Hand and Wrist

Ligamentous injuries of the hand

Zahab S. Ahsan[a] and Jeffrey Yao[b]

ABSTRACT

The carpometacarpal (CMC), metacarpophalangeal (MCP), proximal interphalangeal (PIP), and distal interphalangeal (DIP) joints of the hand are supported by highly intricate and functionally vital ligamentous structures. Injuries to these ligaments are very common. After injury to these ligaments, adequate management must be provided to maintain functional integrity of the digital joints. Most of these ligament injuries may be treated without surgery, but some will require operative repair. The ligamentous structures of interest include the CMC ligaments as well as collateral ligaments, volar plates, and flexor tendon pulleys of the MCP, PIP, and DIP joints. This article presents a review of recent literature pertaining to injuries of the aforementioned structures, with a focus on developments within the past 18 months.

Keywords
collateral ligaments, flexor pulley, hand injury, volar plate

INTRODUCTION

Ligamentous injuries of the hand constitute a multivariate clinical problem that is best approached in a timely manner to prevent irreversible changes that will prevent full functional recovery. Ligament injuries concomitant with hand fractures often are missed in the emergency department,[1•] which leads to delayed management. Intervention is determined on the basis of many factors that include but are not limited to patient age, comorbid health conditions, severity of injury, and likelihood of compliance with the postoperative therapeutic protocol. This paper presents a review of the previous 18 months of literature discussing ligamentous injuries of the hand.

THUMB COLLATERAL LIGAMENT INJURY

Collateral ligament injuries of the thumb metacarpophalangeal (MCP) joint are among the most commonly diagnosed hand injuries. Possible consequences include persistent joint instability, considerable pain, and disability. Eighty-six percent of all injuries to the base of the thumb include partial or complete tears of the thumb ulnar collateral ligament (UCL) of the MCP joint.[2•] A systematic approach to the ulnar and radial collateral ligaments of the thumb MCP joint is warranted to optimize therapeutic measures.

Patel *et al.*[3•] and Ritting *et al.*[4•] provided a clinical algorithm and a summary of the anatomy, evaluation, and management of collateral ligament injuries to the thumb MCP joint. The approach entails evaluation of the time elapsed since injury and incorporates important aspects, including concomitant fractures, avulsions, and joint surface integrity. Each of these variables influences the therapeutic protocol, including whether the treatment will be nonoperative or operative.

For patients with an acute grade III thumb UCL injury of the MCP joint, defined as a complete tear of the ligament, Michaud *et al.*[5•] have designed a novel hand-based splint that allows for a controlled amount of thumb MCP joint motion throughout daily activities. This design was based on the documented benefits of early active movement for ligament healing.[6] A 15-year retrospective evaluation of the splint showed early pain relief and effective recovery with full-time wear. Complications of the splint included tube breaking, low, variable, or deficient patient compliance, and skin irritation. Construction of the splint requires only Polyform (Sammons Preston, a Division of Patterson Medical, Bolingbrook, IL), Aquatube (Sammons Preston, a Division of Patterson Medical, Bolingbrook, IL) and Velcro (Velcro USA Inc., Manchester, NH). A full technique of splint design was presented in the article. Management with this splint would not be recommended for a patient with a Stener lesion, which refers to a complete UCL tear of the thumb MCP joint with adductor pollicis aponeurosis interposition. This interposition prevents apposition of the torn end of the UCL to the proximal phalanx, and healing is prevented. These injuries should universally be treated with operative repair.[7] Doty *et al.*[8] presented a case report of a radial collateral ligament tear of the thumb MCP joint with the proximal portion of the of the radial collateral ligament (RCL) interposed with the abductor aponeurosis, producing a Stener-like lesion. Operative treatment is indicated for this injury.

For UCL injuries requiring soperative intervention, these ligaments typically are avulsed from the base of the proximal phalanx. Intraligamentous suture repair rarely is possible because of the avulsion of the ligament from the

[a]*Indiana University School of Medicine, West Lafayette, IN*
[b]*Stanford University Medical Center, Redwood City, CA*
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Correspondence to Jeffrey Yao, MD, Stanford University Medical Center, 450 Broadway Street, Suite C442, Redwood City, CA 94063
Tel: +650 721 7635; fax: +650 721 3470;
e-mail: jyao@stanford.edu

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bone, and the ligament must be repaired back down to bone. Although interosseous suture technique remains a viable option, the use of mini bone anchors is the most common technique for repairing the UCL. Newer bone anchors are now available for these repairs. The 2.5-mm PushLock suture anchor system (Arthrex Inc., Naples, FL) is an alternative to the conventional Bio-SutureTak suture anchor (Arthrex Inc., Naples, FL), which allows the surgeon the option of using different types of sutures for the anatomic fixation of a ligament before placement of the anchor into the bone. Jarrett *et al.*[9••] conducted a biomechanical analysis of the 2.5-mm PushLock suture anchor for the repair of thumb UCL injuries of the MCP joint. The 2.5-mm PushLock suture anchor was found to be less likely to fail at the suture-ligament interface and required a statistically greater force to generate a 2-mm gap at the repair site. The comparisons were made in identical biomechanical environments to minimize variables; this study was limited to cadaver testing that did not involve or include physiological healing *in vivo*.

Thumb UCL injuries often are neglected in the acute setting, with patients seeking medical advice late after the UCL rupture has become chronic. Typically, the ligament is no longer repairable 8 weeks beyond the injury. Many treatment options exist for chronic UCL ruptures, most commonly involving static ligament reconstruction with free tendons or arthrodesis of the MCP joint if arthrosis has developed.

Current methods of postoperative follow-up involve physical examination and radiographs. These methods are limited in their ability to assess recovery in the early phase because of the restrictions of physical evaluation of ligament integrity for the first several months and because the ligament cannot be seen on radiograph. The use of MRI was studied for postoperative assessment of patients treated for chronic rupture of the UCL of the thumb with a free tendon graft reconstruction.[10•] Preoperative and postoperative MRI radiographs were obtained at 2, 12, and 24 months in an effort to determine if MRI was useful in follow-up. The images provided excellent visualization of the ligament reconstruction with the coronal T2TSE without fat suppression as the most useful image sequence. It was recommended that only patients with a suspected postoperative graft failure undergo follow-up MRI for the prudent use of resources.

Stress testing is a standard technique for the diagnosis of ulnar and radial collateral ligament tears at the MCP joint of the fingers. Lee *et al.*[11•] presented a case report for a locked MCP joint that occurred after stress testing to evaluate a RCL and volar plate injury. Operative treatment was necessary in this case. The patient was brought to the operating room to correct the problem and repair the ligament. Intraoperative findings revealed an RCL and posterior capsule tear with the proximal end of the RCL entrapped between the metacarpal head and proximal phalanx. Because of this possible consequence of incarceration of the ligament and subsequent joint locking, it is encouraged that stress testing be performed with caution in suspected RCL and UCL injuries of the thumb MCP joint.

FINGER COLLATERAL LIGAMENT INJURIES

Operative intervention typically is not indicated for finger collateral ligament injuries as conservative treatment typically yields a satisfactory result. Operative correction may be necessary in cases of failed conservative management or chronic symptomatic instability. Dislocation of the proximal interphalangeal (PIP) joint may lead to rupture of the UCL or RCL of the PIP joint, with avulsion of the volar plate possible upon hyperextension. Mantovani *et al.*[12••] provided a case report describing the reconstruction of the PIP joint UCL with a palmaris longus tendon autograft for chronic instability in a high-performance athlete. This technique was employed to achieve global stability of the PIP joint without altering normal joint biomechanics and allowed for the conservation of normal anatomic orientation, yielding a possible option for the treatment of high-performance athletes who rely on maintenance of joint stability while retaining a full range of motion. Surgical alternatives to palmaris longus autograft reconstruction include arthroplasty and arthrodesis, which both alter the functionality of the joint. In the described case, complete recovery of function was observed. At 4 years, no deformity was visible, and the patient exhibited a full range of motion and grip strength nearly equal to the contralateral side. Further study in a greater number of patients is required before widespread acceptance of this technique for reconstruction of this challenging joint.

To further understand the neurophysiological function of the human PIP joint, Chikenji *et al.*[13•] performed a quantitative analysis of the distribution of encapsulated nerve endings in the PIP joint. Immunohistochemical techniques were used to detect type I (Ruffini), type II (Pacini), and type III (Golgi) nerve endings in the PIP joint and surrounding structures in 12 fresh cadavers. The central slip and lateral bands of the extensor mechanism, collateral ligaments, volar plate, and pulleys were included in the evaluation. Results indicated the presence of only types I and type II nerve endings in the PIP joint, with a higher density of nerve endings observed in the proximal region of the joint. Physiologically, type I nerve endings are low-threshold, slowly-adapting receptors that sense stretch while type II nerve endings are low-threshold, rapidly-adapting receptors that respond to pressure and vibratory stimuli. Type I nerve endings were found in the highest density at the volar plate of the PIP joint, suggesting that the stretching of the volar plate is sensed during PIP joint hyperextension. Type II nerve endings were highest in density in the collateral ligaments, indicating mechanical sensation from the C1 pulley during finger movement.

VOLAR PLATE INJURY

Traumatic volar plate injuries of the PIP commonly are caused by hyperextension. Yoong *et al.*[1•] presented the volar plate avulsion fracture as an injury not to be missed in the emergency department because of the risk of substantial loss in joint mobility, chronic dorsal instability, and increased likelihood of early arthrosis. A diagnostic algorithm was presented for efficient identification of the injury. Lateral

views were key for the diagnosis of a subtle subluxation of the PIP joint, which may be identified by the "V" sign on the true lateral radiograph. The "V" sign is described as a crescent-shaped gap at the dorsal aspect of the PIP joint, in which the joint surfaces are neither parallel nor congruent (Figure 1).[14]

While early recognition and treatment are indicated for a good outcome, patients often present weeks after the initial injury, or the injury may be missed upon initial consultation. Povlsen and Singh[15•] discussed the issue of late nonoperative treatment of volar plate injuries. A total of 16 injuries are presented with a mean follow-up of 27 days (range 14–79 days); six sustained a dorsal dislocation, five were volar avulsion fractures, and the remaining five were classified solely as hyperextension. Patients were treated with a static extension block splint set a 20° flexion for the first 2 weeks, after which it was remolded to neutral and was worn full time for the first 6 weeks. If a fixed flexion contracture formed after 6 weeks, a dynamic extension splint was used. Outcomes were assessed in terms of range of motion and extension lag. The patients displayed a mean improvement in range of motion of 25° (range 2–52°) with mean residual extension lag of 10° (range −4–56°). It was concluded that a good outcome without operative intervention is possible despite the delay of presentation up to 4 weeks after initial injury. PIP joint injuries have been classified as hyperextension (type I), dorsal dislocation (type II), and fracture dislocation (type III).[16] Patients presenting with type I and stable postreduction type II injuries of the volar plate may fully recover if provided with management from a qualified hand therapist. However, the chance of extension lag development increases with an increase in delay of presentation.

Melone *et al.*[17•] investigated the long-term functional outcome of isolated volar plate repairs for chronic dorsal instability of the PIP joint. The initial trauma typically is an avulsion of the volar plate from its distal insertion on the middle phalanx from a hyperextension force coupled with lateral deviation. Their technique and retrospective review of 25 patients having undergone volar plate advancement of the PIP joint is presented. The surgical technique entails a Brunner incision at the volar aspect of the PIP joint followed by an incision of the flexor sheath between the A2 and A4 pulleys, retraction of the flexor digitorum superficialis and flexor digitorum profundis tendons, and meticulous scar debridement of the volar plate. A shallow trough is created in the base of the middle phalanx and absorbable traction sutures are secured to the widest margins of the volar plate and passed through the middle phalanx with the use of Keith needles. The joint is transfixed at 15° of flexion with a 0.35-mm Kirschner wire. Maximal tension is applied, the volar plate advanced, and the sutures tied on the dorsal surface of the middle phalanx. The joint is immobilized for 3 weeks, at which point the Kirschner wires are removed and extension-block splinting is continued for 6 weeks. Their results indicate a consistent recovery of joint stability and improvement of pain symptoms. Mean range of motion improved from 69° to 86° postoperatively with grip strength recovery to 90% of the contralateral side. The mean Disability of the Arm, Shoulder, and Hand (DASH) score was 5.6 at the final follow-up. No recurrence of the abnormality was noted with all subjects returning to full occupational and athletic endeavors.

To better understand the physiology of the PIP joint, Saito and Suzuki[18•] used ultrasonography to conduct a biomechanical study of the PIP volar plate. They identified three main phases of volar plate motion during finger flexion. First, the volar plate slides proximally along the condylar slope of the proximal phalanx. Upon reaching 30° of joint flexion, the second phase constitutes and elevation phase in which the most distal part of the volar palte elevates volarly. The third phase consists of the lip of the middle phalanx rolling dorsally into the recess. A force from the A3 pulley likely induces the elevation step of the volar plate.[19] This is verified in pathologic volar plate motion lacking elevation in patients with an A3 pulley release.

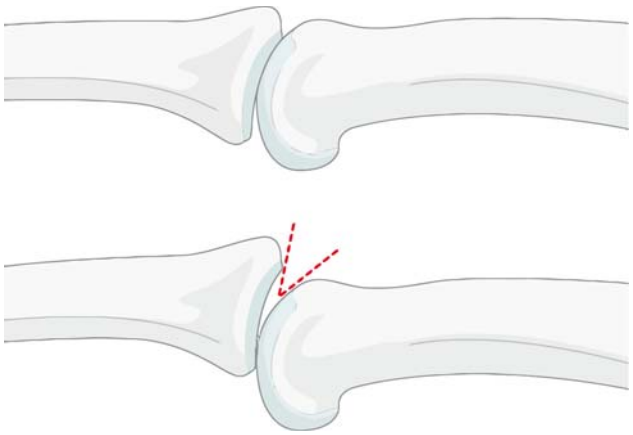

FIGURE 1. V sign. The normal appearance of the joint is seen in the figure above. Below, after a proximal interphalangeal (PIP) joint injury, a crescent-shaped gap at the dorsal aspect of the PIP joint in which the joint surfaces are neither parallel nor congruent is visible.

FLEXOR PULLEY INJURY

Annular pulley injury previously has been reported in rock climbers from use of the crimping grip (hyperextended distal interphalangeal [DIP] joint with a flexed PIP joint) coupled with a loss of balance and eccentric load on the fingers.[20•,21] A series of A4 pulley ruptures in baseball pitchers also has been reported.[16] Repetitive extension trauma from the fastball pitch commonly involves the long finger. Physicians should be cognizant of this possible injury, as an early diagnosis will permit a shorter treatment course. Diagnosis is made through physical examination followed by MRI confirmation. Imaging of the digit in flexion and comparison to the contralateral side allows for observation of volar subluxation of the flexor digitorum profundis tendon covering the middle phalanx. Patients are prescribed a treatment regimen, including rest, ice, pulley splinting (splints placed over the injured pulley to provide support, Figure 2), and nonsteroidal anti-inflammatory drugs (NSAIDs). At least a 2-week rest period is recommended, followed by an interval-throwing program with a

FIGURE 2. Pulley splint. Provides support directly over the A2 (pictured) or A4 pulley.

protected finger and a full return to competition at 6–12 weeks.[8]

Stenosing synovitis of the flexor pulley may result in painful triggering. AFterfailed conservative management (corticosteroid injections, trigger splints, NSAIDS), A1 pulley release often is indicated. Smith *et al.*[22•] assess the safety of sonographically guided percutaneous finger and thumb A1 pulley release with the needle and knife techniques. Efficacy and safety were evaluated based on injury to neurovascular bundles and the completeness of the A1 pulley release in cadaver specimens. After the release of 40 fingers and 10 thumbs with each method, no neurovascular injury, major tendon laceration, or A2 pulley injury was noted. Knife releases displayed an increased likelihood of anatomically complete A1 pulley release compared with the needle technique. The authors concluded that the sonographically guided percutaneous releases are safe and should be considered in the treatment algorithm of trigger fingers.

CARPOMETACARPAL (CMC) LIGAMENT INJURY

The mainstay of management for CMC joint dislocation is reduction of the joint, although the optimal treatment remains controversial. Fotiadis *et al.*[23•] reported an acute isolated thumb CMC dislocation treated with ligamentous reconstruction of the dorsal capsule. The CMC joint capsule was repaired in an end-to-end fashion with 3-0 Vicryl interrupted sutures. At 3-year follow-up, the patient displayed a full recovery of function. The authors concluded that CMC dislocation should be treated operatively with dorsal capsulorraphy and ligament repair.

On the contrary, according to Okita *et al.*,[24•] if the CMC joint is stable after reduction and manipulation, cast immobilization is an adequate treatment for CMC dislocation. If unstable, pinning on the day of injury is sufficient, and ligament reconstruction is needed if repair is delayed by 2 weeks. This approach remains the current standard of care.

It has been reported that increased CMC joint laxity correlates with the risk of ligament injury.[25•] One-hundred and sixty-three patients were assessed for CMC laxity by stress view radiography. The study indicated that a greater generalized laxity significantly correlated with a higher radiographic stress view ratio and also may present a predisposition for the later development of CMC osteoarthritis.

CONCLUSION

Ligamentous injuries of the hand very commonly are seen in a hand surgeon's practice. While most injuries may be treated nonoperatively, in select patients, operative management may be indicated. The recent literature discusses new treatment options as well as highlights the recent advances in imaging of these intricate structures.

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