (a measure of relative flatness or roundness) and correlating these data with radial instability values measured in the second portion of the study. These data were examined to determine if the morphology of the MC head correlates with radial instability seen during stress testing.

Fourteen fresh frozen cadaveric thumbs were disarticulated at the carpometacarpal joint, and the skin and subcutaneous tissue on the radial aspect were excised, leaving the joint capsule, tendons, and ligamentous structures intact. The flexion-extension arc of the MCP joint was measured using a finger goniometer. Radiographs were obtained in the coronal plane using the same fluoroscopy machine, providing an anteroposterior view of the joint surface of each specimen placed at the same distance from the image intensifier. Four independent observers measured the radius of curvature of each MC head using templates accurate to 1 mm. Kappa values were calculated to assess interobserver error.

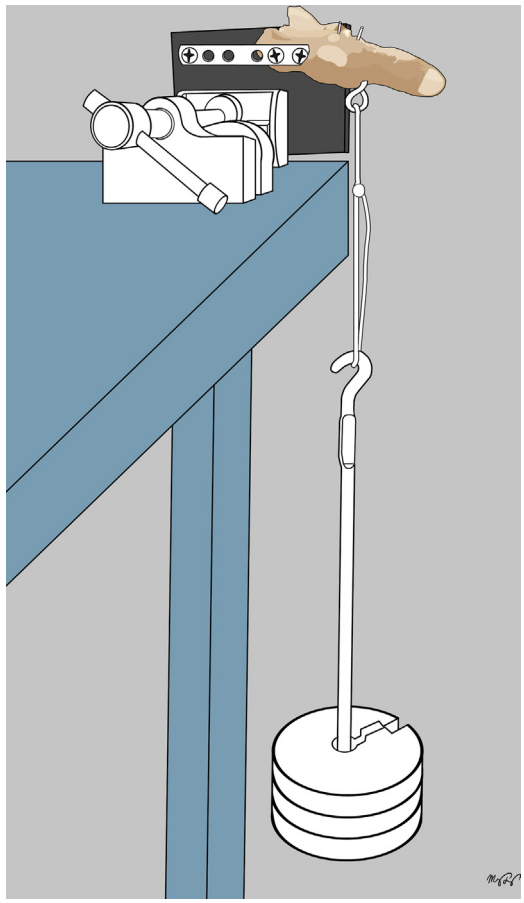

FIGURE 1: Thumb MC custom jig. Metal eyelet inserted in the ulnar aspect of the proximal phalanx, 1.5 cm distal to the joint.

The thumb MC was then fixed to a custom jig. A metal eyelet was inserted into the ulnar aspect of the proximal phalanx, 1.5 cm distal to the joint (Fig. 1). This jig allowed for controlled flexion and extension and ulnar deviation of the joint without allowing pronation or supination of the proximal phalanx. Small circular marker pins were placed into the bone at the RCL origin and insertion and served as markers for measuring the ligament length (Fig. 2).

A 200 g (2 N) load was applied to the proximal phalanx eyelet, which produced an ulnar-directed stress similar to a study of the ulnar collateral ligament conducted by Adams and Muller.[5] The distance between