Thumb Ligament Injuries

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Learning Objectives

- Discuss the anatomy and kinematics of thumb joint ligaments.
- Describe the kinematics of thumb joint ligaments.
- Illustrate the clinical and radiographic methods of diagnosing thumb ligament injuries.
- Detail nonsurgical and surgical treatment methods for thumb ligament injuries.
- Feature treatment outcomes of thumb ligament injuries.

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Thumb ligament injuries are common, particularly those involving the metacarpophalangeal joint. Our understanding and treatment of these injuries continues to evolve. This article provides a comprehensive review of recent literature with updates pertaining to the anatomy, function, diagnosis, and treatment of thumb ligament injuries. *(J Hand Surg Am. 2015;40(4):835–842. Copyright © 2015 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Thumb ligaments, UCL, CMC, basal joint, metacarpophalangeal.

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THE EXTRAORDINARY MOTION OF the human thumb, particularly out of the cardinal plane of the hand, affords it functionality that distinguishes us from our phylogenetic forebears. As with the glenohumeral joint, however, the thumb's mobility in multiple planes comes at the expense of stability. There is little intrinsic stability of the joints afforded by the skeleton alone, so the majority of thumb metacarpophalangeal (MCP) and trapeziometacarpal (TMC) joint stability is provided by the capsuloligamentous structures, which are frequently injured.

The interphalangeal (IP) joint is the least complex of the 3 joints and functions primarily as a hinge. It is the most stable of the 3 joints in the thumb and so is injured least. The MCP joint is transitional between a ginglymus and condyloid joint in which the base of the proximal phalanx hinges over a dome-shaped metacarpal head with a variable radius of curvature and a propensity for ulnar or radial laxity if the collateral ligaments are injured or incompetent. Harris and Joseph[1] showed wide variability in thumb metacarpal head shape. More-spherical shaped heads usually had a greater arc of motion. Flatter heads allowed less motion resulting in tilting rather than gliding at the extremes of motion predisposing the joint to a greater likelihood of ligament injury. Acute abduction (radially directed) injuries to the MCP joint that tear the ulnar collateral ligament (UCL) are referred to as "skier's thumbs," and chronic injuries are known as "gamekeeper's thumbs." Traditionally, incomplete injuries have been treated nonsurgically, acute and subacute complete tears by repair of the ligament, and chronic complete tears by reconstruction. Although this algorithm remains the standard of care, we will present new methods for radiologic evaluation and surgical treatment. The corresponding adduction (ulnarly directed) force across the MCP joint can tear the radial collateral ligament (RCL) and the treatment algorithm is similar to the UCL.

The TMC joint has the least inherent bony stability because of its shallow, biconcavoconvex saddle shape, and is stabilized by several ligaments that have been ascribed various degrees of structural significance. Historically, the anterior oblique ligament (AOL), or "beak" ligament, had been considered the most important to TMC joint stability.[2] Incompetence or laxity of the AOL have been considered to cause TMC subluxation and surgical procedures were developed to reconstruct the AOL and restore stability to the TMC joint. New research has highlighted the importance of other ligaments, particularly the dorsoradial, and their contribution to proprioception and TMC joint stability.

Rather than reiterate the currently accepted means of treatment, the remainder of this article will focus on updates to the basic science, radiologic and physical examination, and surgical treatment relevant to thumb ligament injuries.

ANATOMY

The IP joint of the thumb is a relatively simple hinge and moves only in the sagittal plane. The bony architecture is flatter in the coronal plane and does not allow side-to-side translation like the other joints of the thumb. Alternatively, the MCP joint relies heavily on the UCL and RCL for lateral stability. The UCL consists of the proper and accessory collateral ligaments. The UCL is a thick band measuring 4 to 8 mm wide and 12 to 14 mm long.[3] The proper UCL originates from the dorsal ulnar aspect of the metacarpal head and inserts on the proximal volar aspect of the proximal phalanx. The accessory UCL is contiguous with and just volar to the proper UCL and inserts on the volar plate of the MCP joint. The RCL also consists of proper and accessory components. It, too, has been measured from 4 to 8 mm in width and 12 to 14 mm in length. It originates from the dorsoradial aspect of the metacarpal head and inserts on the lateral tubercle of the proximal phalanx.[3] Recently, a cadaveric study was performed to improve the definition of the anatomic origin and insertion points of the UCL and RCL. That study showed that the RCL and UCL originate from a point one third of the way down the metacarpal head from dorsal to volar. They both insert in a similar location on the proximal phalanx, one quarter the distance from the volar to the dorsal cortex. They also originate 3 to 5 mm proximal to the metacarpal articular surface and attach 3 mm distal to the articular surface of the proximal phalanx.[4]

The sesamoids of the thumb MCP joint are often ignored, but have been implicated as playing an important role in MCP stability, particularly in extension. Rotella and Urpi[5] subdivided the collateral ligaments of the thumb MCP joint into the MCP ligament and the sesamoid-metacarpal ligament. They showed that when the MCP ligament alone was sectioned, the MCP joint opened to 30° when fully extended. With additional sectioning of the sesamoid-metacarpal ligament, the MCP joint opened to 45° and there was total lateral and rotational instability. They suggested that this second injury is required to cause gapping of the joint that allows adductor aponeurosis interposition and the development of a Stener lesion. Radiographically, the sesamoid bones are normally aligned parallel to the metacarpal head and phalangeal base, but with complete collateral disruption, this parallelism is disrupted and can be diagnosed on x-ray.

Early studies of TMC joint anatomy defined 4 main ligaments: anterior oblique, dorsoradial, intermetacarpal, and posterior oblique. Recently, another 12 ligaments have been described, for a total of 16 ligaments.[6] The volar ligaments, primarily the AOL, were historically thought to be the primary stabilizers of the TMC joint. *In vivo* studies suggested that when the TMC joint subluxes or dislocates, the AOL is torn or attenuated as the metacarpal translates dorsally.[7] A

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cadaveric study emphasized the importance of the dorsoradial ligament (DRL) as the principal restraint against dislocation of the TMC joint. The DRL must be torn to allow dorsal subluxation of the joint, and the AOL shears off the metacarpal volarly during complete dislocations.[8]

More recent studies increasingly stressed the importance of the dorsal ligaments, and deemphasized the AOL. Ladd et al[6] evaluated the microscopic composition and range of motion of the dorsal, volar, and ulnar ligaments in cadavers. The dorsal ligaments were significantly thicker than the volar and ulnar ligaments. Zhang et al[9] performed arthroscopic and gross dissection of 5 cadaveric hands. They also noted that the dorsal ligaments (posterior oblique, dorsal central, dorsoradial) were highly consistent in location and caliber whereas the AOL and UCL varied. D'Agostino et al[10] performed anatomic and biomechanical testing of the AOL and DRL and showed that the DRL was significantly more stout, stiff, and had a higher hysteresis than the AOL. Although none of these studies were truly *in vivo*, their implications uniformly suggest that the DRL is equally, or perhaps more, important to TMC stability than the AOL.

The dorsal ligaments may also contribute to TMC joint proprioception. Hagert et al[11] studied the microscopic innervation and presence of mechanoreceptors in the TMC joint using 10 cadaveric hands. They found a greater distribution of nerve endings in the dorsal ligament group, and the Ruffini receptor, which monitors joint position, was the most common type. Mobargha et al[12] expanded upon the idea of mechanoreceptors and studied human subjects undergoing surgery for osteoarthritis. The DRL and AOL were harvested from 11 patients. The DRL showed organized collagen bundles and the AOL showed disorganized connective tissue. The DRL also had more mechanoreceptors and nerve endings than the AOL, consistent with Hagert's work. The authors believe that their study provides a future direction related to proprioceptive rehabilitation or prevention.

The UCL of the TMC joint is also receiving increasing attention. Ladd et al[6] and Zhang et al[9] found that the UCL insertion is more volar and ulnar on the first metacarpal than originally appreciated, and should be renamed to the "first volar trapeziometacarpal ligament" given its location. They concluded that it is the volar equivalent of the dorsal trapeziometacarpal ligament.

DIAGNOSIS

Patient history and clinical assessment of ligament laxity play a key role in the diagnosis of MCP collateral ligament injury. UCL injuries are caused by a forced radial deviation of the thumb MCP joint. Examination involves recreating this force and assessing instability. The metacarpal is stabilized while a radially directed force is applied to the proximal phalanx. This is performed in extension as well as 30° of flexion to assess the accessory and proper collateral ligaments, respectively. Numerous studies have suggested that anywhere from 20° to 45° of angulation is diagnostic of a complete ligament injury. Comparing the injured side to the contralateral uninjured thumb, a 10° to 15° difference in laxity has been proposed to be diagnostic of a complete tear.[13–15]

Mayer et al[16] showed the importance of proper physical examination technique when evaluating MCP stability. Using 12 fresh cadaver specimens, they tested UCL stability in normal thumbs and thumbs with resected UCLs. When they stressed the thumb MCP joint in supination they noted false positives for complete ligament injury. When the thumb was examined in pronation, false negatives were appreciated. This highlighted the importance of neutral rotation when evaluating the thumb for ligament injury.

Malik et al[17] studied 200 thumbs in 100 normal individuals and found that 34% of their patients had a side-to-side difference in thumb MCP UCL laxity greater than 10° when stressed in extension. In flexion, 23% showed a difference of 10° or greater. They suggested that, given the normal variation between thumbs, the detection of a solid end point is a more reliable clinical examination finding than the degree difference in laxity between sides.

TMC joint ligament injuries are less common than those at the MCP joint, but should not be overlooked. To examine a thumb for TMC laxity, the base of the metacarpal is gripped with the examiner's thumb and index finger and is translated relative to the trapezium.[18] A normal TMC joint has little radioulnar motion and no pain with manipulation, whereas one with an acute ligamentous injury will have laxity and pain. Grading laxity is somewhat subjective, but laxity of 2 to 3 mm or more compared with the contralateral, presumably normal thumb is likely to be pathologic. A TMC joint with longstanding posttraumatic laxity may be painless and loose, or might already have evidence of TMC arthritis, such as a positive shoulder sign or grind test.

RADIOGRAPHIC EVALUATION

Radiographs are the primary imaging tool for evaluation of the TMC joint and the basis for the staging of basal joint arthritis by Eaton and Littler.[19] In addition to their staging system, these authors described a technique to diagnose TMC hypermobility radiographically with a dynamic stress view, which accentuates subluxation of the metacarpal on the trapezium. This is done with posteroanterior radiograph of bilateral basal joints with pressure exerted simultaneously by the radial thumb tips against one another. A similar technique may be used to diagnose dorsovolar laxity by opposing the thumbnails forcefully during a true lateral view of both basal joints. This latter projection is more functionally relevant as hypermobility in this plane translates to instability with lateral pinch.[18]

Plain radiographs are routinely used after a history of trauma to the thumb to diagnose avulsion fractures or gross subluxation and instability of the MCP joint. Given the potential inaccuracy of physical examination findings in diagnosing UCL tears, McKeon et al[20] used fluoroscopy and evaluated radial translation of the proximal phalanx on the thumb metacarpal head. Using 68 cadaveric hands, they released the proper and the accessory UCL and observed subsequent changes in radial translation. Thumbs with complete disruption of the UCL demonstrated more than 2 mm of radial translation, while isolated release of the proper UCL did not show any translation. They posited that this is easily quantifiable in an office setting using fluoroscopy, and is highly specific for a complete collateral injury. Hunter et al[21] also showed that radiographs may be useful in the diagnosis of chronic collateral ligament injuries. The authors reviewed radiographs on 22 patients known to have acute (8 patients) or chronic (14 patients) collateral ligament injuries. In 12 of the 14 chronic cases, an exostosis at the head of the metacarpal was seen, and was not appreciated in any of the acute injury patients. These authors showed that this finding has high specificity, but low sensitivity, for chronic thumb MCP collateral ligament tears.

ADVANCED IMAGING

Magnetic resonance imaging (MRI) studies have shown exceptional accuracy in the evaluation of ligament injury, cyst formation, and osteoarthritis.[22] Chiavaras et al[23] evaluated the ability of ultrasound to accurately visualize the AOL of the TMC joint. They reviewed 4 cadaveric hands and 40 asymptomatic volunteers. The cadavers were dissected after ultrasound-guided injection of methylene blue into the AOL to prove that the ligament was visualized. Ultrasound allowed correct visualization of the AOL in 4 of 4 cadavers and 39 of 40 volunteers. The intact proximal attachment was found in 80 of 80 thumbs, and the intact distal attachment was visualized in 75 of 80. The authors concluded that ultrasound is a good method to evaluate ligament integrity, and is less expensive than MRI. Teixeira et al[24] also studied ultrasound of the TMC joint. The AOL was seen in 10 of 10 healthy volunteers and 9 of 10 cadaver hands. They also injected two of the TMC joints with saline to mimic an effusion, and this greatly improved visualization. Both studies showed that ultrasound is becoming a more reliable method for diagnosing thumb ligament injuries, and may ultimately supplant MRI as the preferred imaging technique.

MRI and ultrasound can be used to diagnose collateral ligament injuries of the thumb MCP joint, although, historically, their use was not emphasized because of the relative accuracy of physical examination. A recent literature review reported 76% sensitivity and 81% specificity for diagnosing complete MCP ligament tears using ultrasound.[25] In a retrospective review of 127 patients, 79 patients underwent ultrasound examination shortly after injury. There was one false positive, giving a sensitivity of 92%.[26] A second retrospective study reviewed 26 patients and created a criteria for accurate ultrasound diagnosis of complete UCL tears. Identifying the absence of normal UCL fibers spanning the MCP joint, and a well-defined heterogeneous mass proximal to the metacarpal tubercle resulted in 100% sensitivity and specificity.[27]

MRI for thumb MCP collateral ligament injury has been shown to be superior to ultrasound and is 100% sensitive and specific.[28] Another study in which MRI was used in 34 asymptomatic volunteers showed that signal intensity of the collateral ligaments varies and a high signal of the UCL was found in one third of the patients, which could result in overdiagnosis of UCL injury. They also noted a recess at the base of the MCP dorsal capsule in 33 of 34 normal volunteers that could be mistaken for a complete UCL tear.[29]

TREATMENT

The treatment of MCP ligament injuries is guided by joint stability or lack thereof. Grade 1 and 2 injuries of the RCL and UCL are treated with immobilization for 4 to 6 weeks. Grade 3 injuries (complete tears of the UCL) are typically treated with surgical repair or reconstruction depending on the time since injury. Grade 3 injuries have a high incidence of chronic instability when treated nonsurgically because of the forces across the joint with everyday use, and the relative frequency of Stener lesions. Grade 3 injuries of the RCL have shown a low incidence of Stener lesions but such cases have been reported.[30] Nevertheless, surgical repair is recommended for complete RCL tears as the adductor pollicis and extensor pollicis longus may otherwise cause excessive ulnar deviation and persistent instability.[31] Kottstorfer et al[32] retrospectively evaluated the outcome of patients with either grade 3 RCL tears or acute bony avulsions of the RCL. Of the grade 3 tears, 9 were treated nonsurgically and 3 patients did not regain full, painless range of motion and 2 required reconstruction. Conversely, of the bony avulsions, 21 were treated nonsurgically with no significant difference in ultimate functional outcome compared with the uninjured, contralateral side.

Repair technique for acute and subacute RCL and UCL tears is similar because the ligament is frequently avulsed from the bone and requires reattachment. The UCL is usually avulsed from the base of the proximal phalanx while the RCL avulses with equal frequency from the phalanx and the metacarpal head. Originally, a transosseous suture was tied over a button on the opposite side of the phalangeal base. Newer methods use bone anchors with equally good results and greater ease of use. Moharram[33] prospectively evaluated 27 patients with open UCL repair and found the joints were equally stable compared to the contralateral, uninjured thumb, and there were no implant complications. Crowley et al[34] compared the stability of suture anchor repairs treated with early controlled active mobilization to immobilization in 12 randomized patients. Though the sample size was small, they found no more complications in the early mobilization patients who regained maximum range of motion more rapidly.

There are a variety of surgical reconstructive options for chronic UCL injuries. Historically, using the ligament remnant beyond 3 to 6 weeks after the injury resulted in recurrent laxity postoperatively and only fair outcomes.[35,36] Tendon transfers for dynamic stabilization have been used, including extensor indicis proprius, extensor pollicis brevis (EPB), and adductor advancement or reattachment. Nevaiser et al[37] first described the use of the thumb adductor advanced into the base of the proximal phalanx in 18 patients, and they reported good results as long as there was no evidence of MCP joint arthrosis. Because this was a dynamic procedure, the potential for persistent passive laxity existed. Sakellarides et al[38] offered another dynamic option, transferring the distal insertion of the EPB tendon, with good mid-term results in 16 patients, two of whom had early arthrosis.[38] They suggested that this was a better option because it prevented further arthrosis rather than exacerbating that which was already present. Local tendon grafts from abductor pollicis longus and EPB can be used, but free tendon autograft reconstruction using palmaris longus is most common. We are not aware of the frequency with which dynamic reconstructions are used, but free tendon graft reconstruction for static stabilization is the preferred treatment because it seems to recapitulate the normal anatomy most closely.

Chronic RCL tears can be treated with similar reconstruction techniques. Direct repair, advancement of abductor pollicis brevis (APB), and free tendon grafting have all been performed. Iba et al[39] presented a new technique of RCL reconstruction in which the dorsal half of the APB tendon is left attached distally and inserted onto the radial side of the metacarpal head proximally (Fig. 1). In a small series of 8 patients, postoperative Disabilities of the Arm, Shoulder, and Hand questionnaire scores were low, grip and pinch strength were greater than preoperative levels, and there were 6 fewer degrees of motion of the MCP joint than preoperatively.

Numerous reconstruction configurations and surgical techniques have been evaluated for UCL and RCL injuries including figure of eight, triangular configuration, reverse triangular configuration, and rectangular. Lee et al[40] compared these 4 configurations biomechanically and found that all led to a stable MCP joint with valgus loading. The triangular configuration with apex proximal was the only one that restored range of motion similar to the normal MCP joint, however; others had varying degrees of flexion or extension loss. Martinez-Villen et al[41] evaluated 31 patients, 10 of whom underwent apex proximal reconstruction (Glickel modification[42]). They noted a 10° loss of flexion and an 8° loss of extension, which they note may have been from excessive tensioning of the graft. All patients returned to work and had 95.5% of key-pinch strength at final follow-up. Carlson et al[43] also tested an anatomical UCL and RCL reconstruction technique using palmaris longus tendon and bioabsorbable interference screws at anatomical origin and insertion sites (Fig. 2). In 30 cadavers, they tested MCP flexion with the native ligament, then after reconstruction. They noted no significant difference in MCP flexion after UCL or RCL reconstruction. The authors believe that interference screws allow an anatomical reconstruction without causing flexion loss.

Acute TMC dislocations and fractures are uncommon and usually result from axial loading of a flexed TMC joint. There is no consensus about optimal treatment. If the joint is stable, casting for 6 to 8 weeks may be sufficient. Others advocate closed

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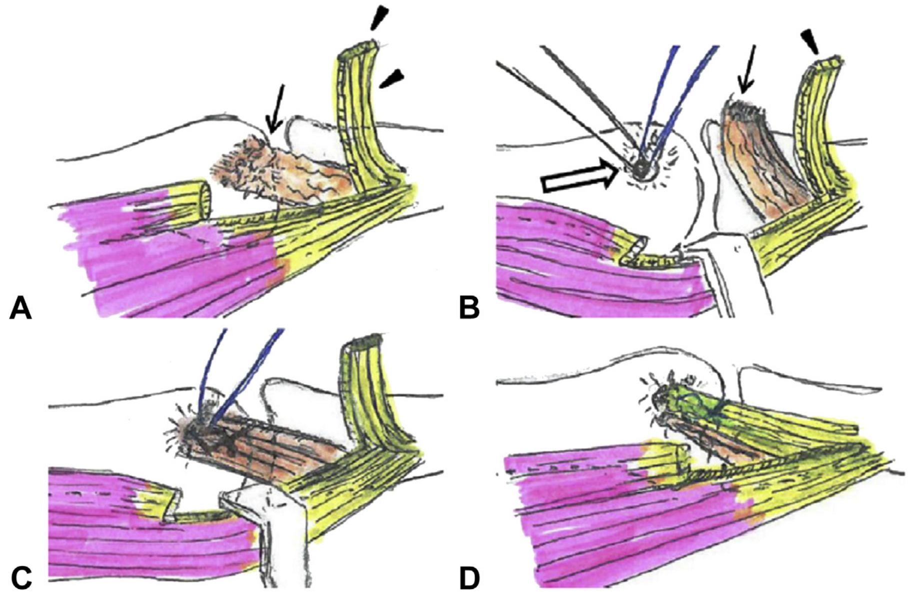

FIGURE 1: Diagram of the reconstruction method, showing **A**, **B** the dorsal half-slip of the tendinous component of the APB (arrowheads) and chronic RCL injury (black arrow); **B** the bone anchor with 2 nonabsorbable sutures on the lateral metacarpal head (white arrow); **C** the proximally advanced RCL fixed on the metacarpal head using a nonabsorbable suture of the bone anchor; and **D** a half-slip of the APB tendon fixed using another suture. (Reprinted with permission from Iba K, Wada T, Hiraiwa T, Kanaya T, Oki G, Yamashita T. Reconstruction of chronic thumb metacarpophalangeal joint radial collateral ligament injuries. *J Hand Surg Am.* 2013;38(10):1945−1950. Copyright © 2013, Elsevier Limited.)

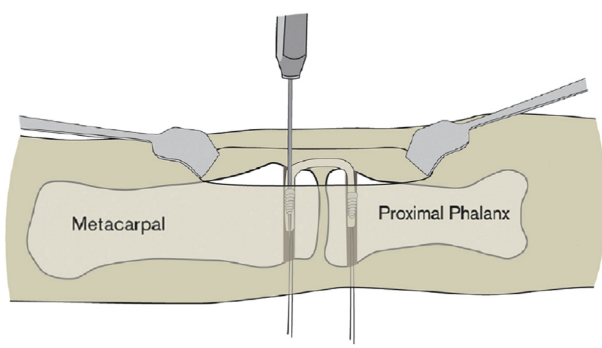

FIGURE 2: An interference screw is first placed in the phalanx. The graft is then tensioned with the MCP in 30° of flexion and the second interference screw is placed in the metacarpal. Sutures emanating from the contralateral side are cut off at skin level. (Reprinted with permission from Carlson MG, Warner KK, Meyers KN, Hearns KA, Kok PL. Mechanics of an anatomical reconstruction for the thumb metacarpophalangeal collateral ligaments. *J Hand Surg Am.* 2013;38(1):117−123. Copyright © 2013 Elsevier Limited.)

reduction and percutaneous pinning to stabilize the joint while the ligament heals. If the TMC joint is unstable after reduction, one treatment option is reconstruction of the anterior oblique ligament using half of the flexor carpi radialis tendon, which is left attached distally and passed through a gouge hole in the base of the thumb metacarpal from volar to dorsal. This functionally reconstructs both the AOL and DRL.[2] This technique may also be used for chronic TMC laxity, as long as there is no TMC arthritis that would be made more symptomatic by tightening the joint. Rayan et al[44] described a simpler, less morbid procedure to tighten the TMC joint based on the aforementioned studies, suggesting that the DRL is more important to TMC stability than the AOL. They performed dorsoradial capsulodesis of the redundant DRL tissue in patients with laxity and pre-arthritic Eaton stage 1 disease with good outcomes in all five patients.

Unlike the MCP joint with considerable arthritis, there are many surgical options for the arthritic TMC joint, ranging from simple synovectomy to arthrodesis. Silastic arthroplasty has been abandoned because of long-term failure rate due to osteolysis and synovitis. Arthrodesis has shown varied results. Retrospective studies show similar function and pain relief with arthrodesis compared to ligament reconstruction or trapeziectomy; with longer follow-up, however, these studies report complications and more frequent revision surgery.[45,46] A level 1 randomized controlled trial compared arthrodesis to trapeziectomy with ligament reconstruction. The study was prematurely terminated due to a markedly higher complication rate with arthrodesis. Because of this, the study was underpowered, but the results were telling, nonetheless; they reported moderate and severe complications of nonunion, delayed union, and chronic regional pain syndrome.[47]

Thumb ligament injuries are common given the inherent bony instability of the TMC and MCP joints. Much of our knowledge of the thumb TMC joint is based on early work by Eaton and Littler, and their understanding of the anatomy and surgical solutions that they devised and refined have withstood scrutiny and the test of time. Athough treatment algorithms have evolved slowly over the past 50 years, the current knowledge reviewed here should inspire the reader to think creatively about how we are diagnosing and treating these injuries and whether we can do so in a more efficacious and cost-conscious manner while providing patients with the best possible outcomes.

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JOURNAL CME QUESTIONS

Thumb Ligament Injuries

Which of the following statements is most accurate about the metacarpophalangeal joint anatomy of the thumb?

a. It is a hinge joint
b. It has the least inherent bony stability of the 3 thumb joints
c. It is the least complex of the 3 thumb joints
d. It is transitional between a ginglymus and condyloid joint
e. Its metacarpal head shape has no impact on joint motion

Which of the following statements is most accurate about the grade 3 ulnar collateral ligament injury of the metacarpophalangeal joint of the thumb?

a. Ultrasound has less than 50% sensitivity diagnosing this injury
b. Ultrasound is superior to magnetic resonance imaging in diagnosing this injury
c. Associated bony avulsion is usually from the head of the metacarpal
d. There is a low incidence of Stener lesions as compared to a radial collateral ligament injury
e. There is a high incidence of chronic instability when treated nonsurgically

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