

ROLE OF MR IMAGING IN THE MANAGEMENT OF "SKIER'S THUMB" INJURIES

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Injury to the ulnar collateral ligament (UCL) of the thumb metacarpophalangeal (MCP) joint is commonly associated with skiing. *Skier's thumb* is an acute rupture of the UCL of the MCP joint. When the ruptured UCL is displaced superficial to the adductor aponeurosis (Stener lesion), the interposed aponeurosis may interfere with ligament healing. Open surgical treatment has been recommended to repair displaced UCL tears in the presence of a Stener lesion. Frequently, a ruptured UCL can be identified by the presence of a bony avulsion. Some authors believe that identification of a Stener lesion with no avulsed bony fragment cannot be predicted with high sensitivity and specificity by clinical examination, arthrography, or stress films. Some reports, however, have indicated successful identification of the Stener lesion.¹ The lack of agreement about sensitivity and specificity of available diagnostic procedures for Grade III UCL thumb injuries makes this injury and its treatment controversial. This arti-

cle discusses our knowledge of UCL injuries and how MR imaging, with shortening scan times and decreasing cost, can be used to accurately diagnose acute Stener lesions associated with skier's thumb and avoid unnecessary surgery.

HISTORY

Petitpierre first associated UCL injuries of the thumb MCP joint with skiing in 1939.²⁴ In 1955, Campbell⁵ described chronic laxity of the thumb UCL in 24 Scottish gamekeepers. He determined that this injury was caused by repeated, excessive stress placed on the UCL. In 1981, Gerber et al¹⁰ coined the term *skier's thumb* and applied this to an acute injury of the UCL of the MCP joint.

ANATOMY

The thumb MCP joint is a diarthrodial ginglymoid joint. The fibrocartilaginous struc-

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ture of the MCP palmar plate is unique and opposite to that of the digital proximal interphalangeal (PIP) joints. The distal two thirds of the MCP fibrocartilage is thick and the proximal one third is thin; in contrast, the distal palmar plate of the digital PIP joints is thin and the proximal plate is thick. The thin area of confluence is known as the *pars flaccida*. The sesamoids are located in the volar plate at the insertions of the flexor pollicis brevis and the adductor brevis.

The UCL originates from the MCP head, passing in a proximal-dorsal to distal-palmar direction to insert on the lateral tubercle of the proximal phalanx. The UCL is 4 to 8 mm in width, with an average length of 12 to 14 mm. The accessory collateral ligament originates superficially and in a palmar fashion to the UCL proper and blends distally with the palmar plate (Fig. 1). The adductor pollicis has three insertions: (1) the ulnar sesamoid and palmar plate; (2) the lateral tubercle of the proximal phalanx; and (3) the dorsal expansion. The insertion confluent with the dorsal expansion hood and superficial to the

UCL is the adductor aponeurosis, which becomes continuous, distally, with the extensor pollicis longus (EPL) tendon.

MECHANISM AND INCIDENCE OF INJURY

Skier's thumb is the most common upper extremity injury in skiing and is second only to knee medial collateral ligament injury when reporting skiing injuries.^{21, 25, 30} The incidence of UCL injuries ranges from 35% to 80% of all upper extremity injuries, and UCL injuries occur eight times more frequently than radial collateral ligament injuries of the MCP joint.^{21, 25, 30}

Understanding this injury has plagued many clinicians. In 1982, Engkvist et al¹⁹ found that when a fall occurs, release of the ski pole at impact forces the thumb into abduction and extension, creating a tear or rupture of the UCL (Fig. 2). Ski pole type (conventional or strapless grip) does not contribute to the frequency of this injury.¹⁹

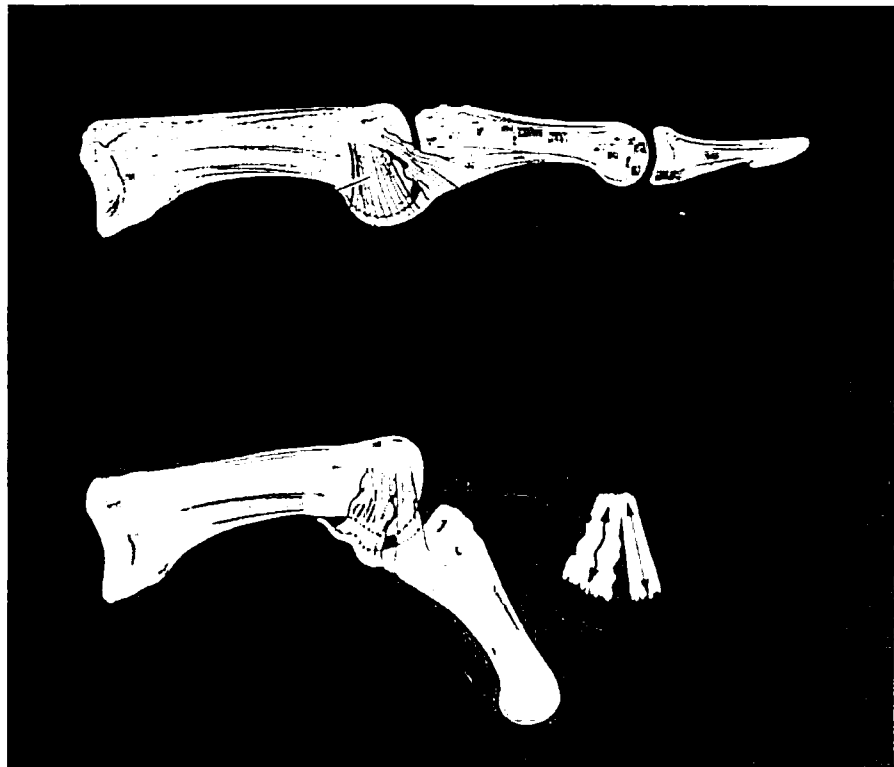


Figure 1. The ulna collateral ligament (proper and accessory).

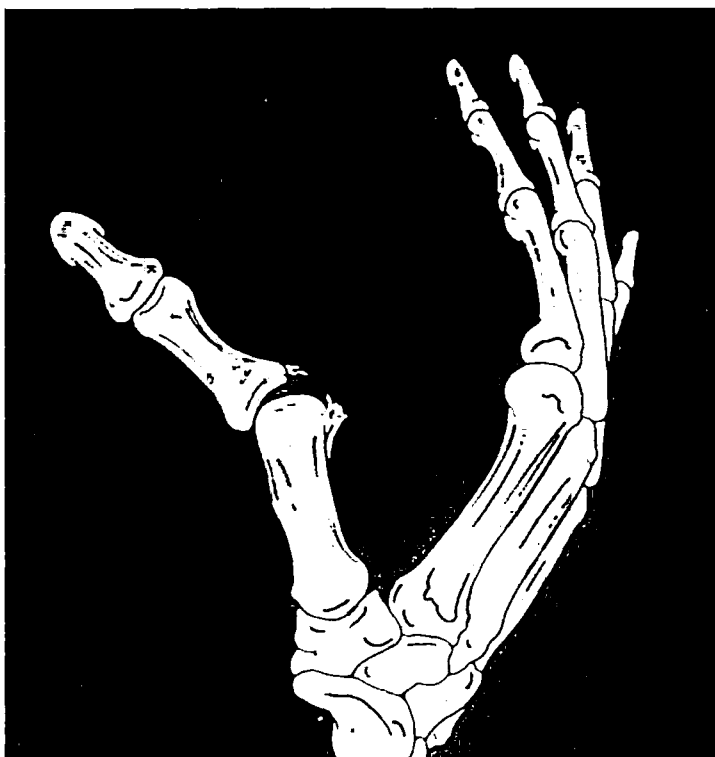


Figure 2. Ulna collateral ligament (UCL) tear from a mechanism of thumb abduction and extension.

DIAGNOSIS

Thumb MCP range of motion is highly variable: 10° to 100° in flexion, with an average of 75° ; and 0° to 90° in extension, with an average of 20° . Coonrad and Goldner⁷ found passive abduction of the thumb to be approximately 0° to 20° with a mean of 10° . Because the accessory collateral ligament is taut in extension and loose in flexion, the position of the joint when abduction stress is applied will determine which ligament is tested. The thumb flexion angle is therefore an important factor in the physical examination of the UCL.

Previously, it was believed that the UCL proper was taut in flexion, whereas the accessory UCL was taut in extension. Metacarpophalangeal laxity in extension was attributed to an accessory UCL injury and MCP laxity in flexion was attributed to a UCL proper injury. Adams and Muller,² however, showed that both accessory UCL and proper UCL strain are proportional to the MCP flexion angle.

According to Smith, because the ligament origin on the MCP is dorsal to the flexion-extension axis and inserts into the proximal phalanx palmar, the collateral ligaments give dorsal support to avoid palmar subluxation of the proximal phalanx.²⁶ In chronic UCL injuries, the supinated deformity is seen as a rotational event, often with palmar subluxation of the proximal phalanx, and should be looked for on a lateral radiograph or during physical examination.

CLINICAL TESTING

Moberg²⁰ showed in a cadaveric study that the UCL will rupture under 15 to 20 kg of pressure. An examiner is unlikely to generate such a force in vivo; therefore, examiner conversion of a stable skier's thumb to an unstable thumb is unfounded, even with the use of anesthesia. In addition, dynamic stabilizers, such as the palmar plate and proximal phalanx insertions of the adductor pollicis, will

help avoid the creation of a Stener lesion by manipulation.

The essential lesion in skier's thumb is an acute rupture of the UCL. In sectioning studies, transection of the UCL resulted in an average of 42° of radial MCP laxity.^{15, 22} These studies also revealed that the adductor aponeurosis does not contribute to MCP stability.

Stener²⁹ recognized that the adductor aponeurosis often becomes interposed between the damaged ligament and the attachment site on the proximal phalanx. Stener noted that 25 of 39 patients (64%) presented with soft-tissue interposition and that this anatomic derangement prevented UCL healing. Although the UCL can be torn midsubstance, he found that it was most commonly torn at its origin or insertion, with a distal-to-proximal ratio of 5:1. Many studies reflecting differences in surgical criteria and diagnostic techniques have found a difference in Stener lesion incidence ranging from 14% to 66%.^{1, 15, 18, 22, 26}

Allred³ and Abrahamsson et al¹ have each shown that swelling over the dorsal ulnar aspect of the MCP joint is associated with the Stener lesion and complete UCL rupture.^{1, 3, 12, 26} These clinicians found that a tender palpable prominence over the ulnar aspect of the MCP is an indication for surgical repair. In a prospective study of 24 patients, Abrahamsson et al¹ operated on only those patients presenting with a tender palpable mass, and although radiographic stress testing was performed on all patients, the results were not used to determine which patients were treated surgically. Seven of eight patients treated surgically had gross instability and four of 16 nonoperative patients had gross instability. Because both groups had good results, Abrahamsson et al concluded that the presence of a palpable MCP mass could be used to determine necessity of surgical treatment. In their prospective clinical study, however, Heyman et al¹⁴ found that an MCP palpable mass was 100% sensitive for the diagnosis of a Stener lesion but only 46% specific. Therefore, Heyman et al concluded that the absence of a palpable MCP mass does not rule out a Stener lesion.

The position of the MCP joint is an important factor in clinical stress testing of the UCL. Heyman et al¹⁴ have shown that normal MCP radial stress laxity ranges from 7° to 25°, with an average of 16° in extension and 30°

in flexion. There is disagreement in the literature as to the amount of laxity in degrees and to the range of motion in which the testing accurately indicates UCL rupture. Some authors advocate extension testing, some advocate flexion testing, and some still advocate both. Heyman et al¹⁴ indicated that ligament disruption and displacement are likely if extension instability is greater than 35° and laxity is greater than 15° in the injured versus the noninjured thumb. Eaton and Dray⁷ and Palmer and Louis²² both concur with Heyman et al and recommend clinical testing of the thumb MCP joint at 35° of flexion. Abrahamsson et al¹ believe that testing at greater than 30° of flexion will reveal a rupture. Several authors believe that a difference of 15° in laxity between the injured and noninjured thumb is sufficient to indicate a complete UCL rupture. Smith,²⁰ however, used a 45° side-to-side difference in laxity in limiting the test to a Grade II UCL tear. Unfortunately, to date, no study has shown the specificity and sensitivity for comprehensive stress testing of the MCP joint of the thumb in determining existence or extent of UCL rupture (Fig. 3).

Determining the type of end point (soft or firm) is essential in the diagnosis of UCL rupture. Many authors believe that a soft end point will result in an accurate diagnosis.¹⁹



Figure 3. Stress testing in a patient with an UCL tear.

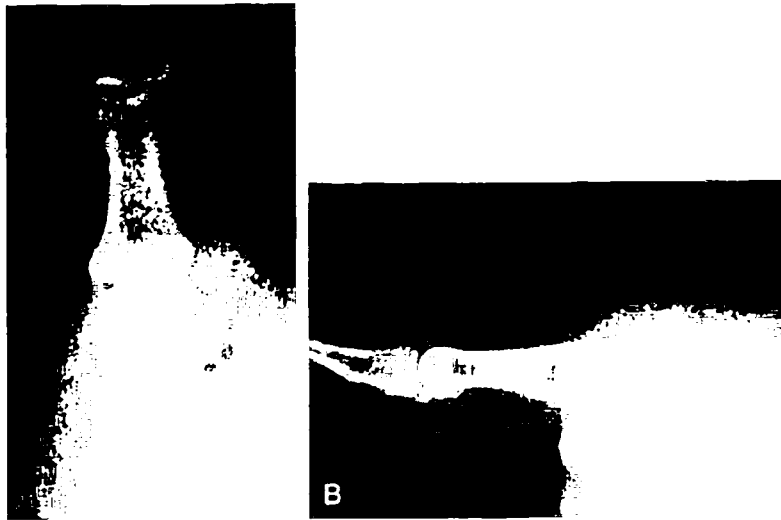


Figure 4. Typical anterior posterior (A) and lateral view (B) radiographs showing volar subluxation, in a patient with an UCL tear.

Heyman et al¹⁴ found that many surgeons prefer to flex the thumb MCP to 15° and compare the abduction opening or valgus laxity with that of the contralateral thumb. Miller¹⁹ and Abrahamsson et al¹ found that several surgeons will operate with absolute laxity measurements of 30° of valgus instability.

STRESS RADIOGRAPHS

Clinical estimates of radial stress laxity have been found to be 5° to 15° greater than radiographic measurements; it should be noted that radiographs are difficult to obtain with the MCP joint in flexion. Guidelines have shown that a normal radiograph of stress testing reveals 0° to 4° of abduction, a mild laxity of 5° to 10°, moderate laxity of 11° to 30°, or a severe laxity of greater than 30° of abduction (Fig. 4).

Some authors have described stress testing as an effective means for establishing a diagnosis for UCL injury to the thumb MCP joint. Heyman et al¹⁴ concluded that the presence of a palpable mass at examination, instability in extension greater than 35°, and 15° greater laxity side-to-side difference in the thumb (89% incidence of Stener lesions) indicates accessory and proper UCL ligament disruption (Fig. 5).

ARTHROGRAPHY

Several studies have addressed the diagnosis of UCL injury with arthrography.³ The procedure is simple to perform by injecting 0.5 to 1 mL of 60% Renografin (Renografin-60, Bracco Diagnostics, Princeton, NJ), mixed with or preceded by 0.5 mL of 1% lidocaine HCL (Xylocaine, Astra Merck, Wayne, PA), into the MCP joint via a dorsoradial ap-



Figure 5. Stress radiograph in a grade III UCL tear.

proach.¹⁸ If there is a complete UCL rupture, the dye may be seen leaking on the ulnar side of the capsule in the adductor tendon, indicating a Stener lesion. Arthrography can help discriminate a partial tear versus a complete rupture of the UCL and, as stated previously, identification of a Stener lesion. No studies have correlated arthrography results with operative findings, however, nor has any study established reliability or sensitivity and specificity of this procedure. The procedure, although helpful, is obviously invasive.

MR IMAGING

MR imaging is the method of choice when exploring and diagnosing soft-tissue injuries and has been shown to be useful in the evaluation of thumb UCL injuries. In cadaver studies, Spaeth et al²⁷ and Hinke et al¹⁵ used MR imaging to accurately identify UCL tears and to discriminate between nondisplaced UCL injuries and Stener lesions. If MR imaging proves to be both sensitive and specific in defining the pathoanatomy associated with UCL injuries, then the care of patients with acute UCL injuries could be significantly improved. The authors have performed a study to determine the reliability of an MR imaging diagnosis of skier's thumb with an associated Stener lesion.

Materials and Methods

A double-blind prospective, cross-sectional study involving 34 subjects was performed. Admission into the study required the surgeon to determine by usual standards (clinical guidelines, stress testing, palpable mass) that the thumb was a Grade III UCL tear that needed surgical repair. Twenty-five patients were admitted to the study and the remaining nine subjects were noninjured volunteers. There were 20 women and 14 men, with a mean age of 35 years (range 13–69 years). The 19 right-hand thumb patients and 15 left-hand thumb patients underwent preoperative MR imaging. The results were not revealed to the patient or the surgeon. All Internal Review Board forms were completed prior to the examination and no patient incurred any cost for additional testing.

MR images of the MCP joint were obtained with a 0.5 T MR imaging system (T5, Phillips

Gyrosan, Shelton, CT, 0.5 Tesla Magnet). The patient was placed on the scanning table with the injured thumb on the patient's side or prone on the table with the arm and injured thumb overhead, as tolerated by the patient. The injured hand was positioned such that the coronal plane of the thumb lay parallel to the table top. A 3-inch circular surface coil was centered on the thumb MCP joint. The thumb position was as close to the isocenter of the magnet as allowable. T1-weighted axial images and gradient-echo T2*-weighted coronal images were aligned along the planes of the MCP joint of the thumb, using a 256 × 192 matrix, 3-mm slice thickness, and a 0.3-mm interslice gap. Two signal acquisitions were performed for each sequence. Total examination time, including setup, positioning, and two image sequences, was 20 minutes.

Four blinded experienced radiologists were instructed to review the 34 MR imaging sequences and indicate evidence of a distal avulsion or proximal avulsion; a tear, with or without a Stener lesion; or a noninjured thumb (no tear). The radiologists were then instructed to review radiographs and stress test results. If the secondary review did not agree with the MR imaging indication, the difference was noted. The indication of absence or presence of a Stener lesion was then compared with the surgical findings in the 25 injured patients.

The sensitivity, the probability of indicating a Stener lesion given that the patient does have a Stener lesion, and the specificity, the probability of nonindication given that the patient does not have a Stener lesion, were then calculated for each radiologist. Positive predictive values, the probability that a patient has a Stener lesion given a positive test, and negative predictive values, the probability that a patient does not have a Stener lesion given a negative test, were also calculated for each radiologist.

Results

Of the 19 Stener lesions diagnosed by surgical procedure, 15 were distal soft-tissue avulsions, three were distal bony avulsions, and one was a midsubstance tear. Sensitivity ranged from 89.5% to 100% and specificity ranged from 86.7% to 100%. The interclass correlation coefficient, a measure of the reliability of the MR imaging measurements, was



Figure 6. MR image coronal view of normal patient (A) and patient with grade III UCL tear (B).

84.8%, with a 95% confidence interval. The positive predictive values ranged from 90% to 100% and the negative predictive values ranged from 88% to 100% (Figs. 6 and 7).

Discussion

Numerous studies on UCL injuries of the MCP joint of the thumb have been published

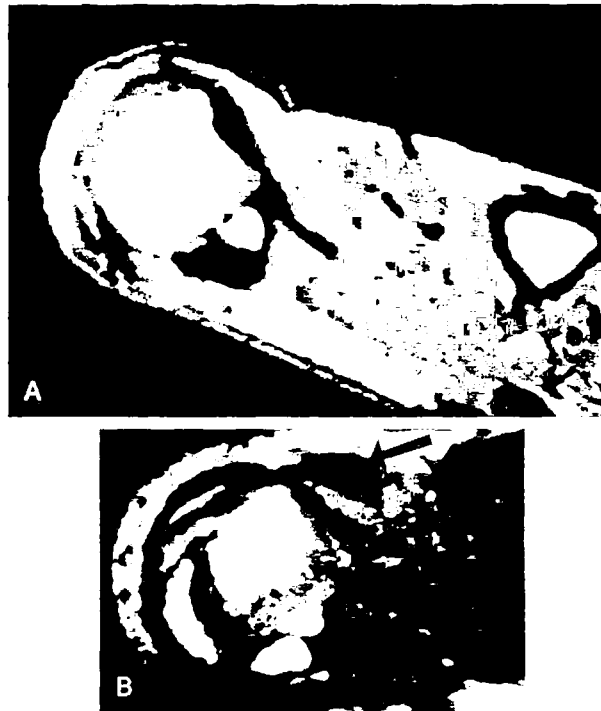


Figure 7. MR image axial view of normal patient (A) and patient demonstrating a Stener lesion (B) with the proximal UCL remnant (arrow) displaced superficial to the adductor aponeurosis.

since Petitpierre's 1939 report.²⁴ Even though MR imaging has been in use since the early 1980s, few authors have studied its sensitivity and specificity in diagnosing the Stener lesion. The results of this study, however, are consistent with the few authors that have reported on the use of the MR imaging in assessing UCL injuries.^{18, 28}

Spaeth et al²⁸ evaluated the use of MR imaging in discerning displaced versus nondisplaced UCL tears in cadaveric specimens.²⁸ They found sensitivity and specificity to be 100% and 94%, respectively. They further concluded that MR imaging indication of ligament displacement is good and appears to be highly sensitive in the diagnosis of a ruptured UCL.

In another cadaveric study, Hinke et al¹⁵ reported that Stener lesions could be differentiated from non-Stener lesions in 73% of subjects. They also concluded that MR imaging depicts the UCL and adductor aponeurosis well and accurately shows both tears of the UCL and Stener lesions.

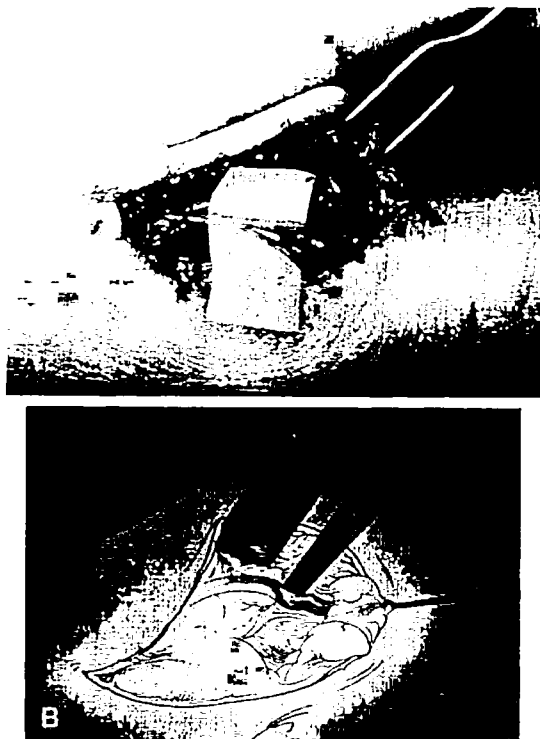


Figure 8. A and B, Dorsal ulna sensory nerve of the superficial radial nerve in a patient with a UCL tear.

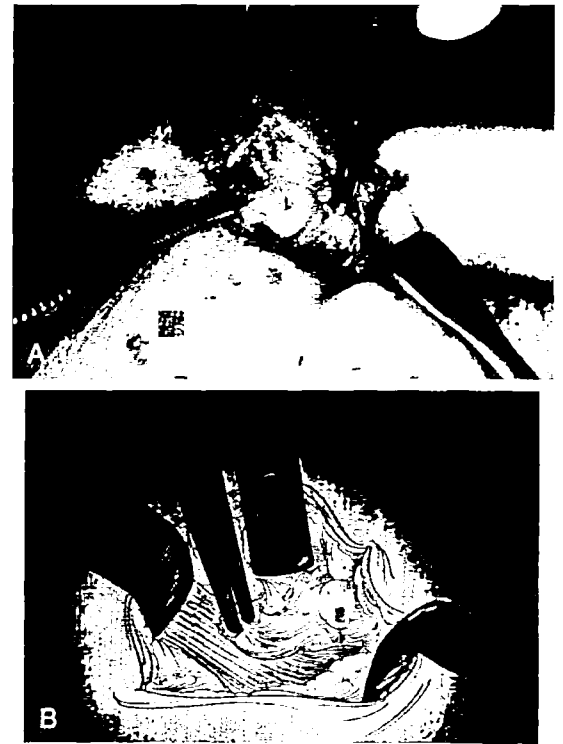


Figure 9. A, Right thumb with a Stener lesion in the Adson forceps. B, Left thumb with Stener lesion in the forceps.

Louis and Buckwalter¹⁸ studied MR imaging and its use in detecting UCL injuries. They found that in two of three cases, MR imaging confirmed the complete UCL rupture with distal avulsion and proximal displacement consistent with a Stener lesion. The authors concluded that MR imaging is effective in evaluating soft-tissue injuries with "a degree of clarity not possible with previous imaging techniques," such as arthrography and stress radiographs.

In an effort to confirm these findings, Harper et al¹¹ studied the efficiency of MR imaging, MR arthrography, and stress radiography in differentiating UCL tears in 14 patients with UCL injuries. They found that stress radiography results were often falsely negative and they were not able to discern between displaced and nondisplaced tears.¹¹ MR arthrography accurately diagnosed 13 of 14 UCL tears (93%), with a sensitivity of 100%.¹¹ MR imaging, however, was found to be the most reliable device in differentiating among normal, displaced, and nondisplaced

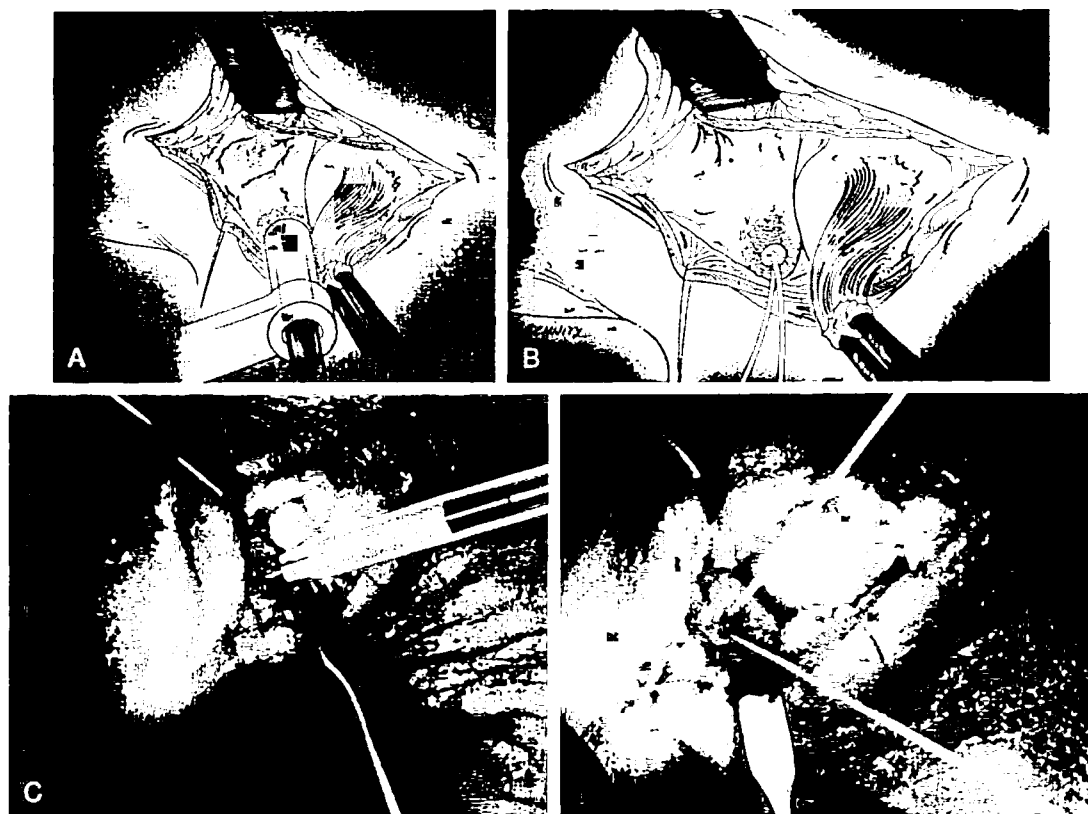


Figure 10. A, Right thumb with drill in place for mini-anchor. B, Sutures of mini-anchor coming out of the proximal phalanx in a left thumb. C, Left thumb with mini-anchor in place. D, Left thumb with sutures of mini-anchor protruding from the proximal phalanx.

UCL tears, with 100% sensitivity and specificity.

Hergan et al¹³ studied the usefulness of ultrasound and MR imaging in the differentiation of displaced and nondisplaced UCL tears. They reported that ultrasonography correctly identified tears in 15 of 17 patients (88%), whereas the sensitivity and specificity of MR imaging were 100%.¹³ Hergan et al concluded that both ultrasonography and MR imaging are useful in evaluating UCL tears, but that MR imaging is more effective in accurate indication of a UCL tear.

Surgical Intervention

Surgical intervention is best illustrated by the procedure the authors used in repair of a UCL tear in a patient with a positive MR

image and a Stener lesion. The dorsal ulna sensory branch of the superficial radial nerve is identified and protected with the skin incision. The Stener lesion is then identified. The adductor aponeurosis is cut at 90° to its fibers. The MCP joint is inspected for any soft-tissue interposition. The proximal phalanx is curetted and prepared if the avulsion is off site. The proximal phalanx is drilled and an anchor is placed in the predrilled hole. The UCL is then repaired using the sutures attached to the anchor. The adductor aponeurosis is repaired and the skin is closed (Figs. 8–12).

CONCLUSION

MR imaging has been shown to be both sensitive and specific in distinguishing displaced versus nondisplaced acute, Grade III,

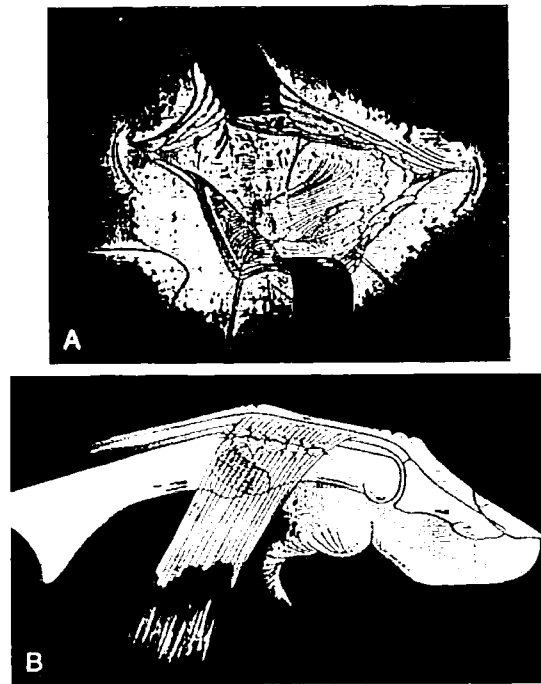


Figure 11. A, A repair of the UCL in a right thumb. B, Repair of adductor of the right thumb after UCL repair.

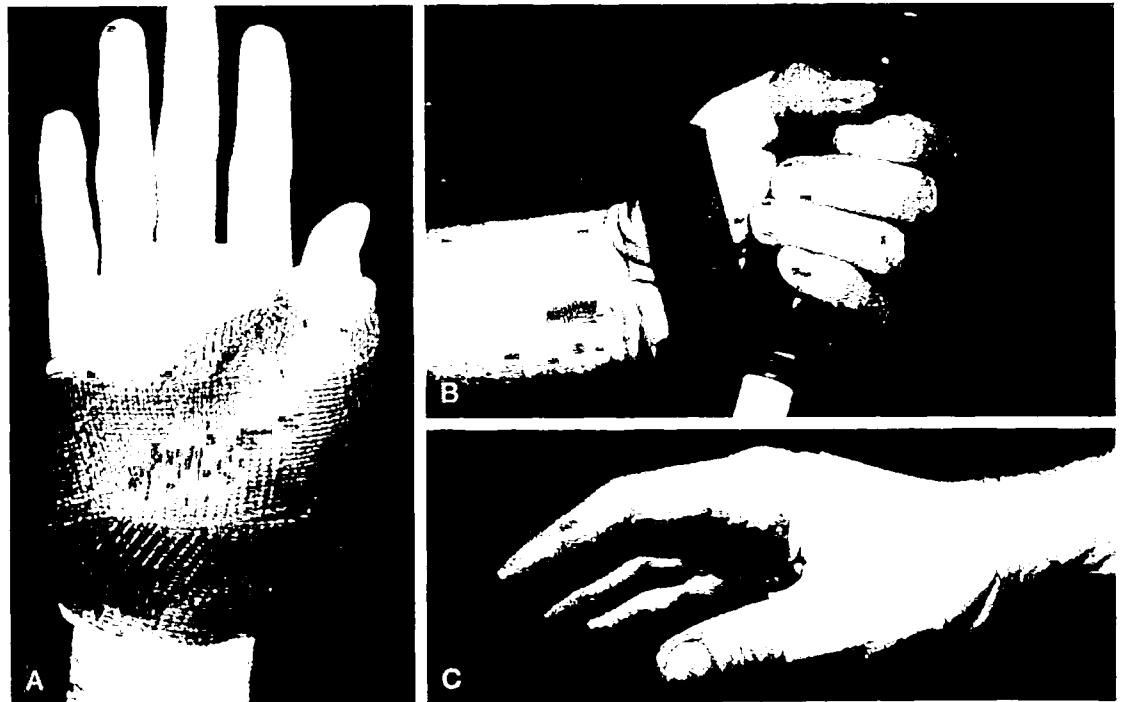


Figure 12. A, Postoperative wrist gauntlet cast in place. B and C, Functional hand splint in a patient with UCL repair 8 weeks before.

unstable UCL lesions of the thumb MCP joint.^{11, 13, 15, 18, 28} MR imaging is a valuable diagnostic tool for evaluating skier's thumb, and allows physicians to determine more accurately the correct course of treatment without subjecting the patient to extraneous costs or invasive procedures.

In 1994, Kozin and Bishop¹⁶ advocated operative exploration as the most reliable method in identifying Stener lesions. There is now strong evidence, however, that MR imaging is a reliable, sensitive, and specific method for identifying Stener lesions. Hinke et al¹⁵ state that "MR imaging is paramount in determining whether treatment should be nonoperative or operative." Diagnostic use of MR imaging should decrease the incidence of unnecessary surgical interventions for patients with nondisplaced tears. A conservative, nonoperative approach in treating Grade II and III UCL tears has been shown to be effective in many studies.^{2, 6, 12, 23, 27}

Although Louis and Buckwalter¹⁸ found MR imaging useful in evaluating the injuries to the MP joint of the thumb, they believe that the cost is prohibitive. We believe, however, that advances in shorter scanning times will lower the cost of this type of MR imaging. In the future, MR imaging will become the primary diagnostic tool in determining the extent of UCL injuries and appropriate treatment for a patient with skier's thumb.

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