Review Article

Perilunate injuries/lunate dislocations and radiocarpal dislocations

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Abstract: Perilunate injuries/lunate dislocations and radiocarpal dislocations are rare, but important and significant periarticular injuries of the wrist. They are high-energy injuries and are associated with significant soft tissue and ligamentous disruption in addition to often times subtle bony injury. Early recognition, appropriate management, and restoration of normal anatomy are critical to regain patient functionality and improve outcomes. We present case examples of each to highlight surgical technique and perioperative considerations.

Keywords: Perilunate; lunate; radiocarpal; dislocation; fracture

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Perilunate injuries and lunate dislocations

Introduction

Acute perilunate injuries and lunate dislocations are rare but potentially devastating injuries of the carpus seen in high-energy trauma. The often underwhelming physical exam and subtle radiographic findings make these injuries prone to being missed on initial presentation, which can occur in up to 25% of cases (1-3). Missed diagnosis or delayed treatment can lead to chronic instability and an alteration in joint biomechanics, causing post-traumatic degenerative changes of the wrist (3). Early recognition and intervention is crucial.

Initial management should include an attempted closed reduction, followed by surgical stabilization in a timely fashion (3-6). This injury should be treated surgically to avoid poor outcomes (7-10). Operative treatment should aim to restore carpal alignment, repair ligamentous disruption, and treat evolving median nerve compression (11,12).

Case history

A 26-year-old right-hand dominant male nurse presented to the Emergency Department after falling onto his left side from a height of 12 feet while climbing a rope at a fitness center. His left wrist was mildly painful and swollen with intact skin. He had progressive diminishing sensation in the median nerve distribution. Radiographs, as shown in *Figure 1*, demonstrated a stage IIB volar lunate dislocation (1,13). An attempted closed reduction was unsuccessful. He underwent an open reduction internal fixation of the carpus, scapholunate ligament repair, and an open extended carpal tunnel release.

Technique

The patient was brought to the Operating Room and placed supine on a stretcher with a hand table. Closed reduction was unable to be achieved under general anesthesia with muscle relaxation. Open reduction was performed through an extended carpal tunnel approach given his median nerve symptoms. The lunate and scaphoid were noted to tent the volar wrist capsule, with a small transverse rent overlying the Space of Poirier and through the midsubstance of the radioscaphocapitate ligament. The carpal bones were reduced and the capsular rent and ligament were repaired

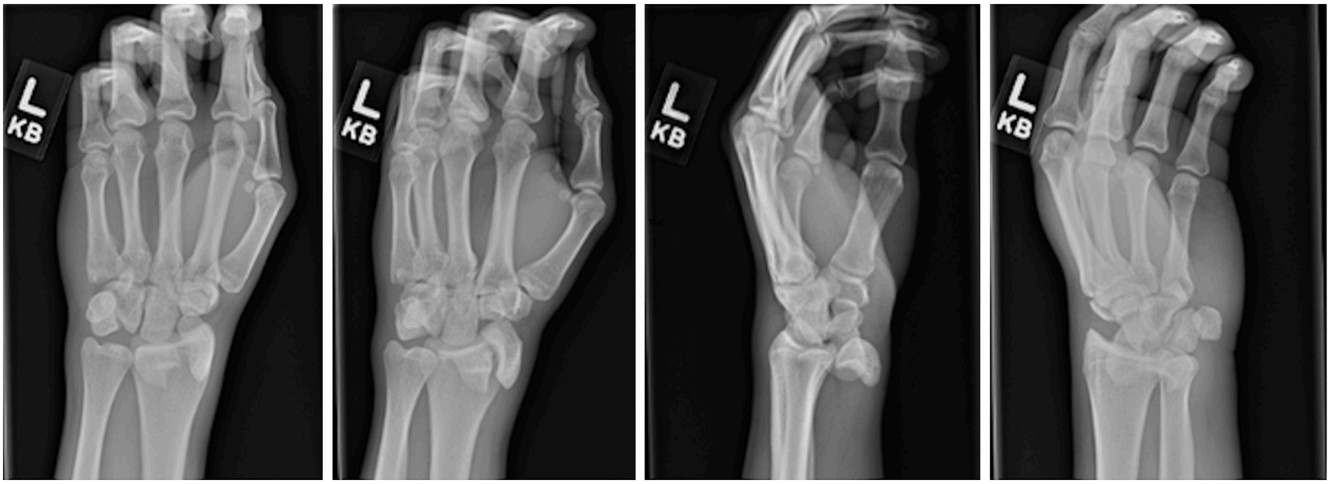

Figure 1 Demonstrates anterior-posterior (AP), lateral, and two oblique radiographic views of the left wrist demonstrating volar lunate and scaphoid dislocations.

with a monofilament suture.

A standard dorsal approach to the wrist was taken through the third dorsal compartment. A posterior interosseous nerve neurectomy was performed. An inverted T-shaped capsulotomy was performed. The lunate was noted to still be volarly subluxated and extended. The capitate head had three small full thickness cartilage defects and the scapholunate interosseous ligament (SLIL) was completely torn from the dorsal scaphoid.

The carpal bones were reduced by pinning the lunate to the radius in a neutral position. Additional Kirschner wires (K-wires) were placed into the dorsal lunate and scaphoid. The joysticks were clamped together to restore the scapholunate angle. The carpus was pinned using 0.054" K-wires given the patient's stature, although generally 0.062" K-wires are preferred. Special attention was given to the pin locations within the proximal pole of the scaphoid to avoid interference with suture anchor placement. A mini-Mitek suture anchor was placed at the site of the SLIL disruption to facilitate repair with a horizontal mattress suture. The dorsal capsule and extensor retinaculum were repaired. The extensor pollicis longus (EPL) remained transposed. The patient was placed into a sugar-tong splint and a sling. Intra-operative final radiographs can be seen in *Figure 2*.

The patient was transitioned to a short arm thumb spica cast one week post-operatively and eventually a removable splint the week before his 10-week post-operative pin removal. After pin removal, he initiated therapy for wrist range of motion followed by strengthening. At final follow-up, he lacked only 10-degrees of wrist extension. His radiographs, as shown in *Figure 3*, demonstrated maintained reduction but with some early degenerative changes, dorsal intercalated segment instability (DISI) deformity, and early ulnar translocation of the carpus. He returned to the gym and full duty work.

Discussion

Both perilunate injuries and lunate dislocations can involve damage to the ligaments, bones, or both. Those that are purely ligamentous in nature are defined as lesser arc injuries, and those with bony involvement are defined as greater arc injuries, i.e., fracture-dislocations (12).

As described by Mayfield *et al.* (14), the most common directionality of a perilunate dislocation is dorsal. The carpus, however, can "rebound" volarly, displacing the lunate in a palmar direction, causing a lunate dislocation (4). Thus, a volar lunate dislocation (more common than dorsal) is often considered the end stage of a dorsal perilunate dislocation rather than a separate injury (1,2,5,14-16). Herzberg *et al.* further classified lunate dislocations (1). Stage IIA injuries are defined as partial subluxation of the lunate from its fossa with less than 90 degrees of rotation, while stage IIB are defined as complete dislocation of the lunate from its fossa into the carpal canal with greater than 90 degrees of rotation.

Non-operative treatment of these injuries is not indicated unless comorbidities prohibit the patient from undergoing surgery. Closed reduction should almost always be

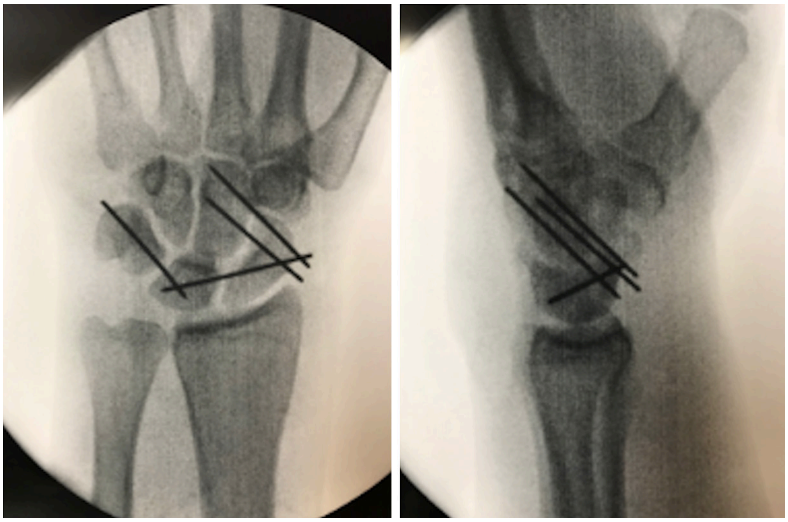

Figure 2 Demonstrates anterior-posterior (AP) and lateral intra-operative fluoroscopic views of the left wrist demonstrating open reduction internal fixation of volar scaphoid and lunate dislocations with two K-wires transfixing the scaphocapitate joint, one K-wire transfixing the scapholunate joint, and one K-wire transfixing the lunotriquetral joint.

Figure 3 Demonstrates anterior-posterior (AP) and lateral radiographic views of the left wrist from the most recent follow up visit. There has been interval removal of hardware. The scaphoid is slightly flexed compared to the lunate (DISI deformity) and there are early degenerative changes visualized in the midcarpal joints with improving osteopenia. DISI, dorsal intercalated segment instability.

attempted first with pre-procedural traction and complete muscle relaxation, followed by surgical stabilization (1-3,17).

Surgical stabilization in the form of open reduction internal fixation is recommended, as it has been found to be superior to closed or arthroscopic reduction and internal fixation due to improved visualization and repair of bone and soft tissue injuries (1-6,9-11,16-22).

Volar, dorsal, or combined volar-dorsal approaches have been described to treat perilunate and lunate dislocations, which has been historically controversial (3,4,7,9,11,15,18,21,22). All described techniques usually include some form of dorsal approach, to facilitate direct repair of the dorsal scapholunate ligament (1). A straight dorsal incision is made centered over or just ulnar to Lister's tubercle. The extensor retinaculum is incised along the third dorsal compartment, exposing the second through fourth dorsal compartments. A posterior interosseous nerve neurectomy is often performed. The dorsal capsule is frequently avulsed off the distal radius and the dorsal carpal ligaments are usually torn (6). If possible, a ligament sparing capsulotomy is made to expose the carpus (5). It is imperative to inspect the extent of the bony and soft tissue damage, particularly to the capitate head. If a dislocation persists, there will be an obvious abnormal space between the capitate and the distal radius. In a lunate dislocation, the lunate can be reduced with good visualization and manual pressure after removing any interposed tissue (3).

Once reduced, the carpus is stabilized using K-wires. Fixation across the intercarpal joints can also be performed using cannulated screws or interosseous cerclage wires, which can be placed through smaller, separate incisions (1,4,5,11,23-27). Some argue against the use of K-wires as they do not feel they are stable enough to maintain rigid fixation, and also carry the risk of pin site infection (4,11,26).

The senior author prefers the use of K-wires because they are readily available, cost-effective, and easy to implant and remove. When restoring normal carpal alignment, a K-wire is placed from the dorsal radius through the lunate to stabilize it in neutral position. K-wires are then placed anterograde through the triquetrum and the scaphoid, the pins are pulled flush with the articulations to the lunate. This allows better control of pin placement within the lunate after reduction. K-wires are placed into the dorsal lunate and scaphoid and used as joysticks to restore the scapholunate angle. The reduction is held and checked by clamping the joystick wires together with a hemostat. The proximal row is reduced and the previously placed wires are advanced retrograde into the lunate. The midcarpal joint is stabilized with two scaphocapitate pins, or one scaphocapitate pin and one triquetral-capitate pin to control midcarpal motion. The pins are cut below the skin.

The SLIL is repaired primarily with a suture anchor. Repair of the LTIL has not been shown to improve outcomes (1,4-6,8,11,23,28). The senior author does not routinely repair this ligament, unless already performing a carpal tunnel release and the joint is easily accessible through the traumatic rent in the volar capsule. In general, however, ligaments should be repaired into their anatomic position for added stability to the carpus, though some may not be amenable to this due to the extent of damage (3-5). The dorsal capsule and extensor reticulum are repaired with the EPL tendon transposed.

Those who prefer to do an isolated dorsal approach will make an additional volar incision under certain circumstances, which include progressive median nerve dysfunction requiring a carpal tunnel release or open reduction of a volar lunate dislocation (4,11).

The volar approach is through an extended carpal tunnel incision. Retraction of the carpal tunnel contents and exploration of the palmar capsule frequently reveals a "rent" between the radiocapitate and radiolunate ligaments in the form of an upside-down smile (3,29). The lunate is reduced and the LTIL can be repaired either primarily or with a suture anchor, the overlying capsule is then repaired with non-absorbable suture (2,11). An exclusive dorsal approach may restore the lunotriquetral interval indirectly and allow the ligament to heal in an acceptable position obviating a second incision which can contribute to wound complications, slower recovery of digital flexion strength, and flexor tendon adhesions (4,15).

Overall, the combined volar-dorsal approach has the benefits of increased exposure and direct anatomic repair of all major ligaments, although its overall clinical benefit remains unclear (1,5,11,12,16,18,27-29).

Even in the setting of timely treatment, the majority of patients will develop post-traumatic arthritis (1,15,30). Worse outcomes and prognosis are associated with delay in treatment, open injuries, persistent carpal malalignment, and fracture-dislocations (1,4,15,16). Other complications include persistent median nerve dysfunction, complex regional pain syndrome (CRPS), tendon ruptures, residual carpal instability, and avascular necrosis of the lunate (2,5,15,16,27). However, patients still tend to do well clinically and functionally despite the above (1,2,15,16,30).

Figure 4 Demonstrates the anterior-posterior (AP), oblique, and lateral radiographic views of the right wrist which demonstrate a dorsal radiocarpal dislocation with distal radius and ulnar styloid fractures.

Radiocarpal dislocations

Introduction

Radiocarpal dislocations entail partial or full loss of contact of the carpus with the articulating surface of the distal radius (31). They are similarly rare injuries that usually occur in young, males subject to severe trauma. A thorough history, physical exam, and evaluation of radiographs should be performed to make the diagnosis.

Treatment should involve an initial closed reduction followed by open surgical stabilization. Non-operative treatment was historically described, however more recent literature suggests that all radiocarpal dislocations should be stabilized surgically due to instability and severe capsuloligamentous injury (32,33).

As with perilunate injuries/lunate dislocations, missed, delayed, or suboptimal treatment of radiocarpal dislocations can lead to wrist instability and eventual post-traumatic arthritis (34-38).

Case history

A 54-year-old male presented to the Trauma Bay as a polytrauma after he collided with a school bus while riding a motorcycle. He complained of severe pain in the right wrist with decreased mobility, which was noted to be swollen with an obvious deformity and intact skin. His neurovascular exam was complicated by obtundation. Radiographs (see *Figure 4*) demonstrated a dorsal radiocarpal fracture-dislocation with a radial styloid fragment that included the entire radioscaphoid fossa. There was an associated ulnar styloid fracture. The patient's injury pattern was consistent with a type II dorsal radiocarpal dislocation (34). A closed reduction was performed and the wrist immobilized. Once stable from his injuries, he underwent open reduction internal fixation of the radius with a carpal tunnel release.

Technique

The patient was brought to the Operating Room and placed supine on a stretcher with a hand table. Given severe swelling of the hand and wrist and an unreliable neurological exam, the decision was made to prophylactically release the carpal tunnel through a standard volar approach. The median nerve appeared swollen and there was a large hematoma within the flexor tendon sheath, which was decompressed.

A standard dorsal approach to the wrist (described in previous section) was taken where two fracture fragments were identified in addition to the large radial styloid

Figure 5 Demonstrates the anterior-posterior (AP), oblique, and lateral radiographic views of the right wrist, which show open reduction internal fixation of the distal radius using cannulated screws and bone suture anchors. The carpus alignment is restored.

fragment: one involving the dorsal lip of the radius and the other, Lister's tubercle and its accompanying dorsal articular segment. Inspection of the joint noted partial thickness cartilage scoring of the proximal scaphoid and lunate.

Attention was first directed to the large radial styloid fragment, which was reduced and fixed using two 3.0 mm cannulated screws through a separate incision to avoid irritation to the superficial branch of the radial nerve. The wrist was stable through a range of motion under fluoroscopy. The dorsal capsular avulsions were repaired with suture anchors. The capsule and extensor retinaculum were repaired with the EPL transposed. The distal radioulnar joint (DRUJ) was stressed and noted to be stable in all positions of forearm rotation. The radiocarpal joint was stressed under fluoroscopy and noted to be stable. The patient was placed into a forearm based volar wrist splint. Post-operative radiographs are shown in *Figure 5*.

The patient was converted to a short arm cast followed by a removable brace. At the 3-month post-operative visit, the patient was pain free with only slight limitation in range of motion, but still with a 100-degree total arc of motion. He was discharged from physical therapy and was released to full duty work. Final radiographs (see *Figure 6*) demonstrated a healed radial styloid fracture and ulnar styloid nonunion. The radiocarpal joint was reduced without evidence of ulnar translocation.

Discussion

While volar dislocations have been reported, the most common directionality of a radiocarpal dislocation is dorsal in nature (39,40). The strong volar radiocarpal ligaments tear or avulse in conjunction with disruption of the ulnar attachments to the carpus, which then translates freely, dorsally and radially (3,32,34,40-46). Concomitant bony avulsion fractures of the radial and ulnar styloid are common (40,47).

Dumontier *et al.* classified radiocarpal dislocations into two groups (34). Type I injuries are purely ligamentous or have a radial styloid fracture which is less than one-third of the radioscaphoid articulation. The radioscaphocapitate ligament is assumed to be ruptured rather than avulsed given its anatomic attachment to the radius 5 mm from the styloid tip. Type II injuries have a styloid fracture that is greater than one third of the radioscaphoid articulation, representing an avulsion of the critical extrinsic volar

Figure 6 Demonstrates the anterior-posterior (AP), oblique, and lateral radiographic views of the right wrist, which show continued maintained alignment without hardware complication, as well as callus formation representing bony healing.

ligamentous stabilizers (34). Type I injuries are extremely rare and likely involve complete disruption or tearing of all the volar radiocarpal ligaments, making this injury pattern extremely unstable (32-34,40,41,44-46,48-51).

Initial management should include a closed reduction, pushing the translated carpus back onto the distal radius fossa with traction. While the reduction is often easy to perform, maintenance of reduction may prove difficult given the extent of associated ligamentous injury (3,32).

Dumontier *et al.* provided a 27-patient retrospective review to support and describe surgical technique (34). This is the largest series to date.

They recommend an open, volar approach for type I injuries in order to perform an open reduction of the carpus with capsule and ligamentous repair, and K-wire fixation of the lunate under the radius. In type I injuries involving a tip of radial styloid fracture, the volar radiocarpal ligaments should be directly repaired to the volar lip of the intact radial styloid (3,34). Various ways to repair the capsular and ligamentous elements, including suture anchors and/or tendon grafts have been described (52,53). Additional radiocarpal stabilization in the form of K-wires, a dorsal spanning plate, or an external fixator should be considered to augment the ligamentous repair.

In contrast, Dumontier *et al.* as well as other authors recommend an open, dorsal approach for type II injuries with K-wire fixation of the distal radius via styloid pinning (34,47). The senior author prefers the use of two cannulated screws for the styloid fragment because they do not require removal and avoids potential pin site infection and irritation. Routine volar approach is not required as bony fixation will restore wrist stability as the volar ligamentous stabilizers are usually intact and attached to the styloid fragment. The wrist should be stressed under fluoroscopy, and if there is continued instability after fixation, then a volar approach should be taken to examine and repair any disrupted volar ligamentous structures.

Additional surgical considerations should include removing all interposing soft tissue and free osteochondral fragments, which has been shown to improve outcomes (41,54). Small dorsal capsular avulsions are either directly repaired with non-absorbable suture or with the aid of suture anchors.

There is no clear evidence to support a unified recommendation for post-operative care for these injuries. Dumontier *et al.* did recommend retaining the K-wire (fixing the lunate to the distal radius) in type I injuries for at least 2 months (34). They also suggest that adjunctive immobilization in the form of a cast or external fixator for 6 weeks in type II injuries is “probably necessary” (34).

Most surgeons can likely agree that K-wires need to be removed anywhere from 6–12 weeks post-operatively and that some form of immobilization should be required at least for 6 weeks to allow soft tissue and bony healing before proceeding to strengthening.

There have been mixed conclusions with regards to patient outcomes after radiocarpal dislocations. Some reported cases have had good outcomes despite the severity of injury, while others have reported poor functional results (32-37,39,42,48,49,55,56).

The feared complication (particularly in type I injuries where the volar radiocarpal ligamentous complex has been disrupted) is ulnar and volar translation of the carpus (34,50). Dumontier *et al.* believed this complication could be prevented by the K-wire fixation of the lunate into the distal radius, which is retained for 2 months post-operatively (34). Other studies have suggested that adequate capsule and ligament repair can prevent ulnar translation (38).

This complication spares type II injuries because the volar radiocarpal ligaments are intact and attached to the radial styloid fracture fragment (34).

The other known complication that can affect outcomes is the development of post-traumatic arthritis, which develops even if ulnar translocation does not occur (34-38). Some studies suggest that intracarpal lesion ligament repair can lead to better outcomes, though patients can still go on to develop osteoarthritis secondary to the associated degree of cartilaginous injury (43).

The severity of the injury will likely dictate the development of post-traumatic arthritis which may affect outcomes. Regardless, anatomic restoration of bony and ligamentous injuries should be ideally achieved in order to optimize patient satisfaction and function.

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