Radiocarpal Fracture-dislocations

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Abstract

Radiocarpal fracture-dislocations most often are caused by high-energy trauma. These difficult, uncommon injuries involve significant soft-tissue and osseous trauma, requiring meticulous reduction and fixation. The mechanism of injury is generally a severe shear or rotational insult. Anatomically, the dislocation results in disruption of the radiocarpal ligaments and, usually, both the radial and the ulnar styloid. Understanding the anatomy of the radiocarpal joint is central to understanding the osseous and soft-tissue constraints that are disrupted with a radiocarpal dislocation. Diagnosis can be reliably made on physical examination and radiographic evaluation. Radiocarpal fracture-dislocation injuries must be differentiated from Barton fractures. Associated injuries such as open fractures, neurovascular involvement, and distal radioulnar dislocations also must be taken into account. Closed reduction can be obtained relatively easily, but open reduction and internal fixation is typically necessary to ensure accurate anatomic restoration of injured bone and ligaments.

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Radiocarpal fracture-dislocations are complex injuries characterized by dislocation of the radiocarpal joint. The dislocation may be in either a dorsal or a volar direction and can be associated with fractures of the cortical rim of the distal radius, the radial styloid, and the ulnar styloid. Prior to the descriptions of Pouteau[1] in 1783 and Colles[2] in 1814, a deformed wrist after injury was often considered to be dislocated.[3] However, these early authors, without the benefit of radiographic assessment of the injury, in most cases were making an educated guess. On occasion, a postmortem examination of the affected wrist was done. According to Malgaigne,[4] fractures of the distal radius accounted for <10% of the fractures seen at l'Hotel Dieu in Paris between 1827 and 1830. However, Dupuytren,[5] who worked at the same institution as did Malgaigne, believed that fractures of the distal radius were common. Both agreed that the previously held view of deformed wrists representing a dislocation rather than a fracture was incorrect.[3]

The radiocarpal dislocation injury was truly first recognized and described by Malle in 1838, when he identified a volar radiocarpal fracture-dislocation.[3] Shortly thereafter, Marjolin[3] and Voillemier[6] identified and reported dorsal radiocarpal fracture-dislocations. All of these observations were made from examination of postmortem specimens.

Radiocarpal fracture-dislocations are estimated to account for just 0.2% of all wrist injuries.[7] Few large series exist, and most accounts in the literature consist of case reports.[8-19] Destot[8] reported the first

Figure 1

A B

Posteroanterior **(A)** and lateral **(B)** views of a dorsal radiocarpal fracture-dislocation.

Figure 2

Lateral view of a Barton fracture depicting the large articular fracture fragment (arrows) that, in contrast to a radiocarpal fracture-dislocation, remains in continuity with the carpus.

radiographically documented case of a radiocarpal fracture-dislocation in 1926. The patient had an open injury and eventually succumbed to sepsis. The few series that are available suggest that these injuries are the result of severe high-energy trauma and that they occur most commonly in young men.[20-25]

These injuries are associated with a spectrum of injury patterns. Dorsal dislocations are more common than volar dislocations[20,22,24,25] (Figure 1). The soft-tissue disruption can lead to radiocarpal instability, resulting in ulnar translocation and multidirectional radiocarpal instability.[19,26]

Radiocarpal fracture-dislocation injuries must be differentiated from marginal or rim fractures of the distal radius. These latter injuries have been eponymously associated with John Rhea Barton,[27] who in 1838 provided what is considered to be the earliest description of a marginal shearing fracture of the distal end of the radius. Radiocarpal fracture-dislocations represent a high-energy shear and rotational injury to the wrist with or without a fracture of the radius or ulna. In contrast, Barton fractures are compression injuries in which the articular surface of the fractured distal radius remains in contact with the proximal carpal row holding the intact radiocarpal ligaments (Figure 2). In addition, the displaced articular fragment in a Barton fracture forms a substantial part of the entire distal radial articular surface, which is in contrast to the smaller cortical rim or styloid fractures that typically occur with radiocarpal fracture-dislocations.

Anatomy and Pathophysiology

The articular surface of the distal radius is biconcave and triangular, with the radial styloid process forming the apex of the triangle. The sigmoid notch forms the base and articulates with the head of the ulna. The extrinsic radiocarpal ligaments, capsule, and the scaphoid and lunate fossae of the distal radius provide stability to the radiocarpal joint.[28]

The volar surface of the distal radius is relatively flat. However, the very distal margin slopes volarly in the form of a ridge from which the strong volar radiocarpal ligaments originate. The short radiolunate ligament begins at the ulnar volar margin of the lunate facet and inserts on the volar surface of the lunate. The short radiolunate ligament is the primary soft-tissue restraint against volar translation of the carpus.[29] More radially, the radioscapholunate ligament, the long radiolunate ligament, and the stout radioscaphocapitate ligaments take their origin along the volar rim of the distal radius.[29] The stout radioscaphocapitate provides restraint against ulnar translation of the carpus.[30] On the ulnar side of the wrist, the ulnolunate and ulnotriquetral ligaments originate on the volar side of the triangular fibrocartilage complex, which in turn inserts into the base of the ulnar styloid.[31]

The dorsal surface of the distal radius is convex and serves as the floor of the dorsal extensor compartments. When viewed from the lateral aspect, the most distal dorsal edge of the radius extends past the distal edge of the volar surface, providing the site of origin of the dorsal radiocarpal ligaments.

Radiocarpal fracture-dislocations may be envisaged as an internal disarticulation of the wrist joint. This global injury of varying degrees is a product of several factors: position of the radiocarpal joint at impact, the strength of the radiocarpal ligaments, the strength of the bony structures, and the magnitude and rate of deforming forces. Bohler,[32] who originally postulated the mechanism of injury for dorsal radiocarpal fracture-dislocations, stated that a compressive and rotational force occurs against a hyperextended and pronated wrist.

Our understanding of injuries involving the carpus, its ligaments, and the distal radius changed considerably after the comprehensive description of injury mechanisms by Mayfield et al[33] in 1980. These descriptions clarified the spectrum of injury that can occur with similar loading patterns. These authors were the first to suggest that the rotational force, which is an essential feature in the causation of radiocarpal fracture-dislocations, is in effect an "intercarpal supination." They further demonstrated that wrist extension and ulnar deviation produced tension on the volar radiocarpal ligaments, which caused avulsions of the volar radial lip or radial styloid. Thus, it appears that in addition to a rotational component, radiocarpal fracture-dislocations involve a shear and angulatory component, with translation of the carpus resulting in peeling off of the carpus from the radius and ulna. Depending on the magnitude and direction of the force, the wrist deforms, with a variable amount of bony and soft-tissue injury. The most commonly avulsed fracture fragments include the radial styloid by the radioscaphocapitate ligament,[30] the volar lunate facet by the short radiolunate ligament,[29] and the ulnar styloid.

Clinical Features

The patient typically presents with a painful, swollen, and deformed wrist. The most common mechanisms of injury are falls from a height, motor vehicle injuries, and industrial injuries.[20-25] Consequently, open wounds and associated injuries are common (Figure 3). Recognition of this injury demands a complete trauma evaluation for injuries of all extremities and organ systems. In one series of open radiocarpal fracture-dislocations, an associated fracture or injury to other organ systems was found in every patient.[22]

Neurologic deficits of the injured extremity are common and are often associated with vascular insufficiency of the hand.[20-24] Arterial occlusion secondary to the deformity may result in ischemia, which should be corrected by expeditious reduction of the joint with longitudinal traction.[21] Neurologic injury is also common, particularly with open injuries.[22,24] The median nerve is more often involved than is the ulnar nerve.[24] Less commonly, a radiocarpal dislocation may be associated with an irreducible distal radioulnar joint dislocation when soft tissue (eg, tendon, nerves) or osteoarticular fragments become incarcerated within the joint.[24,34,35]

Figure 3

Open wound associated with dorsal radiocarpal fracture-dislocation.

Radiographic Evaluation

Plain radiographs consisting of posteroanterior and lateral views of the wrist are obtained initially to assist in making the diagnosis. Evaluation of fracture geometry is facilitated with radiographs obtained after provisional reduction with longitudinal traction. Examination of the radiographs should begin with identification of fractures of the distal radius, distal ulna, and carpal bones. An oblique view can aid in identifying fracture fragments. Fractures of the radial or ulnar styloid are examined carefully, with emphasis placed on their size and location.

On the posteroanterior view, alignment of the carpus is evaluated by examining the position of the lunate relative to the radius. Normally, the lunate is in alignment with the ulnar column of the distal radius, with a minimum of two thirds of the lunate articulating with the distal radius.[36] With complete radiocarpal ligament disruption, the carpus tends to translocate ulnarly down the radioulnar slope of the distal radius (Figure 4). The posteroanterior radiograph is also carefully examined for intercarpal ligament injury, such as scapholunate or lunotriquetral dissociation. The relationship of the radiocarpal and midcarpal joints is assessed by evaluating the alignment of the capitate, the lunate, and the articular surface of the lunate fossa of the distal radius. The three Gilula arcs—radiocarpal, proximal midcarpal, distal midcarpal—should be colinear.[37] Disruption of the Gilula arcs or overlapping of normally equally spaced carpal bones is highly suggestive of injury to the supporting ligaments, the carpal bones, or both.[37] Scapholunate ligament injuries in particular must be suspected when a radial styloid fracture exits at the interval between the scaphoid and the lunate fossae[38] (Figure 5).

Figure 4

Ulnar translation of the carpus after reduction of a radiocarpal dislocation. Note that the lunate is positioned over the distal ulna and not the lunate fossa of the distal radius.

Figure 5

Scapholunate ligament injury presenting with mild scapholunate diastasis. Note the radial styloid fracture exiting at the level of the scapholunate interval, indicating a high risk of a scapholunate ligament disruption. Such a disruption was confirmed intraoperatively.

Figure 6

Lateral view of dorsal dislocation illustrating loss of colinearity of the capitate, the lunate, and the articular surface of the radius.

Figure 7

A B C

A, Plain radiograph demonstrating radiocarpal fracture-dislocation. Anterior **(B)** and lateral **(C)** three-dimensional computed tomography scans illustrating ulnar and dorsal subluxation of the radiocarpal joint associated with a large radial styloid fracture fragment.

Loss of colinearity of the lunate with the articular surface of the radius on the lateral view indicates disruption of the radiocarpal joint (Figure 6). In general, the lateral view demonstrates the direction of the radiocarpal dislocation. Marginal rim fractures are best evaluated on the lateral view. The so-called teardrop view or 10° proximal view is helpful in evaluating fractures of the volar rim and lunate facet.[36]

With technological advances, the routine use of computed tomography for wrist injuries is increasing. Although not mandatory, computed tomography can aid in the evaluation of cortical rim fractures, fracture depression of the articular surface, and the relationship of the carpus and distal radioulnar joint (Figure 7). Magnetic resonance imaging may be useful in studying soft-tissue injuries, particularly in evaluating the scapholunate and lunotriquetral ligaments. Occult injury to the intercarpal ligaments has been suggested to result in late intercarpal disruption.[16,25]

Classification

Classification of radiocarpal fracture-dislocations ideally should encompass the identification of all bone and soft-tissue injuries, grading the risk of instability, and subsequently directing treatment. Two classification schemes have been discussed in the literature.

Moneim et al[21] classified radiocarpal fracture-dislocations into two types based on the presence or absence of concurrent injury to the intercarpal articulations (Table 1). In a type I injury, the normal carpal anatomy is maintained, with dislocation of the radiocarpal joint. Type II injuries involve intercarpal injuries (specifically, scapholunate or lunotriquetral intercarpal ligament injuries) in addition to the radiocarpal dislocation. This second type represents a more complex pattern and could be considered a variation of a perilunate fracture-dislocation as described by Mayfield et al.[33]

Dumontier et al[25] also classified radiocarpal fracture-dislocations into two groups, but their system is based on the extent of radial styloid involvement (Table 2). Group 1 injuries include pure ligamentous radiocarpal dislocations or dislocations with only a small cortical or radial styloid avulsion fracture. Group 2 injuries include dislocations with a large radial styloid fracture fragment involving at least one third of the scaphoid fossa of the distal radius. On the dorsal surface, the ligamentous injury represents more of a capsuloperiosteal avulsion than a true tear of the dorsal radiocarpal ligaments. Group 1 injuries consist of global ligamentous injuries, which have the potential for multidirectional instability; as such, they pose a greater treatment challenge than do group 2 injuries.[25] In group 2 injuries, the radiocarpal ligaments remain attached to the fractured large radial styloid fragment.[30] Stability can more reliably be restored with secure anatomic fixation of the fracture than can occur with the more pure ligamentous injuries seen in group 1.

Table 1

Moneim et al[21] Classification of Radiocarpal Fracture-dislocation

Type I	Radiocarpal fracture-dislocation without associated intercarpal dissociation
Type II	Radiocarpal fracture-dislocation with an associated intercarpal dissociation

Table 2

Dumontier et al[25] Classification of Radiocarpal Fracture-dislocation

Group 1	Radiocarpal fracture-dislocation that is purely ligamentous or involves only a small cortical avulsion fracture off the radius
Group 2	Radiocarpal fracture-dislocation associated with a large radial styloid fracture fragment (involving at least one third of the scaphoid fossa)

Management

Successful management of radiocarpal fracture-dislocations requires evaluation and treatment of the columns of the wrist, while taking into account the direction of dislocation and the presence of any intercarpal injuries. Three treatment principles are recommended: (1) concentric reduction of the radiocarpal joint, (2) identification and treatment of intercarpal injuries, and (3) stable repair of the osseous-ligamentous avulsions.

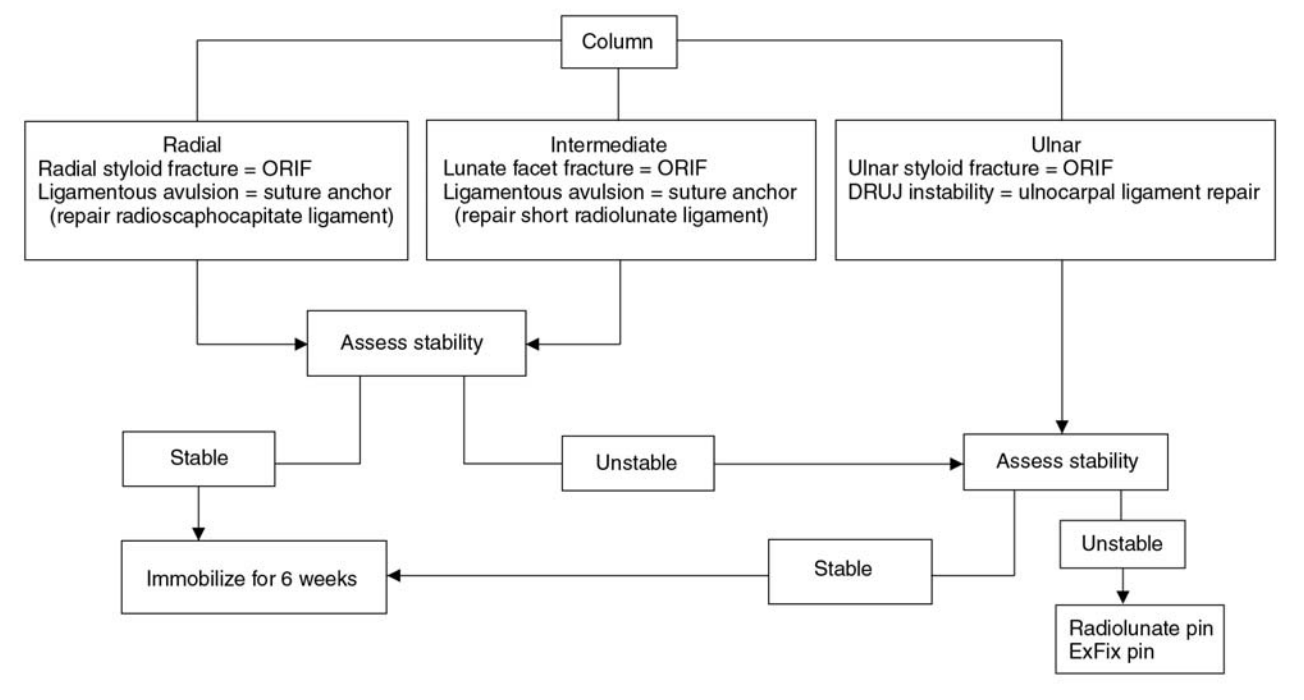
To better direct surgical treatment and to address all aspects of the injury, we have adopted the columnar concept of the carpus as described by Navarro[39] and modified by Taleisnik,[40] as well as the columns of the distal radius and ulna as described by Rikli and Regazzoni.[41] Each column of the distal radius and ulna, namely, the radial, the intermediate, and the ulnar, is approached separately in a stepwise fashion to achieve radiocarpal stability.[41] Concomitantly, the columns of the carpus, which include the mobile lateral column (ie, scaphoid), the flexion-extension central column (ie, lunate, distal carpal row), and the rotatory medial column (ie, triquetrum), are evaluated for intercarpal ligamentous injury and resultant carpal instability.[40] By addressing every column individually, radiocarpal and intercarpal stability can be achieved.

Although closed reduction and cast immobilization have been reported to yield satisfactory results in the management of radiocarpal dislocations,[10,11,14,21] we consider these injuries to be complex and unstable conditions that routinely warrant surgical reduction and fixation to attain a stable, concentric, and congruent wrist. All irreducible dislocations, open injuries, and cases involving neurovascular embarrassment require surgical treatment.[21,22,24,35]

The steps in surgical treatment of radiocarpal fracture-dislocation are (1) provisional radiocarpal joint reduction, (2) decompression of neurovascular structures, (3) exposure and débridement of the joint, (4) treatment of intercarpal injuries, and (5) fracture fixation and/or soft-tissue repair (Figure 8). We recommend the use of general anesthesia.

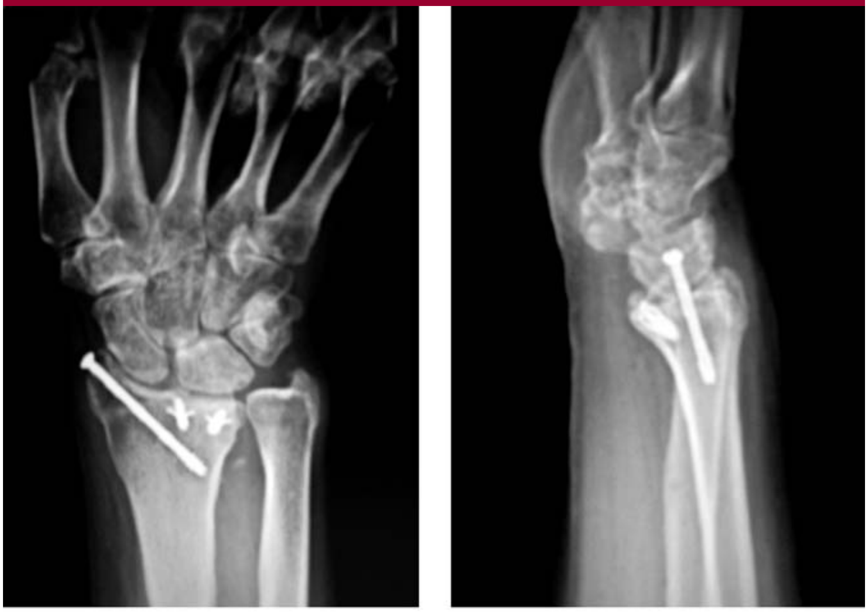
The wrist is provisionally reduced with longitudinal traction. An external fixator may be applied to hold the joint reduced. An extensile volar approach ulnar to the flexor tendons and median nerve is used so that both the carpal tunnel and Guyon canal can be decompressed as needed. The radiocarpal joint is examined through the volar capsular site of disruption. The joint is irrigated and débrided of any loose cartilage or bone fragments. Stay sutures or suture anchors are then placed in the area of capsular and ligament disruption but are not tied down. Fluoroscopy is used to identify any carpal fractures or interosseous ligament injuries, particularly of the scapholunate or lunotriquetral ligaments. Intercarpal ligament injuries are

Figure 8



Treatment algorithm for radiocarpal fracture-dislocations. DRUJ = distal radioulnar joint, ExFix = external fixation, ORIF = open reduction and internal fixation

Figure 9



A B

Anteroposterior **(A)** and lateral **(B)** radiographs demonstrating open reduction and internal fixation of the radial and intermediate columns of a radiocarpal fracture-dislocation. Note the screw fixation of the radial styloid and anchor fixation within the distal radius (ie, volar ligament repair).

confirmed and treated through a separate dorsal capsular incision. A subperiosteal approach through the floor of the third extensor compartment is used. The columns of the joint are approached sequentially.

Beginning with the radial column, the fractured radial styloid is accurately reduced and internally fixed. Fixation options include a Kirschner wire, compression screw, or plate application (Figure 9). Either a Kirschner wire or screw fixation can provide stable fixation of the radial styloid. Screw fixation provides the added benefit of compression, assuming that the styloid fragment is large enough to accommodate a screw without requiring later removal and pin-tract complications. Volar, radial, or dorsal plating is selected based on the fracture personality and surgeon preference. Moving to the intermediate (ie, central) column, fractures of the lunate facet that are amenable to fixation should be repaired with internal fixation using screws or a tension band wire loop.[42] When fractures of the radial styloid and/or the lunate facet are not amenable to fixation, soft-tissue repair is undertaken by direct suture repair or with suture anchors (Figure 9). Stay sutures that previously were placed to repair the extrinsic volar ligaments are tied. The origins of the short radiolunate and radioscaphocapitate ligaments are repaired in particular to avoid late volar subluxation or ulnar translocation, respectively. Reduction and stability of the fixation is confirmed both visually and radiographically.

The ulnar column is approached in the presence of injury to the distal radioulnar joint and ulnar support ligaments (ie, ulnolunate, ulnotriquetral) or when instability persists after fixation of the radial and intermediate (ie, central) columns. Large ulnar styloid fractures require internal fixation with screws or tension band wiring. This procedure usually restores a concentric distal radioulnar joint. In the presence of persistent instability, the distal radioulnar joint is examined and evacuated of any interposed tissue, followed by repair of the ulnocarpal ligaments. Persistent instability can be addressed by pinning the distal radioulnar joint in midsupination.

Additional stability to the construct can be provided with the use of an external fixator or radiolunate pin. The external fixator is especially useful in situations in which daily care of an open wound is needed. Application of a radiolunate pin can be used intraoperatively to maintain stable reduction of the radiocarpal joint while fracture fixation and soft-tissue repair are undertaken. If necessary, the external fixator or radiolunate pin may be left in situ postoperatively for 4 to 6 weeks to reinforce reduction of the radiocarpal joint.

Outcome

Despite being a complex wrist injury, radiocarpal fracture-dislocation can achieve a satisfactory outcome provided the surgeon follows these treatment principles: concentric reduction of the radiocarpal joint, treatment of intercarpal injuries, and sound repair of the osseous-ligamentous injury. There are few large series on this subject in the literature and, to our knowledge, only three with more than eight patients.[22,24,25]

Mudgal et al[24] reported on a series of 12 patients who presented with radiocarpal fracture-dislocation. Four cases were open injuries, seven had neurologic compromise, two had an intercarpal ligamentous injury, and five had an associated injury. Excluding patients with concomitant intercarpal injury, mean wrist motion on follow-up assessment consisted of 53° of extension, 59° of flexion, 82° of pronation, and 74° of supination. These results are consistent with the other large series in the literature, which indicate that an overall 30% to 40% decrease in total arc of wrist flexion-extension can be expected following successful open treatment.[22,25]

Using the criteria of Knirk and Jupiter,[43] Mudgal et al[24] identified 3 of 12 patients as having evidence of radiocarpal arthritis. Dumontier et al[23] reported that 3 of 27 patients developed radiocarpal arthritis, while Schoenecker et al[44] reported that four of the six patients in their series developed arthritis.

Factors predictive of an inferior outcome include open injury, complete radiocarpal ligamentous injury, associated nerve injury, and intercarpal ligamentous injury. Intercarpal injury, particularly of the scapholunate ligament, can significantly compromise outcome. Moneim et al[21] used the presence of such an injury to classify and guide treatment. In their series, all three patients were treated surgically; unfortunately, all had an inferior outcome. Often, the negative impact of an intercarpal injury manifests late because the injury is initially missed and goes untreated, resulting in late midcarpal and radiocarpal instability.[16,25]

The presence of associated injuries is common and can portend an inferior outcome. Neurologic injuries are generally neurapraxic, and resolution can be expected with decompression.[24] More severe nerve compression or stretch injuries result in an inconsistent neurologic recovery. Nyquist and Stern[22] reported on 10 cases of open radiocarpal fracture-dislocations in which all 10 were complicated by an associated injury and 7 involved neurologic compromise. At follow-up, all patients had variable and inconsistent recovery of sensibility. This is consistent with a study by Soong and Ring,[45] who reported on ulnar nerve palsies following distal radius fractures. These authors found that ulnar nerve injuries are typically neurapraxic and that patients usually experience normal or near-normal recovery of function following decompression.

Ulnar translocation and multidirectional instability may result following complete radiocarpal ligamentous injury in which there is no fracture of the distal radius, as in the case of the group 1 injuries described by Dumontier et al.[25] Early reports highlighted this instability pattern as a late finding encountered during closed treatment.[14,17,26] In a cadaveric study of radiocarpal instability, Rayhack et al[31] sequentially sectioned the radiocarpal ligaments and found that ulnar subluxation of the joint required transection of both the radioscaphocapitate and the radiolunate ligaments. Viegas et al[46] confirmed this finding in their cadaveric study and further studied multidirectional instability. These authors found volar translation to be evident with less ligament disruption than that needed for ulnar translation. It was always evident in the presence of ulnar translation of the carpus. Such injury in conjunction with loss of the ulnolunate ligaments led to progression of the injury from ulnar translocation to multidirectional instability. The authors suggested that the presence of ulnar translation represents a much more global ligament disruption.

Complications

The most common complication following radiocarpal dislocation or fracture-dislocation is residual loss of motion and instability. On average, a patient can expect to lose 30% to 40% of total arc of wrist flexion/extension.[24,25] The other major complication is posttraumatic arthritis related to residual articular step-off.[22,24,25] Chronic radiocarpal and distal radioulnar instability or ulnar translation of the carpus are more common with group 1 injury patterns.[14,15,17,25,26] Less commonly, septic arthritis, tendon rupture, and hardware irritation have been reported.[24,25]

Summary

Radiocarpal fracture-dislocations are the products of high-energy trauma and represent a shear and rotational injury to the wrist, with a variable amount of bone and soft-tissue injury. A high index of suspicion for associated injuries must be maintained, particularly for open wounds, neurologic compromise, and injuries to other organ systems. Radiographs are adequate for diagnosis but must be carefully scrutinized for injury to the normal carpal relationships. Although closed reduction has been described, we recommend open reduction and internal fixation for these complex and unstable injuries. A volar and dorsal surgical approach is used. Surgical principles include concentric reduction of the radiocarpal joint, identification and treatment of intercarpal injuries, and stable repair of the osseous-ligamentous avulsions. Despite the complexity of the original trauma, a satisfactory outcome is attainable. However, a residual loss of motion of 30% to 40% is expected.

References

Evidence-based Medicine: No level I or II studies are cited. Level III/IV (case reports and case-control cohort studies) references include 7-26, 34, 35, 38, and 41-45. Level V (expert opinion) references include 1-6, 27, 36, 37, 39, and 40.

Citation numbers printed in **bold type** indicate references published within the past 5 years.

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