Chapter 10

Acute Scapholunate and Lunotriquetral Dissociation

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INTRODUCTION: The scapholunate (SL) and lunotriquetral (LT) ligaments are interosseous carpal ligaments that provide stability to the proximal carpal row. Injury to these ligaments may lead to carpal instability patterns that have been well described in the literature. Intercarpal ligament tears may be acute or chronic. This chapter will focus on the surgical treatment of acute SL and LT tears.

Before proceeding with a discussion of open SL reduction and ligament repair, it is important to review some pertinent anatomy. The SL interosseous ligament is comprised of 3 parts: an avascular, mostly fibrocartilagenous or membranous proximal portion along with 2 "true" ligaments, one dorsal and one volar. The dorsal portion of the SL ligament is thicker than the volar portion, with transversely oriented collagen fibers. These dorsal fibers have been shown to be important in stabilizing SL translation, whereas the more obliquely oriented volar fibers are more critical in constraining rotation. When the SL ligament complex is torn, the scaphoid has a tendency to flex and the lunate has a tendency to extend, assuming a dorsal intercalated segmental instability (DISI) pattern, an observation that is supported both by *in vitro* and clinical data.

Acute SL dissociation is the most commonly recognized and treated pattern of carpal instability. It usually occurs after a fall on an outstretched hand, with the forearm in pronation and the wrist hyperextended. Diagnosis of these injuries can be difficult and knowledge of normal radiographic parameters is essential. In normal wrists, the radiographic distance between the ulnar border of the scaphoid and the radial border of the lunate is less than 3 mm and the SL angle, formed by the intersection of the longitudinal axes of the scaphoid and lunate on a lateral radiograph, ranges between 30° and 60° (average = 47°). If the SL ligament is disrupted, the scaphoid and lunate may be rendered translationally and rotationally unstable, leading to a widened SL gap, as well as an increased SL angle. These abnormalities are often not present on initial static radiographs.

Acute Scapholunate Open Reduction and Direct Ligament Repair, With or Without Dorsal Augmentation

Examination/Imaging

When examined acutely, the injured wrist may be swollen and extremely tender, thus making the clinical diagnosis of SL ligament injury difficult. If the patient can tolerate differential palpation of the wrist, point tenderness over the dorsal-radial carpus will be present. Palpating 1 cm distal to Lister's tubercle, over the dorsal ridge of the scaphoid and the proximal scapholunate joint, is especially provocative with these injuries.

The scaphoid stress test, as described by Watson, may be difficult to perform in the acutely swollen and painful wrist, but may be better tolerated a few weeks following injury. The scaphoid stress test involves placing the examiner's thumb on the scaphoid tubercle as the wrist is passively brought from a position of ulnar deviation and slight extension to one of radial deviation and slight flexion (Fig. 1). Under normal circumstances, the scaphoid will assume a more flexed position as the wrist is radially deviated and will become more prominent under the examiner's thumb. The examiner's thumb applies volar counterpressure on the scaphoid tubercle, which opposes the normal rotation, thereby creating a subluxation stress to the entire scaphoid, rocking it out of the distal radial fossa. When this thumb pressure is removed, the scaphoid returns to a nonsubluxated position, sometimes with a painful, palpable "clunk." As many patients (especially young women) have at baseline some periscaphoid ligamentous laxity, Watson teaches us to perform this test bilaterally, because its findings are only meaningful when it elicits dorsal pain over the SL interval or results in an asynchronous "clunk" that reproduces the patient's symptoms.

Plain radiographs are essential to the work-up of SL ligament injuries. These include standard posteroanterior (PA), oblique, and lateral films of the injured wrist. Radial and ulnar deviation views of the wrist are also helpful. Because

Figure 1. The Watson's scaphoid stress test is performed by ***(A)*** placing pressure over the distal pole of the scaphoid with the wrist in ulnar deviation followed by ***(B)*** radial deviation of the wrist while maintaining the distal pole pressure and feeling for a "clunk" on deviation or release.

Figure 2. Scapholunate dissociation may lead to a widened scapholunate interval of greater than 3 mm, producing the so-called "Terry Thomas sign."

static SL gaps on radiographs are usually only present in cases of more chronic SL instability, it is important to obtain dynamically loaded images of the wrist, such as an anteroposterior (AP), supinated, clenched-fist view, to appropriately evaluate acute SL ligament tears. In cases of acute SL disruption, such dynamic loading may cause the interval between the scaphoid and lunate to widen on the AP view to a distance greater than 3 mm (Fig. 2). This SL gap has been dubbed the "Terry Thomas sign," in reference to the gap between the front teeth of the British comedian.

As previously noted, complete disruption of the SL ligament complex not only leads to translational instability between the scaphoid and the lunate, but also to rotational instability between the two. When the link between the scaphoid and lunate is rendered incompetent, the scaphoid has a tendency to assume a position of flexion while the lunate assumes a position of extension, thus producing the DISI instability pattern. This pattern is suggested by AP or PA radiographs that show not only a "Terry Thomas sign" but also a scaphoid that appears shortened due to its flexed posture relative to the rest of the proximal carpal row. The "cortical ring" or "signet ring" sign can be seen on AP or PA radiographs; it refers to the dense, circular cortex of the scaphoid tubercle, which is made more prominent as the scaphoid assumes a flexed position. This foreshortened posture of the scaphoid produces more of an end-on view of the scaphoid tubercle than normal (Fig. 3). A distance of less than 7 mm from this cortical ring to the proximal pole of the scaphoid is indicative of SL instability.

The SL angle is formed by the intersection of the longitudinal axes of the scaphoid and lunate and can be determined by evaluating the lateral radiograph. When the SL ligamentous complex is rendered incompetent, the SL angle increases as the lunate assumes an extended position relative to the scaphoid, which has a tendency to flex. An SL angle greater than 60° is consistent with a DISI pattern and suggestive of SL dissociation (Fig. 4). Arthrography,[1] computed tomography (CT) scans,[2] and magnetic resonance imaging (MRI)[3,4] have been shown to be useful in certain cases where clinical examination and standard radiographic imaging prove to be nondiagnostic.

If a complete SL tear can be diagnosed by clinical and radiographic means alone, we do not routinely perform an

Figure 3. The "cortical ring" or "signet ring" sign refers to the end-on view of the scaphoid tubercle on the posteroanterior radiograph as the scaphoid assumes a flexed, foreshortened posture relative to the rest of the proximal carpal row.

Figure 4. A scapholunate angle of greater than 60° on a lateral radiograph is indicative of SL dissociation and a dorsal intercalate segmental instability (DISI) pattern.

arthroscopy before proceeding to the open reduction of the joint and repair of the soft tissues. This is in contrast to our work-up of a patient with persistent wrist pain who has equivocal clinical and radiographic findings. In this subgroup of patients, we believe that arthroscopic evaluation should be undertaken before open exploration of the SL joint, given the promising results of arthroscopic debridement alone in the treatment of partial SL ligament tears.[5,6] If a complete tear is identified on radiocarpal arthroscopy, as is confirmed when the capitate head is easily visualized through an open SL interval (ie, the "drive-through" sign; Fig. 5), open repair is undertaken.

Evaluation Pearls and Pitfalls, Including Associated Conditions

- An essential step in the evaluation of SL ligament injuries is to obtain x-rays of the contralateral wrist as well, because some patients (especially young women) may have normally widened SL intervals bilaterally.
- If an asymmetry is detected, it is vital to make sure that the SL ligament tear is acute in nature, without any degenerative arthritis of the radioscaphoid joint, as in the stage-1 or stage-2 scapholunate advanced collapse (SLAC) wrist (Fig. 6), or of the capitolunate joint, as in the stage-3 SLAC wrist.[7] Indeed, even if the scaphoid and lunate are reduced beautifully and successfully held in that reduced position, the presence of concomitant arthritis will likely lead to a poor result if not addressed.
- A necessary step in the successful treatment of such injuries, therefore, is to make sure that the injury is relatively acute, without the advent of substantial radioscaphoid or intercarpal arthritis. Determining whether an SL gap is representative of a chronic process, as suggested by this patient's spurring of the radial styloid, or an acute-on-chronic one may prove to be difficult. A chronic tear is suggested by a patient who denies any recent trauma and

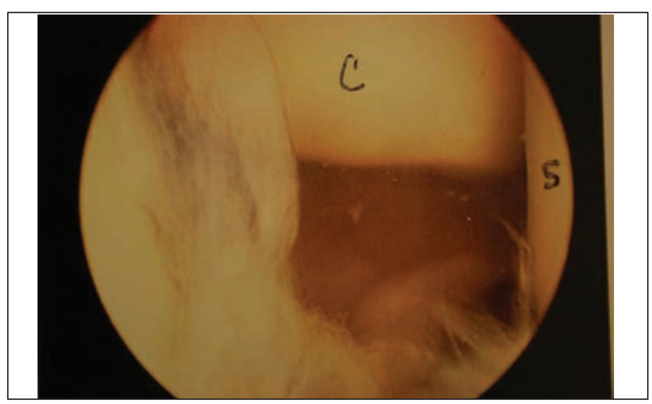

Figure 5. During radiocarpal arthroscopy, if the capitate head is easily visualized through an open SL interval, a complete SL ligament tear is present. C = capitate head; S = scaphoid.

Figure 6. The development of scapholunate advanced collapse wrist involves degeneration of the radioscaphoid articulation and represents a contraindication to performing ligament repair alone. This radiograph demonstrates a stage-2 SLAC wrist, with arthritis of the distal and proximal radioscaphoid joint, and a seemingly uninvolved midcarpal articulation.

whose radiographs reveal a static SL gap, DISI malalignment, and radial styloid-distal scaphoid sclerosis. If the patient has a history of a recent fall, tenderness over the radial wrist, no subtle arthritic findings on x-ray, and SL widening that becomes evident only on a dynamic clenched-fist view, then a diagnosis of a more acute tear is favored.

Operative Indications

- The most widely accepted indication for the direct open repair of an acute SL ligament tear is a history of a wrist injury within 3 weeks of presentation with consistent clinical and radiographic findings. Within this acute time frame, reduction of the scaphoid and lunate should be possible, and the viability of the SL ligament should allow for direct repair. If the presentation is more subacute over a period of 3 weeks to 3 months following injury, this procedure can still be performed, although reduction may prove to be more difficult.
- Subtle radiographic or arthroscopic findings of degenerative arthritis must be critically looked for, because these represent a relative contraindication to the procedure.

Finally, if the presentation is 3 months or more removed from the initial injury, the surgeon may still consider this technique of direct ligament repair, but in all likelihood it will be even more challenging to obtain and maintain an SL reduction. Furthermore, the further out from the initial injury the patient is, the greater the chance for developing degenerative changes about the radioscaphoid joint or atrophy of the remaining ligament, which would serve as a contraindication to this technique. When treating a patient with more chronic SL ligament instability, reconstructive techniques that involve bone-soft tissue-bone autografts, tendon weaves, or partial intercarpal fusions may be more appropriate than the technique described in this chapter.

Other Treatment Options

To understand the alternative treatment options for SL instability, it is important to understand the difference between treating partial and complete tears. In instances in which only a partial SL ligament injury is suspected, arthroscopic debridement alone of the torn ligament has been shown to be quite effective at improving mechanical symptoms and pain. Ruch and Poehling[5] published promising results in 7 such cases of patients with crepitant wrist pain who were treated with arthroscopic debridement alone for partial SL ligament tears; all were highly satisfied with the procedure. Adding thermal shrinkage using radiofrequency probes to arthroscopic debridement for the treatment of partial SL ligament injuries has also yielded good short-term results.[8,9]

Most authors, including us, would not currently recommend arthroscopic debridement alone for the treatment of complete SL ligament tears. In the senior author's (APCW)[6] 1997 review of 28 patients treated arthroscopically for persistent wrist pain due to either a complete or partial SL ligament tear, however, isolated arthroscopic debridement of the torn ligament edges yielded fairly good results in both groups, albeit at relatively short-term follow-up. In that series, 66% of the wrists that had a complete SL tear and 85% of the wrists that had a partial SL tear showed symptomatic improvement at an average follow-up of 27 months. More long-term follow-up of this patient population would be required before any definitive conclusions could be drawn about treating complete SL ligament injuries by arthroscopic debridement alone.

When complete SL ligament tears present in an acute fashion, open reduction and internal fixation of the scaphoid and lunate with simultaneous SL ligament repair is usually possible. A variety of other treatment options exist, especially for patients who present 3 months or more after their initial injury. These options include dorsal capsulodeses,[10] limited intercarpal fusions,[11] tendon weaves (such as those described by Brunelli and Garcia-Elias),[12,13] and bone-soft tissue-bone autografts.[14,15] Treating chronic SL instability in a closed fashion, with aggressive arthroscopic debridement and percutaneous pinning[16] or cannulated screw fixation (as in the reduction-association scapholunate, or RASL, procedure)[17] (Fig. 7) have also been described as options.

Advantages, Disadvantages and Contraindications of the Described Technique

- Open reduction of the SL joint with K-wire percutaneous fixation and direct open repair of the acutely torn SL ligament, with or without dorsal capsulodesis, has the advantage of restoring the patient's native ligamentous anatomy without introducing any donor-site morbidity.
- Arthroscopically-assisted closed reduction and pinning of the SL joint is an attractive treatment alternative because it avoids the morbidity of an open exposure, but it seems to produce less optimal clinical outcomes than does the described technique of direct open repair.
- Dorsal capsulodesis alone has been shown to be quite successful in providing pain relief, but it limits wrist motion and does not provide longer-term maintenance of intercarpal alignment.
- Tendon weaves may offer more robust soft-tissue solutions to restoring SL ligament competence than a direct repair does, but they come with the obvious disadvantage of introducing donor-site morbidity when an autograft is used. Furthermore, balancing tendon lengths and intercarpal alignment can be challenging and long-term data is sparse.
- Bone-soft tissue-bone reconstructions are intriguing and intuitive, but require exacting surgical technique, and long-term data is lacking.
- Although intercarpal fusions, such as scaphotrapezial or scaphocapitate fusions, offer the benefit of permanently securing the scaphoid in a nonflexed position without relying upon soft-tissue repairs or grafts, they are not without fault. Indeed, intercarpal arthrodeses have been associated with a decreased range of wrist motion and grip strength and bring with them a theoretical risk of nonunion, which is not present with soft-tissue procedures.
- Prerequisites for a successful open SL ligament repair include a reducible scaphoid and lunate and a viable SL ligament that withstands a "pick-up" test to see if the SL ligament is substantial enough to hold a repair. If the remaining ligament is felt to be stout, we do not routinely add a dorsal capsulodesis to the direct repair, although many authors do. If the ligament is not identifiable or feels flimsy, as is often the case in more chronic SL instabilities, direct repair alone is contraindicated and the surgeon should consider augmenting the repair with either the dorsal intercarpal ligament, the dorsal capsule, a tendon weave, or a bone-soft tissue-bone graft.
- Both SL ligament repair and/or reconstruction are contraindicated in the presence of concomitant radioscaphoid or capitolunate arthritis. In more chronic cases of SL dissociation, in which the cartilage at the radioscaphoid articulation is compromised, it is essential to include a radial styloidectomy for stage-1 SLAC wrist. For more advanced arthritis, an SL ligament repair should not be performed. In these cases, treatment may consist of a proximal-row carpectomy (for stage-2 SLAC wrist) or a scaphoid excision and capitolunate or four-corner arthrodesis (for stage-2 or stage-3 SLAC wrist).

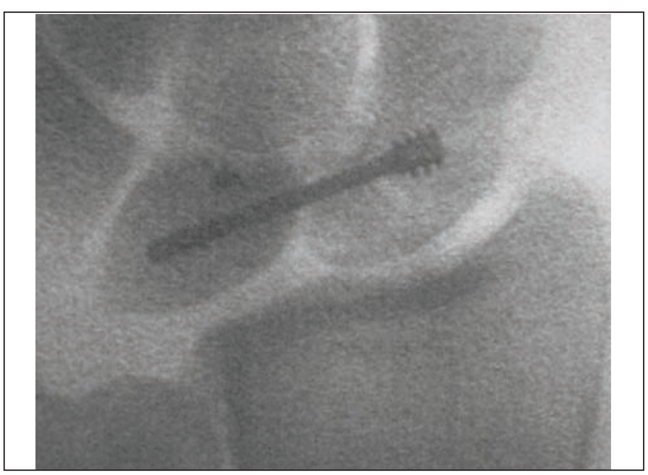

Figure 7. A Herbert screw can be used to maintain scapholunate reduction as seen in this intra-operative fluoroscopic image for definitive treatment or as a temporary device rather than using K-wires.

Instrumentation

Open reduction of the SL joint with direct repair of the SL ligament, with or without dorsal capsulodesis, requires the following:

- Arthroscopic instrumentation if the diagnosis is uncertain
- 1.6-mm (0.062-in) Kirschner wires (K-wires)
- 1.4-mm (0.045-in) K-wires
- Staple reduction clamp, if desired
- 2.0-mm or 2.5-mm suture anchors, absorbable or nonabsorbable
- Image intensifier

Surgical Anatomy

- After the tendons of the third and fourth dorsal compartments are identified and protected, two extrinsic dorsal ligaments of the wrist are encountered: the dorsal radiocarpal (DRC) and dorsal intercarpal (DIC) ligaments.
- The DRC ligament attaches proximally to the dorsal rim of the distal radius and extends distally and ulnarly to the dorsal triquetrum.
- The DIC ligament originates at the dorsal tubercle of the triquetrum, where it interdigitates with the insertion of the DRC ligament fibers and spans out radially toward the trapezoid and scaphoid.
- The ligament-sparing capsulotomy of the wrist preserves the integrity of the DRC and DIC ligaments by splitting their fibers longitudinally and elevating a radial-based flap to expose the underlying carpus.

Positioning

The patient is positioned supine with the operative hand on an arm board.

Exposures/Portals

- Arthroscopic examination is performed before opening if it is needed to confirm the diagnosis of an acute, complete SL ligament tear.
- When the diagnosis is confirmed, a dorsal longitudinal incision is made starting just ulnar to Lister's tubercle and extending distally to the midcarpal joint. Sharp dissection is carried down to the extensor retinaculum, with careful attention to maintain the integrity of superficial neurovascular structures, in particular the branches of the superficial radial nerve radially and of the dorsal sensory ulnar nerve ulnarly.
- With the extensor retinaculum exposed, a scalpel is used to incise the roof of the third dorsal compartment and the extensor pollicis longus tendon is identified and retracted radially. The tendons of the fourth dorsal compartment are retracted ulnarly within their subsheath. Radial and ulnar flaps of the extensor retinaculum are retracted and, at the floor of the fourth dorsal compartment, the terminal branch of the posterior interosseous nerve is identified and sectioned to partially denervate the carpus. Within the interval between the third and fourth dorsal compartments, the dorsal capsule overlying the proximal carpal row is well visualized.

Acute Scapholunate Open Reduction and Direct Ligament Repair, With or Without Dorsal Augmentation

Step 1

- The incision that is made through the dorsal capsule can be longitudinal, transverse, "T-shaped," or "V-shaped" (ligament-sparing), with one limb parallel to the DIC ligament and one limb parallel to the DRC ligament. Whichever capsulotomy is performed, it is important to try to elevate the dorsal capsule and extrinsic ligaments as a layer that is distinct from the underlying dorsal and membranous components of the SL ligamentous complex.
- In cases of acute SL injury, the surgeon will most commonly identify the ligament torn off of the dorsal scaphoid ridge. Occasionally, the ligament will actually be avulsed off of the scaphoid with a piece of scaphoid cartilage that remains attached to the ligament. Less commonly, the SL ligament may be found to be torn off of the lunate or attenuated centrally within its midsubstance. The DIC ligament may also be avulsed from the dorsal proximal portion of the scaphoid and/or the dorsal lunate.
- The SL articulation and midcarpal joint should be evaluated for any free fragments and articular lesions. Complete SL ligament tears produce dramatic gapping when the scaphoid is radially translated and flexed with a probe (Fig. 8). If there are no substantial degenerative lesions that preclude open reduction and direct repair or reconstruction of the SL ligament, the next critical step in the procedure is achieving reduction of the SL articulation.

Step 2

- To facilitate reduction of the SL articulation, vertical 1.6-mm K-wires are placed in a dorsal-to-volar direction in each of the scaphoid and lunate bones. The scaphoid wire should be placed in a distal-to-proximal direction and the lunate wire should be placed in a proximal-to-distal direction, taking into account the flexed posture of the scaphoid and the extended posture of the lunate. After the K-wires have gained purchase into each of these bones, they can then be used as joysticks to derotate the scaphoid out of flexion and the lunate out of extension. If desired, a staple reduction clamp can be used to hold these K-wire joysticks, keeping the SL articulation derotated.
- After the scaphoid and lunate are anatomically reduced, two 1.4-mm K-wires should be placed percutaneously in a radial-to-ulnar direction to maintain this reduction. When inserting the K-wires, thought should be given to the typical topographical course of the superficial radial

Figure 8. Intra-operatively, it is easy to rotate the scaphoid relative to the lunate in cases of complete SL dissociation.

nerve; an angiocatheter may be used as a drill guide to try to prevent iatrogenic injury. We prefer to place one wire traversing the SL joint and one wire traversing the scaphocapitate joint (Fig. 9), although placing 2 wires across either one of these joints is also reasonable (Fig. 10). Anatomic reduction should be confirmed fluoroscopically and by direct inspection, with careful evaluation of the SL angle, as well as the contours of the radioscaphoid and midcarpal articulations. When the reduction is held by the 1.4-mm K-wires, the 1.6-mm K-wire joysticks are removed.

Step 3

- After the SL articulation is anatomically reduced and percutaneously fixed, the integrity of the SL ligament is assessed. If it is substantial, as is frequently the case in acute injuries, one or two 2.0-mm or 2.5-mm suture anchors are placed in the dorsal ridge of the proximal scaphoid at the site of the ligament tear or osteochondral avulsion. Although either an absorbable or a nonabsorbable (radiopaque) anchor may be used, we tend to prefer the latter so that intra-operative and postoperative radiographs can confirm its appropriate placement in the proximal portion of the dorsal scaphoid and its subsequent lack of migration (Fig. 11).

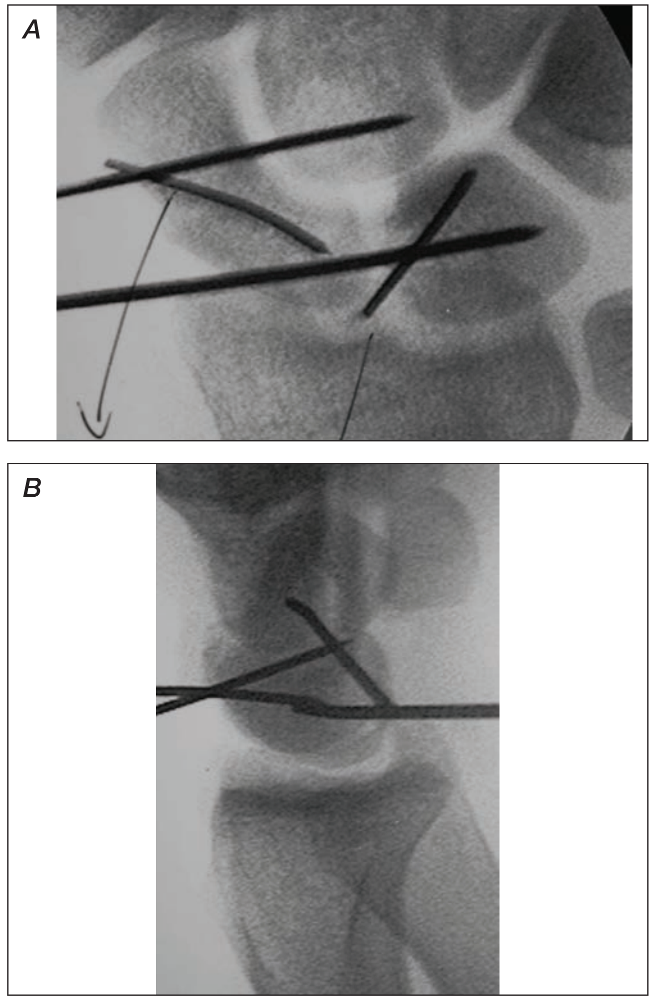

Figure 9. After the 1.6-mm K-wires have been used as joysticks to derotate the scaphoid and lunate, two 1.4-mm K-wires are placed percutaneously from the proximal scaphoid into the lunate and from the distal scaphoid into the capitate to hold the reduction in both ***(A)*** the PA and ***(B)*** the lateral planes. Note that the lunate is no longer extended.

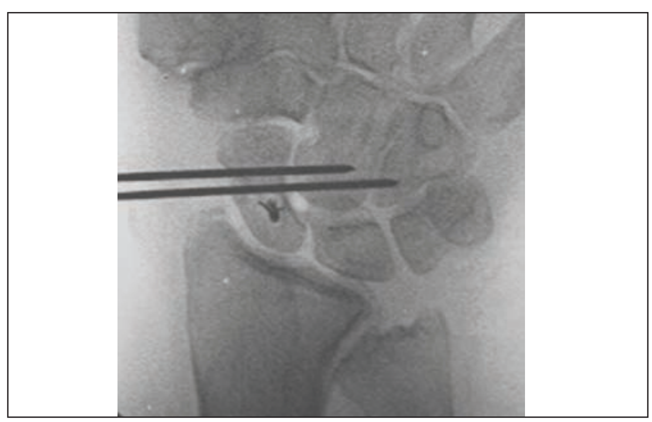

Figure 10. An alternative pinning arrangement could involve placing 2 pins from the scaphoid into the lunate or 2 pins from the scaphoid into the capitate, as shown here.

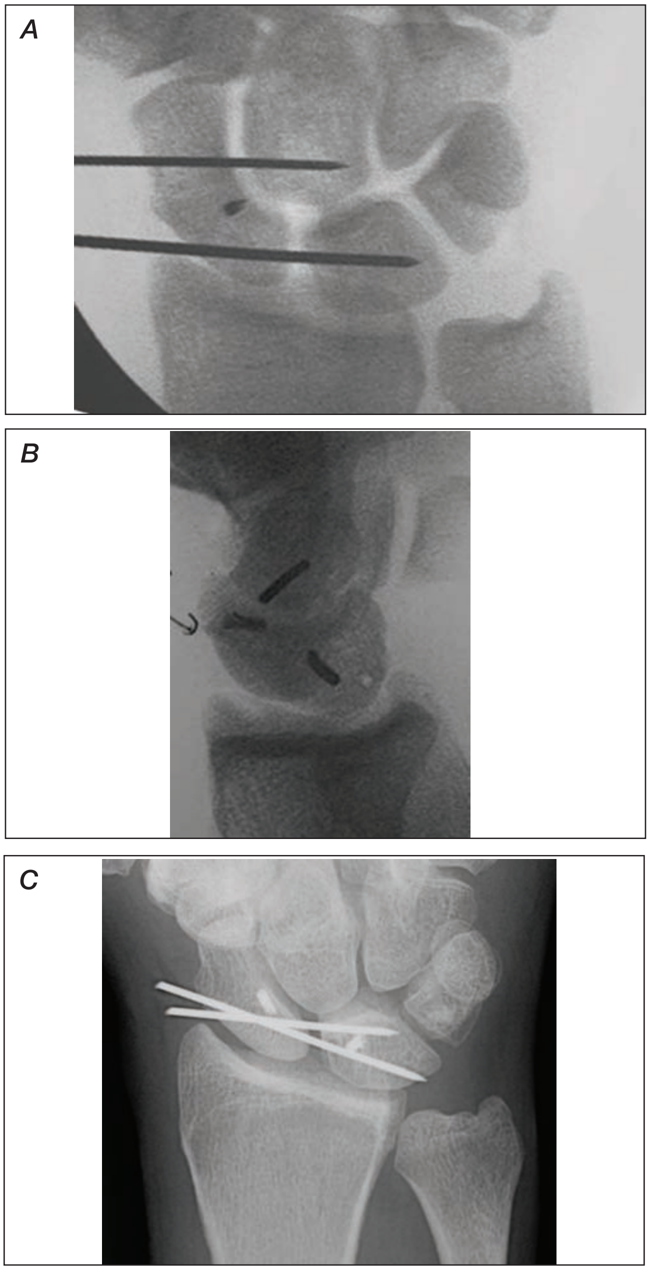

Figure 11. A radiopaque suture anchor is placed in the dorsal ridge of the proximal scaphoid, as shown on ***(A)*** PA and ***(B)*** lateral intra-operative fluoroscopic imaging, to reattach the torn SL ligament to its place of origin. ***(C)*** A final postoperative radiograph demonstrates final anchor and K-wire placement.

- If the SL ligament happened to tear off of the dorsal lunate instead of the dorsal scaphoid ridge, the anchor is placed into the lunate instead.
- In the region from which the SL ligament has torn off, usually the dorsal ridge of the proximal scaphoid, several small K-wire holes are made to promote ligamentous healing back to bone. At this juncture, the SL ligament is then sutured back down to the dorsal scaphoid ridge with the nonabsorbable sutures attached to the anchor(s). On gross inspection this should obscure the proximal SL articulation with ligament tissue (Fig. 12).
- If the DIC ligament was avulsed off of the dorsal scaphoid rim, it can be incorporated into the SL ligament suture-anchor repair. If the DIC ligament was avulsed off of the dorsal lunate, an additional anchor should be placed in the lunate to best restore the extrinsic ligamentous anatomy. If the DIC ligament is not avulsed off of the proximal carpal row, and the SL ligament is noted intra-operatively to be of sufficient quality, we will not routinely incorporate the DIC or dorsal capsule into our SL ligament suture-anchor repair, although many authors do.
- In our patients' hands, deciding whether to augment an SL ligament repair with dorsal ligament/capsular tissue is made on a case-by-case basis, weighing the theoretical benefit of an increase in repair strength against the theoretical risk of limiting wrist flexion. If the SL ligament is insufficient, we will augment our direct repair with a dorsal capsulodesis or by swinging down a portion of the DIC ligament to the dorsal scaphoid to act as a tether to resist scaphoid flexion. Alternatively, one can use a portion of the DIC ligament as a graft material and fix this swung-down section to the scaphoid and lunate with suture anchors. When we know in advance that the SL tear is likely to be more chronic in nature, with no substantial ligament remaining, we have employed both tendon weave reconstructions as well as bone-retinaculum-bone autografts.
- Alternatively, limited intercarpal arthrodeses, such as those between the scaphoid and trapezium-trapezoid

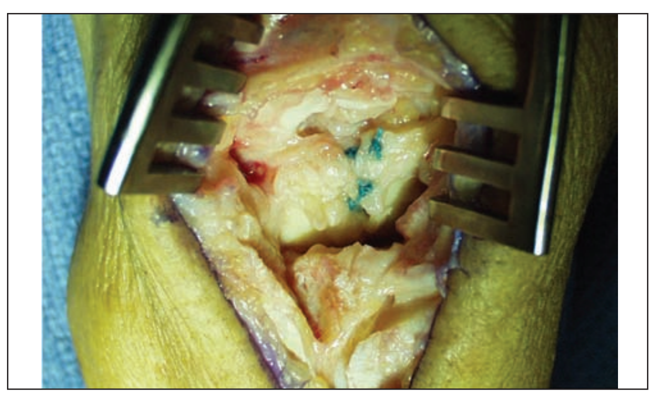

Figure 12. After the suture anchor is placed in the dorsal ridge of the proximal scaphoid, its nonabsorbable sutures are used to reattach the avulsed SL ligament back to its place of origin. After this is done, the proximal SL joint should be obscured by a band of ligamentous tissue.

or between the scaphoid and capitates, have produced excellent results in the hands of some surgeons.[11]

Step 4

- If the quality of the SL ligament is poor, then the dorsal capsule is used to augment the direct repair and is incorporated into the sutures anchored in the dorsal scaphoid ridge. If, however, the SL ligament repair seems robust, the dorsal capsule is then closed to itself with absorbable sutures in an effort to maximize postoperative wrist flexion.
- The extensor retinaculum is closed with absorbable sutures, typically leaving the extensor pollicis longus tendon transposed subcutaneously. The skin is closed routinely. K-wires are cut beneath the skin to decrease the chance of subsequent pin-track infection, because they will not be removed for approximately 12 weeks.

Postoperative Care and Expected Outcomes

- The extremity is immobilized in a long-arm splint with the forearm pronated for approximately 4 weeks. Following this, the wrist is immobilized in a short-arm splint for an additional 8 weeks.
- Radiographs are routinely obtained at 1, 4, 8, and 12 weeks after surgery to assess the maintenance of the intercarpal reduction and the position of the suture anchors and K-wires.
- K-wires are removed at approximately 12 weeks, usually in the operating room under local anesthesia. Following hardware removal, gentle hand therapy is initiated and the wrist may be placed in a removable, short-arm, volar splint for comfort.

Results, Including Complications

- Several retrospective studies[18,19,20] have demonstrated that, when it is used to treat acute tears, this technique produces mostly favorable clinical and radiographic outcomes, albeit at the relatively short-term follow-up of just a few years.
- Despite these reasonably good results, it is worth noting that this technique has not been prospectively evaluated in the literature, nor has it been compared in head-to-head fashion with alternative reconstructive techniques. Furthermore, whether to add a dorsal capsulodesis to the direct repair of acute SL ligament tears is a question that has not been rigorously evaluated. The long-term results of open reduction and direct ligament repair are simply not known.
- Pomerance[21] noted, in a 2006 review of his SL repairs, that he was unable to find a study (as were we) that assessed the outcomes of primary repair of the SL ligament, with or without capsulodesis, with a follow-up of greater than 10 years.
- Complications of this technique include pin-track infections, bending or breakage of pins, and loss of SL reduction. Infections are treated with prolonged antibiotics and, less commonly, premature hardware removal is necessary.

Conclusions

- Although reduction of the SL joint with direct repair of the SL ligament, with or without dorsal wrist capsulodesis, is widely regarded as the accepted procedure for acute SL tears,[22] objectively evaluating whether the results associated with this surgical approach justify its popularity is difficult due to the heterogeneity of study designs that comprises this literature.
- When members of the American Society for Surgery of the Hand were surveyed regarding their expectations for soft-tissue repairs of SL dissociation, only 53% gave a patient with an acute injury a better than 50% chance of returning to a labor job.[22] Such ambivalence has at its root a literature that is inconsistent in its inclusion criteria, surgical technique, and timing of ligament repair.

Acute Lunotriquetral Dissociation: Arthroscopic Debridement of Acute Lunotriquetral Tears With Percutaneous Pinning If Instability Is Detected

Introduction

Unlike the SL ligament, a complete tear of the LT ligament alone is not enough to produce a static carpal instability. Injury to both the LT ligament and the DRC ligament is necessary to allow the lunate to assume a flexed, or volar intercalated segmental instability (VISI), position.

In contrast to the SL complex, the volar portion of the LT ligament is the strongest; the primary restraint of LT translation and the dorsal portion is the chief restraint to rotation. A third component of the LT complex is made up of fibers from the ulnocarpal ligament, which attach to the volar portion of the LT ligament.

Acute LT dissociation is far less common than SL dissociation and, in its most dramatic form, can be seen in the context of a perilunate dissociation. Isolated LT ligament tears are usually the result of a fall onto the outstretched hand, or from lifting injuries with the hand in forced pronation.

Examination/Imaging

Patients with acute LT tears usually present with ulnar-sided wrist pain that is exacerbated by power gripping. The LT ballottement test described by Reagan, Linscheid, and Dobyns[23] involves translating the pisiform and triquetrum volarly and dorsally relative to the stabilized lunate and evaluating whether excessive motion is present and/or if the patient's pain is reproduced (Fig. 13). Kleinman's[24] shear test is similar; the examiner's thumb applies dorsal translation to the pisiform and volar translation to the lunate to reproduce symptoms. As is the case with the scaphoid shift maneuver, the contralateral wrist should be examined for comparison. Lastly, the lunotriquetral compression test can be performed by pushing the triquetrum into the lunate from the ulnar side of the wrist to see if pain develops (Fig. 14).

The standard PA, oblique, and lateral radiographs should be taken, as well as radial and ulnar deviation views. Radiographs should be closely evaluated for ulnar positive variance, osteochondral wear of the lunate, as well as any widening of the LT interval or other abnormal posturing of the triquetrum relative to the lunate or ulna (Fig. 15).

Figure 13. The lunotriquetral ballotment test involves a shearing motion between the two bones.

The SL angle, as we have discussed, is formed by the intersection of the longitudinal axes of the scaphoid and lunate and can be determined by evaluating the lateral radiograph. The normal SL angle is typically thought to be between 40° and 60°. When the LT ligamentous complex is rendered

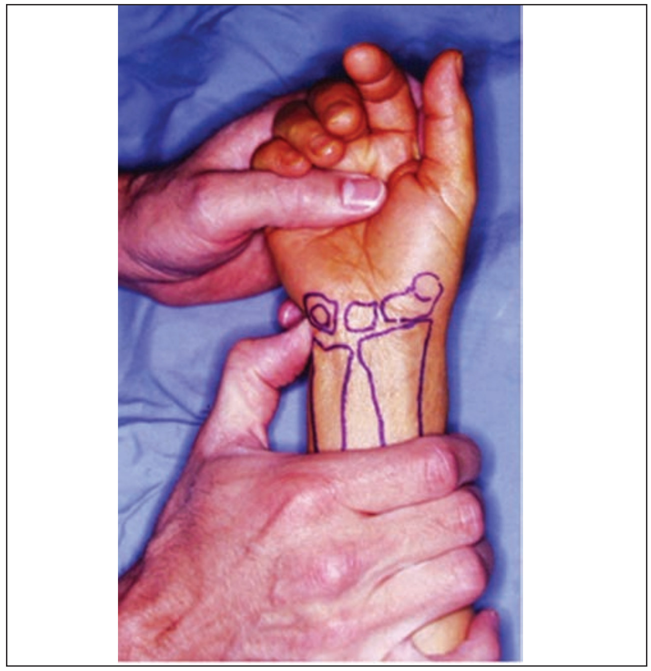

Figure 14. The lunotriquetral compression test involves a compression between the two bones.

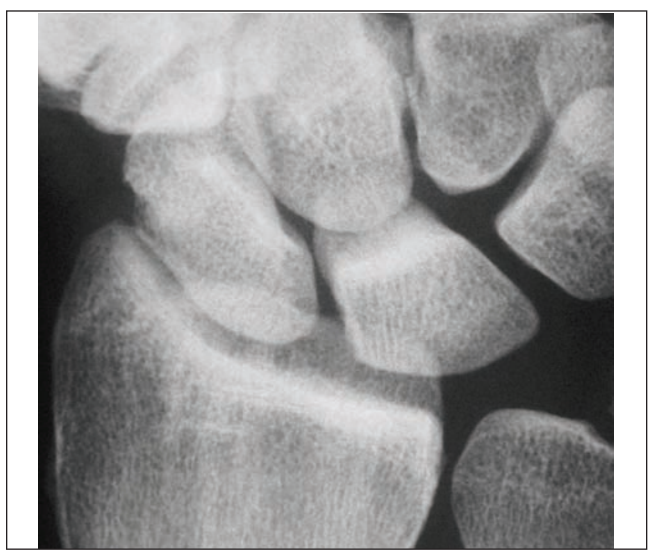

Figure 15. A PA radiograph demonstrates incongruity on the midcarpal joint line at the lunotriquetral interval, consistent with disruption of the lunotriquetral ligament.

incompetent, the lunate has a tendency to flex (through its intact ligamentous attachments to the scaphoid) relative to the triquetrum, which tends to extend. Although an SL angle of less than 40° is *suggestive* of LT dissociation, an isolated tear of the LT ligament, without any other associated instability, is not itself thought to be sufficient to produce this VISI pattern of deformity. Although arthrography and MRI may have roles in the advanced imaging of such injuries, diagnostic arthroscopy remains the most definitive way to identify LT ligament pathology.[25]

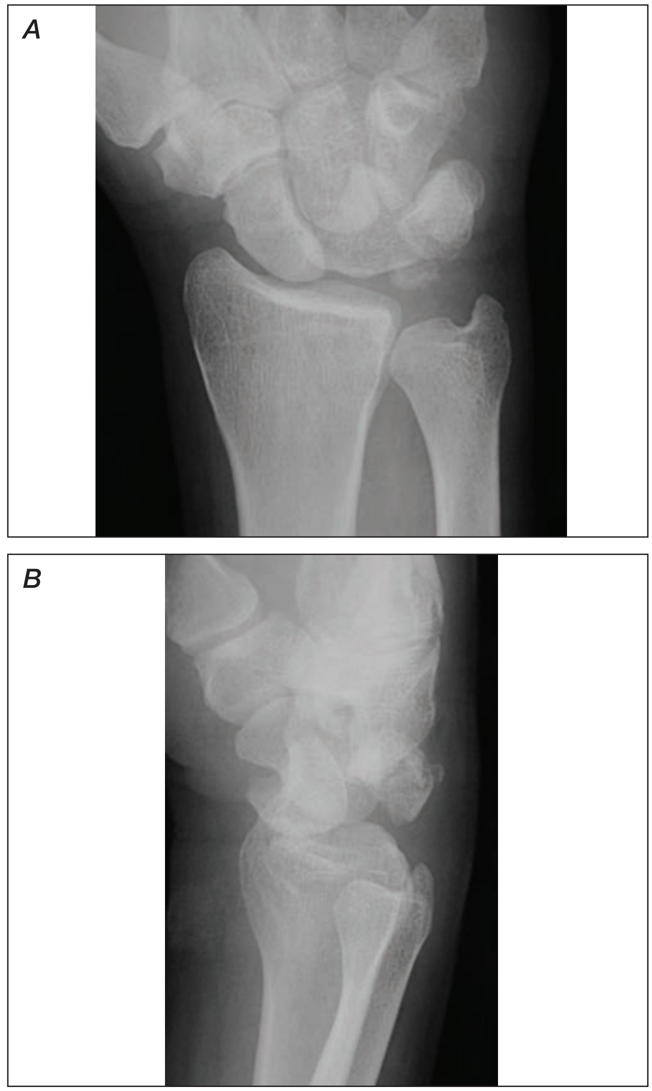

Figure 16. LT ligament injuries can be subtle or they can be obvious, as when they are part of a high-energy perilunate dislocation. A dramatic example of LT dissociation, with associated dorsal extrinsic ligament disruption, is seen here on ***(A)*** PA and ***(B)*** lateral plain radiographs.

Evaluation Pearls and Pitfalls, Including Associated Conditions

- Not all LT injuries are created equal. There is a spectrum of LT tears, from partial tears that do not render the articulation unstable to those that are complete, involve the dorsal extrinsic ligaments, and are associated with dramatic instability.
- The evaluation of LT joint stability is important in determining appropriate treatment. If the joint is stable, nonoperative treatment of an acute LT injury is usually recommended. If ulnar-sided wrist pain persists despite nonoperative treatment, arthroscopic evaluation may be indicated. During diagnostic arthroscopy, a complete evaluation of the wrist should be performed. With arthroscopy, the assessment of LT stability can be made more accurately and the presence of any concomitant ulnar-sided pathology, such as triangular fibrocartilage complex (TFCC) tears, can be determined.
- Accurately diagnosing associated injuries is critical to treatment success. Indeed, if a partial LT tear is diagnosed and appropriately debrided, but the surgeon fails to recognize the patient's ulnar positive variance, central degenerative TFCC tear, and resultant lunate chondromalacia, a poor clinical outcome will likely result.

Operative Indications

Unless a patient has sustained high-energy trauma with a perilunate dissociation (Fig. 16), LT ligament injuries often do not present acutely. If a patient does present following high-energy trauma with such dramatic perilunate instability, or gross LT instability, treatment can be relatively straightforward: (1) open reduction of the lunate with a dorsal-to-volar 1.6-mm K-wire joystick in the lunate and another one in either the scaphoid or triquetrum (Fig. 17); (2) percutaneous pinning of the lunate in its reduced position, securing it from both sides with 1.4-mm K-wires traversing both the LT and SL joints (Fig. 18); and (3) suture-anchor fixation of whatever ligament remnants can be identified, which in the case illustrated were the remnants of the SL and dorsal extrinsic ligaments, both of which were torn off of the dorsal scaphoid ridge (Fig. 19).

Most patients with LT ligament injuries present later, with more subtle ulnar-sided wrist pain. In these cases, appropriate nonoperative treatment should be pursued. This consists of a prolonged course of rest, splinting, corticosteroid injections, and anti-inflammatory medication. More advanced imaging studies, arthroscopic examination, and surgery are reserved for failure of appropriate nonoperative management. In general, 2 to 3 months of nonoperative treatment in a patient with persistent pain is a reasonable

Figure 17. As was the case with open SL reduction, 1.6-mm K-wire joysticks are used to facilitate manual reduction of the extruded lunate back into the lunate fossa of the distal radius.

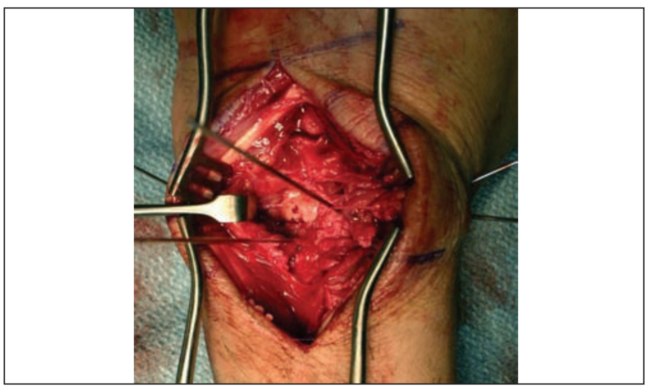

Figure 18. To hold the lunate in a reduced position, percutaneous K-wires are placed both from the scaphoid into the lunate and from the triquetrum into the lunate.

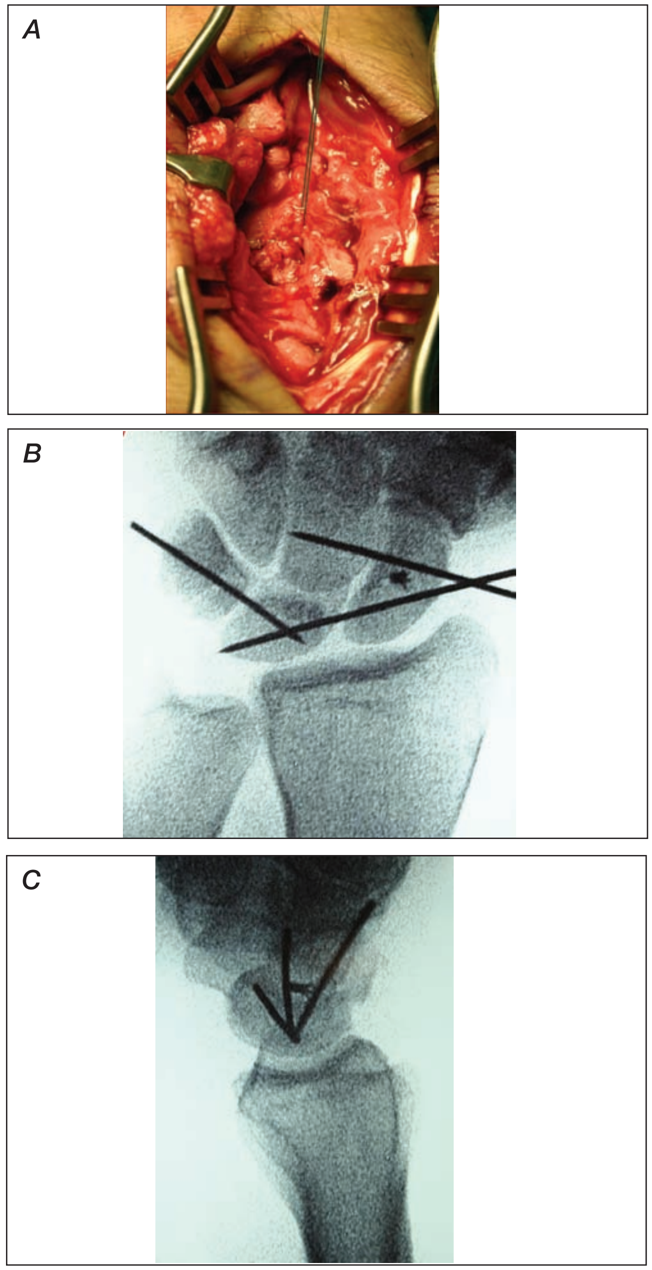

Figure 19. After the SL and LT joints are anatomically reduced and secured with K-wire fixation, a nonabsorbable suture anchor is placed in the dorsal ridge of the proximal scaphoid and used to reattach the avulsed SL ligament and dorsal extrinsic ligaments back to their sites of origin. ***(A)*** The dorsal extrinsic ligaments and dorsal capsule are used as an augmentation to the SL ligament repair. Intra-operative fluoroscopic images, ***(B)*** PA and ***(C)*** lateral, confirm a reasonably good reduction.

indication for arthroscopic surgery, including debridement of the ligament with or without pinning the joint.

Other Treatment Options

- At the time of arthroscopic evaluation, if the LT ligament is found to be only partially torn, we have found debridement alone to be a rather effective treatment.[6] In our review of patients who were treated arthroscopically for persistent wrist pain, 15 wrists were diagnosed with either a complete or partial LT ligament tear, and we found that arthroscopic debridement of the torn ligament edges alone yielded good short-term results. In that series, 100% of the wrists that had a partial LT tear showed symptomatic improvement at an average follow-up of 27 months. Interestingly, even the 9 wrists that had a complete LT tear responded quite well to debridement alone, with 78% of the patients reporting either complete symptom resolution or only occasional symptoms at final follow-up.[6]

- Ruch and Poehling[5] demonstrated similarly excellent results in their series, where 8 partial LT ligament tears were arthroscopically debrided.
- If LT instability is obvious clinically, or at the time of arthroscopic examination is found to demonstrate gross instability on the midcarpal examination, percutaneously pinning the LT interval in an anatomically reduced position is preferred.
- If a peripheral TFCC tear is diagnosed, it is repaired to the joint capsule. This is performed arthroscopically, unless gross distal radial ulnar joint (DRUJ) instability is present, in which case a more formal open repair of the TFCC to ulnar fovea should be considered.
- Because LT ligament avulsion usually occurs off of the volar triquetrum, the approach for open surgical repair is volar, ulnar to the palmaris longus tendon. If feasible, direct ligament repair back to the triquetrum with suture anchors is suggested because it restores the native ligamentous anatomy. Such a direct repair is often not possible, however, because there is frequently not much ligament left by the time the patient presents for surgical treatment.
- In chronic LT instability, where the ligament is found to be irreparable, or should arthroscopic pinning fail, dorsal soft tissue augmentations, tendon weave reconstructions, and LT arthrodeses are all possible options.[26,27] If a static VISI deformity or midcarpal arthritis develop secondary to a chronic LT dissociation, an *in situ* four-corner arthrodesis is an attractive option because an LT arthrodesis will not correct a static VISI deformity. When degenerative changes of the LT ligament result from ulnocarpal impaction syndrome, an ulnar-shortening osteotomy should be strongly considered.
- An ulnar shortening osteotomy may also be considered in a dynamic lunotriquetral instability pattern, because it may tighten up the ulnocarpal ligaments enough to sufficiently stabilize the LT interval and eliminate symptoms. However, this procedure is less predictable when substantial instability exists.

Advantages, Disadvantages and Contraindications of the Described Technique

Because isolated, acute LT tears are relatively rare, the most optimal treatment for them is unknown. In high-energy injuries with dramatic LT instability, open reduction and repair seems indicated. However, in cases of isolated LT tears without obvious instability, most authors agree that nonoperative treatment should be pursued for several weeks to months to see if symptoms subside.[23]

If a prolonged course of nonoperative management fails to provide relief, an arthroscopic examination is performed. This allows for the evaluation of the integrity of the LT ligament and the ulnocarpal ligaments, as well as providing visualization of other concomitant intra-articular pathology, which would likely be missed by proceeding straight to an open procedure. Furthermore, because the LT tear may prove to be only partial in nature, proceeding straight to an open procedure would be rash, since arthroscopic debridement alone has been shown to be so effective in treating these partial lesions. If instability is present at the time of arthroscopic evaluation and there are no associated degenerative changes present, percutaneous fixation across the reduced LT joint is added without any soft tissue repair. Although this has the advantage of minimizing iatrogenic trauma to the wrist, it clearly does not provide any biological basis for lasting LT stability after the pins are pulled, other than intercarpal scar formation. We would not consider this sufficient for the treatment of more chronic cases of LT instability, in which a soft tissue reconstruction or LT arthrodesis must be considered (Fig. 20).

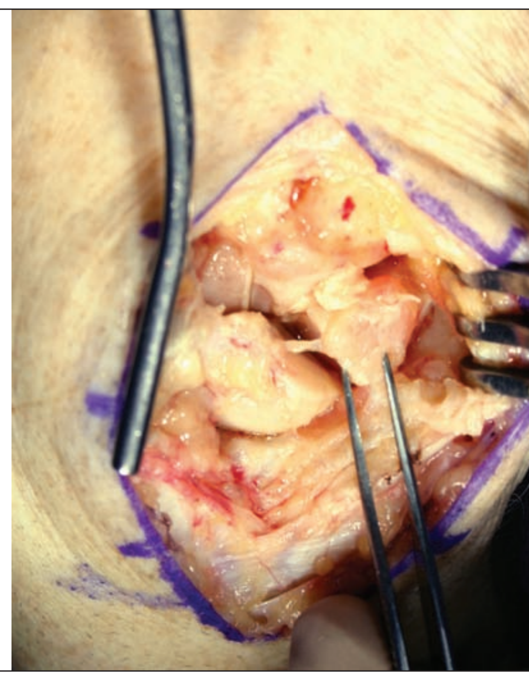

Figure 20. In chronic cases of lunotriquetral ligament tears, open reconstruction is often required because little, if any, ligament fibers remain.

Instrumentation

- Arthroscopic evaluation of the LT joint with percutaneous pinning requires the following:
- Arthroscopic instrumentation: including a 2.3-mm to 2.9-mm arthroscope, a probe, and an oscillating mechanical shaver
- 1.6-mm K-wires
- 1.4-mm K-wires
- Image intensifier

Surgical Anatomy

The relevant surgical anatomy for this technique is simply the dorsal compartments of the wrist; knowledge of the 3-4, 4-5, and 6-U (or 6-R) portals is necessary to safely introduce arthroscopic equipment into the joint.

Positioning

The patient is positioned supine with the operative hand on an arm board.

Exposures/Portals

Traction is applied to the wrist by longitudinal pull on the index and middle fingers through finger-traps attached to a 4.5-kg weight via a pulley. Countertraction is applied to the upper arm, with the elbow flexed at 90°, using a well-padded cuff attached to a 4.5-kg weight via a second pulley. The forearm is pronated and rested horizontally on an arm board (Fig. 21). Inflow irrigation is provided into the wrist joint through the 6-U portal by a 14-gauge catheter. This portal is just volar to the extensor carpi ulnaris tendon and distal to the distal ulna. Alternatively, a 6-R portal may be used.

Portals are then made in the 3-4 interval (between the third and fourth dorsal compartments, just distal to Lister's tubercle) and the 4-5 interval (between the fourth and fifth dorsal compartments, just distal to the distal radius) (Fig. 22).

Figure 21. The forearm is pronated and placed horizontally on an arm board with 4.5 kg of finger-trap traction applied to the index and middle fingers, and 4.5 kg of countertraction applied to the distal humerus.

Figure 22. The 6-U portal is used for inflow irrigation and the 3-4 and 4-5 dorsal compartment intervals are used as arthroscopic portals.

Arthroscopic Debridement of Acute Lunotriquetral Tears With Percutaneous Pinning If Instability Is Detected

Step 1

- A 2.3-mm to 2.9-mm arthroscope is introduced in the 3-4 portal and a probe in the 4-5 portal. The position of the scope and the probe can be switched, depending upon intra-articular findings and what structures need to be accessed. Arthroscopic examination of the radiocarpal and ulnocarpal joints is then performed and the presence or absence of any concomitant intra-articular pathology, such as osteochondral defects or TFCC tears, is noted. If there are no associated lesions that need to be addressed, the LT ligament is carefully inspected for evidence of tearing such as the "shower-curtain sign" (Fig. 23). A probe is used to assess the integrity of its volar and dorsal components (Fig. 24).
- Under arthroscopic guidance, an LT ballottement or shear test can be performed to assess LT stability.

Step 2

- Midcarpal arthroscopy via the midcarpal portals (at the level of the midcarpal joint, radial and ulnar to the fourth dorsal compartment) should also be performed to more accurately assess the presence of LT instability (Fig. 25). If the LT joint is stable, arthroscopic debridement of the torn ligament edges is performed with an oscillating mechanical shaver to stimulate healing; no pins are placed across the joint (Fig. 26).

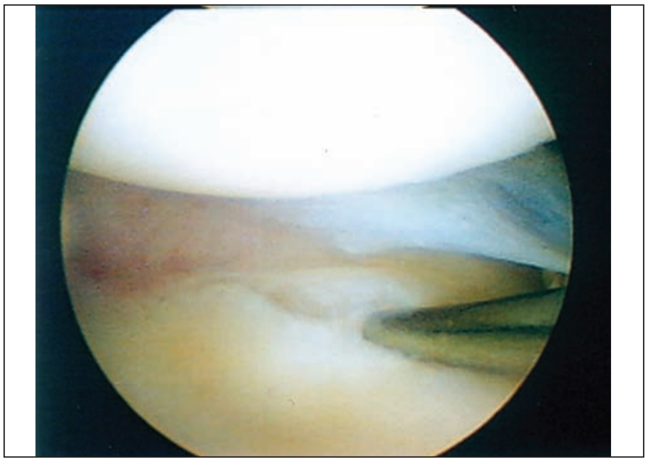

Figure 23. Examining the ulnar region of the wrist demonstrates a central tear of the TFCC (probe) with the "shower-curtain sign" just above that indicating a portion of the LT ligament hanging from the LT interval, consistent with a LT tear.

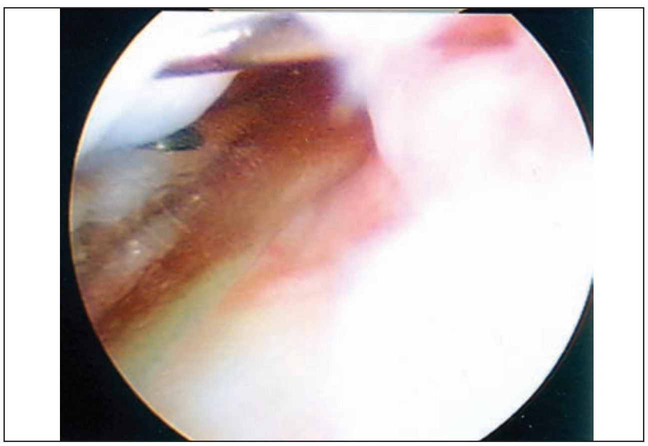

Figure 24. A probe can be placed into the LT interval when a tear exists between the two ligaments.

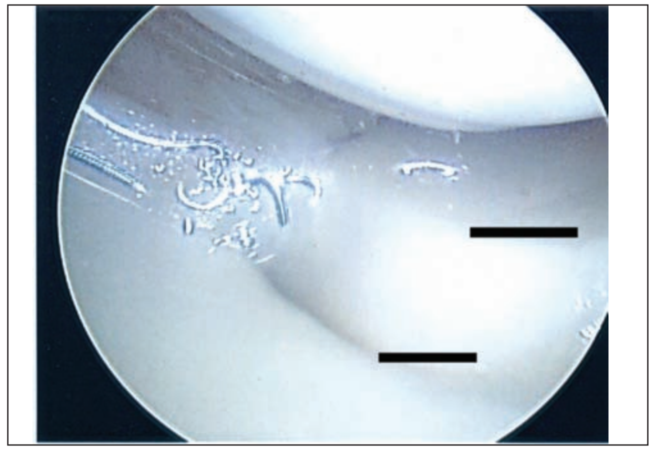

Figure 25. Via the midcarpal portal, a notable step-off (black lines) is noted between the lunate and triquetrum, confirming LT instability.

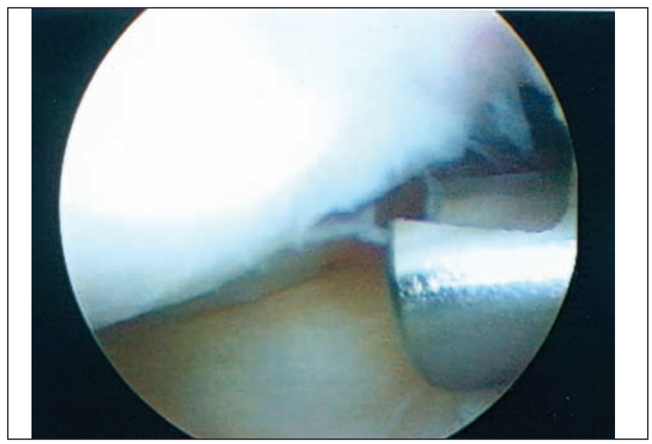

Figure 26. Arthroscopic debridement can be undertaken with a 2.9-mm cutter blade, with or without pinning of the LT interval.

Step 3

- If the joint seems unstable (Fig. 27) and the tear is felt to be acute in nature without any associated arthritic changes, reduction of the LT joint is assured via arthroscopic and/or fluoroscopic means and two or three 1.4-mm K-wires are inserted percutaneously from the triquetrum into the lunate. While inserting the K-wires, thought should be given to the typical topographical course of the dorsal sensory branch of the ulnar nerve; an angiocatheter may be used as a "drill guide" to try to prevent iatrogenic injury. If the LT joint appears to be gapped or malpositioned, using dorsal-to-volar 1.6-mm K-wire joysticks in the lunate and in the triquetrum may be helpful in achieving an anatomic reduction.

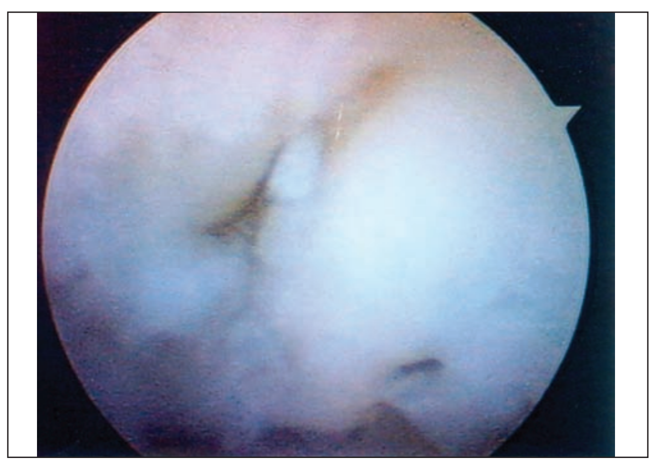

Figure 27. A large tear of the LT ligament is visualized with the arthroscope in the 4-5 portal, which allows for direct examination.

- Sometimes, as the LT pin is being inserted it may push the lunate away from the triquetrum rather than holding them together in a reduced position. In these circumstances, it may be helpful to first place an SL pin from radial to ulnar so that the lunate cannot get away before you insert the LT pin.
- When reduction is achieved, the 1.4-mm K-wires are placed across the LT joint to maintain it. These pins are buried subcutaneously because they will not be removed for approximately 8 weeks. If the LT joint seems unstable despite percutaneous pin fixation, or if the LT ligament tear appears to be more chronic than anticipated, we favor converting to an open procedure and either performing an LT arthrodesis or augmenting the reduction with a dorsal soft tissue or bone-soft tissue-bone reconstruction.

Postoperative Care and Expected Outcomes

- The extremity is immobilized for 8 weeks until the pins are removed. Radiographs are routinely obtained at 1, 4, 8, and 12 weeks after surgery to assess the maintenance of the intercarpal reduction and the position of the K-wires. After the pins are removed, the wrist is protected for another 4 weeks with a removable splint and gentle hand therapy is initiated.

Results, Including Complications

- The data on treating partial LT ligament tears with arthroscopic debridement alone is quite promising.[5,6] The results of arthroscopic treatment of complete LT ligament tears is less clear. Although the senior author's (APCW)[6] series showed pain relief after arthroscopic debridement alone in 7 of 9 patients with complete LT disruption, none of these patients had an LT gap of greater than 3 mm.
- In contrast to these findings, Westkaemper et al.[28] reported poor results in 4 of 5 patients with complete LT tears who were treated with arthroscopic debridement alone.
- Osterman and Seidman[29] reported on a group of 20 consecutive patients who were found to have LT ligament tears. In that series, the ligament was debrided and the LT joint was percutaneously pinned in all cases, although only 4 of the 20 had a provocative "shuck" or LT ballottement test. Concomitant procedures included 5 TFCC debridements, 3 chondroplasties, and 3 distal ulnar resections. At an average follow-up of nearly 3 years, 80% of the patients were found to have good or excellent pain relief. Two patients still had a persistently positive "shuck" test at final follow-up.
- In their series of 57 patients with isolated LT ligament injuries that were treated with either direct ligament repair, ligament reconstruction using a distally based strip of extensor carpi ulnaris tendon, or LT arthrodesis, Shin et al.[27] found that the probability of not requiring further surgery at 5-year follow-up was best in the ligament reconstruction group (68.6%) and worst in the LT arthrodesis group (21.8%).
- Complications of LT pinning include pin-track infections, the bending or breakage of pins, and loss of LT reduction.

Conclusions

- Although a few good case series on the treatment of LT instability have been published over the last 10 to 15 years, a prospective head-to-head comparison of closed reduction and pinning versus open ligament repair and pinning does not exist.
- If instability of the LT joint is noted clinically or arthroscopically, few authors would argue against adding K-wire fixation across a reduced LT interval. However, whether acute LT injuries should be treated by ligament repair or soft-tissue reconstruction remains a question that is unanswered by the literature.
- Although it would likely require a multicenter effort, prospective analyses to compare different surgical options for both SL and LT ligament tears, subdivided into acute (<3 weeks from injury), subacute (3 weeks to 3 months from injury), and chronic (>3 months from injury) cohorts, would be a welcome addition to our literature and could guide us to more effective treatment of these difficult injuries.

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