Radiocarpal fracture-dislocations are uncommon injuries, comprising a spectrum of trauma to the capsuloligamentous complex and osseous structures of the radiocarpal joint along with the adjacent structures. Management guidelines are derived from limited case series and expert opinions. An understanding of the relevant anatomy suggests that restoration of an anatomically reduced joint in conjunction with repair or reconstruction of the osseous and soft tissue structures optimizes outcome. Special consideration should be given to repair of the radial styloid, intercarpal ligaments, and radiocarpal capsuloligamentous complex. The authors report 2 patients with radiocarpal fracture-dislocations in which reduction and stabilization of the carpus was achieved using suture anchor fixation of the volar extrinsic radiocarpal ligaments.

Abstract: Radiocarpal fracture-dislocations are uncommon injuries, with few reported case series in the English literature. Unlike perilunate carpal dislocations and fracture-dislocations, the mechanism and relevant pathoanatomy of traumatic radiocarpal fracture-dislocations is not well characterized. Associated injuries are common with radial styloid, ulnar styloid, and marginal avulsion fractures predominating. Open injuries with significant soft-tissue disruption can occur, leading to persistent instability. The available literature reveals that historically poor functional outcomes are normal after conservative treatment. The paucity of reported cases and incomplete understanding of the spectrum of associated injuries has not permitted a consensus on treatment recommendations, although various methods of operative stabilization and repair have been recommended. Current understanding of the role of ligamentous stabilizers of the wrist suggests that special attention should be given to achieving robust repair of the volar capsuloligamentous complex, which includes stabilization of any associated radial styloid fracture.

The authors describe a surgical technique used after initial closed reduction for 2 patients who sustained dorsal radiocarpal fracture-dislocations treated acutely with operative repair of the volar extrinsic ligaments and capsular structures using suture anchor fixation in conjunction with reduction and fixation of a radial styloid fracture. The authors describe a surgical technique used after initial closed reduction for 2 patients who sustained dorsal radiocarpal fracture-dislocations treated acutely with operative repair of the volar extrinsic ligaments and capsular structures using suture anchor fixation in conjunction with reduction and fixation of a radial styloid fracture. The authors report 2 patients with radiocarpal fracture-dislocations in which reduction and stabilization of the carpus was achieved using suture anchor fixation of the volar extrinsic radiocarpal ligaments.

Anatomy

The complex motion of the radiocarpal, intercarpal, and radioulnar joints is coordinated and constrained by the congruent 3-dimensional anatomy of the osseous structures and the ligamentous complex. The distal radius articular surface is a volarly tilted biconcave surface with fossae for the lunate and scaphoid where the inclination of the radial styloid resists radial translation. Resistance to radiocarpal dislocation or translation is principally dependent on the extrinsic radiocarpal capsuloligamentous complex. The radiocarpal wrist ligaments exist principally as organized collagen fascicles embedded within the capsule. Building on the earlier work by Berger et al., more recent studies have dramatically expanded the understanding of the functional significance of discrete stabilizers of the radiocarpal joint that are commonly disrupted in radiocarpal dislocations. The radioscaphocapitate ligament, the long and short long radiolunate ligaments, the ra-
dioscapoholunate ligament, and the palmar capsule comprise the volar capsuloligamentous complex and make varying contributions to constraining volar, dorsal, and radioulnar displacement. The radioscaphoid and radioscaphocapitate ligaments originate on the radial half of the volar rim of the scaphoid fossa and are functionally disrupted by large avulsion fractures of the radial styloid. The stout radiolunate ligaments originate from the ulnar aspect of the volar distal radius and are disrupted with the volar capsule during dorsal radiocarpal dislocations.

A cadaveric sectioning study by Katz et al demonstrated that the volar capsuloligamentous complex provides the major restraint to the dorsal and volar translation of the carpus. These volar structures contribute 61% and 48% of the mechanical restraint to dorsal and palmar translation of the radiocarpal joint, respectively. This is in comparison with a mere respective 2% and 6% contribution by the dorsal radiocarpal ligament under the same conditions. Enhanced understanding of the functional anatomy of the volar radiocarpal ligaments supports recommendations for operative reduction and fixation of large radial styloid fragments to recreate the stability conferred by the attached ligaments. Other structures, including the dorsal capsule, traversing flexor and extensor tendons, bony anatomy, and collateral ligaments, account for the remainder of this resistance to dorsal and palmar translation.

**Mechanism of Injury**

Many authors have postulated about the exact mechanism of injury (hyperextension, pronation, or torsion) resulting in dorsal radiocarpal dislocations, with emphasis on severe rotational or shear forces. The difficulty in determining this clinically lies in the fact that the majority of injuries result from high-energy mechanisms in patients unable to specifically recall the position of the wrist at the time of injury. Overall, numerous patterns of injury exist, including associated fractures of the forearm and carpus and other ligamentous disruptions. The injury patterns likely reflect variation in the mechanism of injury based on force vector, hand position, and intrinsic tissue properties.

**Classification**

Because radiocarpal fracture-dislocations are noted to be uncommon clinically, corresponding case series reporting these injuries are sparse and have differing classification parameters. Purely ligamentous injuries are rarer, with associated injuries commonly involving the radial styloid, distal radioulnar joint, marginal articular surface of the distal radius, intercarpal ligament, and ulnar styloid or triangular fibrocartilage complex. DuMontier et al reported 27 patients (the largest case series to date) and used a classification scheme based on the presence or absence of an associated radial styloid fracture. Type I injuries have no fracture of the styloid or a fracture of the tip of the styloid with avulsion of the radiocarpal ligaments. Type II fracture-dislocations include radial styloid fractures involving more than one-third of the radial fossa, with the radiocarpal ligaments presumably attached to the displaced styloid. Various treatment approaches were reported, including closed reduction and casting, percutaneous K-wire fixation, external fixation, and open reduction with K-wire stabilization. Outcomes were measured at an average of 27 and 51 months for type I and II injuries, respectively, including wrist range of motion, forearm rotation, pain, and grip strength. At final evaluation, 4 of 7 patients with type I injuries (pure ligamentous) demonstrated ulnar translation of the carpus. In addition, all patients showed reduced range of motion and strength at final follow-up relative to the uninjured side. At 27 months post-injury, patients with type I injuries had notably decreased radioulnar inclination and grip strength compared with patients with type II injuries evaluated at 51 months.

Despite being the largest series of radiocarpal dislocations reported, the DuMontier et al study compromises a diversity of treatment approaches, heterogeneity of injury patterns, significant number of patients unavailable at follow-up, and an incomplete characterization of the injuries sustained by the individuals. The authors concluded that a volar approach to facilitate ligament repair is recommended for type I injuries, and a dorsal approach to permit anatomic reduction of the radial styloid fracture is recommended for type II injuries. Improved outcomes with the achievement of a more anatomic reduction of the radial styloid fracture has also been demonstrated by other authors, with higher energy injuries and increasing comminution of the radial styloid predicting worse outcomes. However, with the overall importance of radiocarpal ligament function well established, the relevance of this classification beyond delineation of the radiocarpal ligament repair required (primarily or indirectly by radial styloid stabilization) remains unclear.

Moneim et al classified 7 radiocarpal fracture-dislocations based on the presence of intercarpal injury, with type I injuries having an intact carpus without intercarpal disruption (with or without a radial styloid fracture) and type II injuries being more complex injuries associated with either a carpal bone fracture or an intercarpal ligamentous disruption. In the series, type I injuries were more commonly dorsally dislocated (3 of 4 patients) and were all successfully managed with closed reduction. The 3 type II injuries were displaced volarily, required open reduction, and demonstrated significant residual dysfunction. Other authors have also documented type II injuries demonstrating worse outcomes despite appropriate treatment to reduce the radiocarpal fracture-dislocation.

In particular, the scapholunate ligament should be care-
fully evaluated because concomitant disruption associated with radiocarpal dislocation and fracture-dislocations has been documented in multiple series. Open ligament repair or reconstruction of the scapholunate ligament can be reliably performed at the time of initial presentation, potentially avoiding the chronic scapholunate ligament disruption that may predispose patients to poor long-term outcomes irrespective of the radiocarpal injury.221 Thus, the wide spectrum of injury associated with radiocarpal fracture-dislocations may support the use of descriptive terminology to enable prioritization of treatment approaches based on the presence of other, often discrete, injuries.

Imaging, Diagnosis, and Management

Establishing that these injuries are a spectrum of pathology involving both the bony and ligamentous structures that stabilize the radiocarpal joint, the significance of this trauma alone supports the indication that radiocarpal fracture-dislocations require immediate reduction to prevent further injury to the carpus and neighboring neurovascular structures.11,15 The carpal dislocation can occur in any direction, although dorsal dislocations predominate. Irreducible radiocarpal dislocation has been described, but gross instability that facilitates manual reduction in the acute setting is the typical result.11,22 Spontaneous reduction can also occur. A high index of suspicion for radiocarpal injury is necessary in patients with a history of significant trauma and wrist pain, swelling, tenderness, deformity, or subtle radiocarpal misalignment on radiographic examination.23 Despite this fact, radiographs remain the principle imaging modality to assess these injuries.

Persistent carpal instability is expected after radiocarpal dislocation, and maintenance of anatomic reduction via closed methods alone can be difficult.16 Mudgal et al18 reported 12 patients with more than 10 years of follow-up and recommended precise restoration of bony radiocarpal anatomy, with emphasis on repair of the radial and ulnar styloid to restore stability and improve outcomes. Similar to the study by Dumontier et al,9 numerous surgical techniques have been reported, including K-wire or plate stabilization, external fixation, primary ligament repair or ligament reconstruction, and bone grafting, depending on the injury pattern. Open treatment should be considered the standard of care with emphasis on repair of volar radiocarpal ligaments and intercarpal disruptions or carpal fractures.

Arthroscopic radiocarpal reduction with removal of interposed soft tissue and percutaneous wire fixation after dislocation has been suggested, and a good outcome was reported in 1 patient.14,20 However, the inability to repair extrinsic ligaments and the relative frequency of associated injuries requiring repair may limit the usefulness of arthroscopic management alone.

The radioscapohamate ligament is often intact when a radial styloid fracture is present; however, if the ligament is also disrupted and does not undergo acute repair and stabilization, sufficient primary healing may not occur.21 Ulnar translation of the carpus following dislocation results from disruption of the radioscapohamate ligament and may lead to long-term function impairment and accelerated degenerative changes of the carpus.16,22 Anatomic reduction of the radial styloid and the corresponding origin of the radioscapohamate ligament, in addition to possible ligament reconstruction with brachioradialis tendon in the irreparable tears, may improve long-term outcomes.24 The sequelae of chronic volar translation of the carpus can become so severe clinically that limited or formal arthrodesis has been recommended.22,25

CASE REPORTS

Patient 1

A 47-year-old man presented to the emergency department several days after sustaining an injury to his dominant left upper extremity after falling off a jet-ski while on vacation in the Caribbean. Radiographs revealed a dorsal radiocarpal fracture-dislocation involving a fracture of the radial styloid (Figures 1A, B). The styloid fracture extended to the medial aspect of the scaphoid fossa and was successfully close reduced at the time of his initial delayed pre-sentation to the emergency department before being splinted and discharged for outpatient follow-up. His neurovascular examination was normal, with no median nerve paresthesias.

Based on the unstable nature of his injury, the authors recommended that he undergo operative repair and stabilization. A volar Henry approach was used to expose the distal radius. The radial styloid was reduced and provisionally fixed with a K-wire prior to cannulated screw fixation. Subsequent reexamination of the carpus demonstrated persistent translation of the carpus with malreduction of the radiocarpal joint. The avulsed extrinsic radiocarpal ligaments incorporating the volar joint capsule were identified, and the volar lip of the distal radius was debrided of residual soft tissue to prepare the bone for ligamentous repair. Three 1.5-mm Micromite (Linvatec, Utica, New York) suture anchors were parallel along the prepared volar lip, and the radiocarpal ligaments were secured. Specific attention was paid to not overtightening the volar extrinsic ligaments to permit normal wrist extension without disrupting the volar repair. Fluoroscopic examination confirmed improved stability of the carpus without displacement of the carpus volar or dorsal to the radial lip when manipulated.

At 9-month follow-up, the patient demonstrated mild (less than 15°) loss of wrist flexion and extension, with full pronation and supination compared with the uninjured
extremity and had returned to work as a manual laborer. Radiographs confirmed reduction of the radiocarpal joint (Figure 1C, D).

**Patient 2**

A 20-year-old right-hand-dominant man presented after a 20-foot fall from a window and reported bilateral wrist pain and deformity. Radiographs revealed a right transradial styloid transtriquetrum perilunate fracture-dislocation and a left dorsal radiocarpal fracture-dislocation with comminution of the radial styloid (Figure 2A, B). The patient’s injuries were initially reduced in the emergency department, and operative repair was recommended based on the patient’s age, functional status, and unstable bilateral injury pattern.

Intraoperative fluoroscopic examination of the left wrist demonstrated scapholunate diastasis and displacement of the carpus volarly and dorsally during manipulation. A volar Henry approach to the distal radius revealed significant comminution of the radial styloid and volar marginal lip. The volar lip was then prepared for repair of the volar radiocarpal ligaments in the aforementioned fashion. Three 1.5-mm Micromite suture anchors were placed on the volar lip of the distal radius and the extrinsic volar radiocarpal ligaments and capsule were repaired. At this point, fluoroscopic examination showed normalization of the scapholunate interval and angle; therefore, 1 interosseous K-wire was placed across the scapholunate joint to maintain the alignment. The radial styloid was too comminuted to permit screw fixation, thus, 1 K-wire was placed through the larger fragment to maintain its position and support the adjacent articular fragments. Fluoroscopic reexamination demonstrated good alignment of the radiocarpal and scapholunate joints and excellent radiocarpal stability during passive range of motion.

Both K-wires were removed at 3-month follow-up, and at 6-month follow-up, the patient had a 60° arc of flexion-extension on the left side, with only slight deficit of pronation and supination. Radiographs showed early signs of clinically asymptomatic posttraumatic arthrosis, with stability of the radiocarpal joint maintained (Figure 2C, D).

**Conclusion**

The majority of carpal dislocations are perilunate injuries reflecting the relative robustness of the radiocarpal ligaments. In contrast, violation of these extrinsic ligaments, which occurs in fracture-dislocations of the carpus, are an even more uncommon injury that generally results from high-energy mechanisms and comprises a characteristic spectrum of osseous and ligamentous injuries that are often not completely appreciated at initial evaluation.

Despite improved appreciation for the relevant pathology of this entity, outcome studies after operative repair of radiocarpal dislocations and fracture-dislocations are not readily available in the literature. Therefore, treatment approaches must be developed that adequately address the spectrum of osseous and soft tissue injuries that occur.

The available outcome studies are small in number and have not specifically examined primary suture anchor repair of the volar ligaments after...
dorsal dislocations. A recent case report demonstrated good outcomes following a dorsal radiocarpal fracture-dislocation in 1 patient following suture anchor repair of the dorsal radiocarpal ligaments and capsule and internal fixation of an associated radial styloid fracture. In contrast, the current authors’ experience suggests that dorsal radiocarpal dislocations are more commonly associated with volar capsuloligamentous complex disruption, an observation more consistent with the demonstrated importance of volar structures in constraining radiocarpal subluxation. Nonetheless, detailed observations following open primary repair of volar structures after radiocarpal dislocation are lacking in the literature. Arthroscopic reduction and pinning of radiocarpal dislocations has also been recently reported, but the current authors’ experience suggests significant carpal instability associated with disruption of the capsuloligamentous complex that may be better stabilized with open soft tissue repair under direct visualization to achieve a more anatomic reduction.

In the current patients with dorsal radiocarpal fracture-dislocations, intraoperative manipulation and fluoroscopic evaluation demonstrated improved carpal alignment and kinematics after volar extrinsic ligament repair. Their experience also confirms prior observations highlighting the importance of anatomic reduction and stabilization of associated radial styloid fractures. Long-term follow-up is needed to evaluate for posttraumatic arthrosis, persistent pain, and functional impairment in patients with these injuries. Although these sequelae have been more thoroughly documented in the perilunate literature, similar findings are expected in patients sustaining these less common wrist injuries as a result of the primary derangement of carpal alignment with corresponding chondral, bony, and ligamentous damage that occurs at the time of initial radiocarpal fracture-dislocation.

References


