Current Concepts in the Treatment of Distal Radial Fractures

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Abstract: Distal radial fractures are among the most commonly encountered traumatic fractures of the upper extremity. Initial trauma mechanism, fracture pattern, associated injuries, and patient age influence treatment and outcome. Although stable fractures are commonly treated conservatively, the past decade has seen changes in surgical practice and techniques. Indications for surgery have been extended and refined based on new insight into the pathophysiology of the distal end of the forearm and technological advances in implant design. Despite the frequency of this fracture, only limited higher-level evidence exists to guide practitioners in decision making for this injury. This article highlights key concepts in the treatment of distal radial fractures and summarizes current evidence.

Fractures of the distal end of the radius account for the majority of upper extremity fractures and for up to 15% of all extremity fractures seen in emergency departments. Apart from pediatric fractures, one must differentiate high-energy injuries in younger patients from fragility fractures seen in elderly patients. Given the topographic vicinity, high-energy fractures of the distal radius can be associated with concomitant injuries to adjacent bones, joints, and ligaments (ie, carpal bones and ligaments, distal radioulnar joint, interosseous membrane), as well as neurovascular injury (Figures 1, 2). Patient treatment targets functional reconstruction of the distal forearm, restoring anatomy and articular congruity. Although earlier recommendations suggested that outcomes are determined by residual joint incongruities, current evidence suggests a multifactorial influence on outcomes, and the literature lacks higher-level evidence. In contrast with the pathophysiology of fractures in younger patients, fractures seen in elderly patients are largely based on skeletal fragility and reduced proprioceptive feedback. Treatment must respect skeletal insufficiency and altered daily activity levels (Figure 3).

Surgical treatment for distal radial fractures has seen a significant evolution over the past decade with the advent of locking plate technologies and anatomic and low-profile plate contouring, as well as the use of novel materials. These innovations have challenged and advanced traditional treatment concepts, including the choice of surgical approach, the use of structural bone grafting, and rehabilitation. Although technological advances offer current surgeons more refined treatment choices, there is a lack of evidence-supported guidance for conservative and surgical treatment of this commonly seen upper extremity fracture.

Surgical Anatomy and Pathophysiology

The carpal surface of the distal radius shows 2 distinct impressions: the scaphoid and lunate facets, which articulate with the correspondingly named carpal bones. Medially, the sigmoid notch (a shallow groove accommodating the ulnar head) forms part of the distal radioulnar joint. This joint allows rotational and translational motion of the forearm during pronosupination. It is stabilized by the dorsal and volar radioulnar ligaments, the joint capsule, the extensor carpi ulnaris, and the triangular fibrocartilage complex, which features a meniscoid disk suspended between the sigmoid notch and the ulnar fovea. Disruption of the distal radioulnar joint commonly leads to unrestrained dorsal translation of the ulnar head in pronation and ulnar-sided pain. Although coronal displacement of distal
radial fractures can directly affect rotatory distal radioulnar joint function, the longitudinal mismatch of nonreduced radial height can lead to pathologic load sharing between the carpus and the forearm bones and to ulnocarpal impingement.

Trabecular condensations underlying the scaphoid and lunate fossa, as well as the thinner cortical structure of the dorsal distal radius, explain typical fragmentation patterns of the distal radius. This fracture distribution forms the basis of the concept of fragment-specific fixation (Figure 4). The lunate can be seen as the center of radiocarpal rotation and constitutes a keystone in carpal architecture. The anatomic alignment of the ulnar-sided radius and maintenance of the volar-prominent lunate facet are essential for the maintenance of wrist motion. Fragmentation of the volar ulnar and dorsoulnar corners of the lunate fossa can lead to rotational carpal subluxation and must be reduced and retained.

The thick volar cortex of the distal radius is covered by the pronator quadratus, distal to which lies an exposed bony ridge known as the watershed line, where flexor tendons and the median nerve lie in the direct vicinity of bone. Implanting hardware at or beyond this region is associated with a higher rate of tendon injuries and must be avoided.

On the dorsal surface of the radius, the extensor tendons run through 6 compartments in close contact to the thinner cortical bone of the radius. The greater depth of the distal radius in the sagittal plane at the level of the third extensor compartment and the adjacent Lister’s tubercle are important for screw placement; radially or laterally to this plane, the sagittal depth of the bone decreases substantially, and shorter screw lengths must be chosen to prevent cortical transgression.

**Radiographic Anatomy**

Standard 3-way radiographic views of the uninjured distal radius demonstrate distinct radiographic features, which are essential for the functional demands of wrist and forearm motion (Figure 5). The normal radioulnar alignment, as seen in standard posteroanterior views of the wrist, features a radial inclination of 22°, radial length of 9 to 12 mm, and ulnar variance of 0 mm. In lateral joint views, the distal radius shows a volar tilt of approximately 11°.

In proper lateral views, as suggested by overprojection of the pisiform over the distal scaphoid pole, the radio-luocapitate axis should appear collinear, without radiocarpal or midcarpal offset and without volar or dorsal intercalated segment instabilities of the lunate. The distal radioulnar joint should appear reduced in these views, and the scapholunate an-
ngle should be between 30° and 60°. In posteroanterior views, the carpal rows should align harmoniously without interruption of curvilinear lines placed along the outlines of the proximal and distal rows (Gilula lines), and no diastasis should be found within the proximal row.13

Based on the injury mechanism, physicians should actively rule out associated carpal injuries and request, when indicated, additional forearm and elbow radiographs to rule out proximal fractures or associated elbow injuries. Axial translations of the radius, as seen in Essex-Lopresti injuries, can lead to a failure of the interosseous membrane and subsequent radial head fractures. In selected cases, postreduction computed tomography scans can aid in surgical planning (Figure 4).14

**CLASSIFICATION**

Fracture classifications aim to facilitate therapeutic decision making and standardize treatment and, ideally, should help define expected outcomes and serve as a research tool. Classifications differentiate between intra- and extra-articular fractures, as well as stable and unstable patterns. They should include information on distal radioulnar joint injuries and trauma mechanism to help appreciate possible associated injuries.

Although traditional eponyms are still used (eg, Colles’, Smith’s, Barton’s, die-punch, and Chauffeur’s fracture),15 they may incorrectly describe injury patterns and are not helpful for treatment and outcome evaluation.

Multiple newer classifications have improved orthopedists’ understanding of fracture patterns and injury severity. Descriptive classifications, such as the Malone16 and Frykman17 classifications, provide detailed anatomic fracture pattern analysis. The well-established AO classification with its subgroups...
may help improve documentation. The injury mechanism–based fracture classification according to Fernandez and Jupiter assigns fractures to bending, shearing, or compressive force mechanisms. This may provide helpful insight into surgical planning, which should reverse the traumatic force direction. Although modern classification systems provide the details needed to classify fracture patterns, their low inter- and intraobserver reliability limits their daily clinic use.

**TREATMENT**

The management of distal radial fractures depends on patient factors, fracture patterns, and stability criteria. The presence of associated injuries influences treatment timing and modality. Initial injury radiographs provide important information on the degree of instability and trauma severity and must be compared with postreduction radiographs (Figure 1 shows the significant translation of the carpus and medial perforation of the ulna through the soft tissues).

Often, no injury radiographs are available for highly unstable injuries that were reduced first and then imaged (Figure 6). Standard emergency department management involves a reduction maneuver under hematoma block and splinting.

Peripheral neurovascular status must be documented before proceeding with any manipulation. The incidence of acute carpal tunnel syndrome has been associated with the initial degree of fracture displacement. This entity differs from secondary carpal tunnel syndrome seen in healed fractures irrespective of operative or nonoperative treatment. Nonresolving acute carpal tunnel syndrome after reduction, as well as clinical suspicion of a compartment syndrome in higher-energy injuries, are indications for urgent carpal tunnel release and fasciotomies. Small lacerations on the ulnar border of the wrist need to be searched for, and commonly represent open fractures. Open fractures, fractures with associated neurovascular injuries, and nonreducible associated carpal injuries need urgent or emergent management in the operating room.

Stability criteria as introduced by Lafontaine et al can aid in assessing the risk for secondary fracture displacement. These include the degree of initial deformity, dorsal angulation greater than 20°, volar displacement, radial shortening, amount of dorsal comminution, intra-articular involvement, associated ulnar fractures, and patient age. Recent studies have shown that one-third of fractures initially deemed stable went on to displace during conservative treatment.

Stable, reduced distal radial fractures without articular involvement, such as those commonly seen in the emergency department, are amenable to conservative treatment with initial splinting and cast conversion in clinic. The widely used practice of sugar-tong splinting to block both wrist and elbow range of motion has been challenged. A recent study showed similar rates in reduction loss comparing this form of immobilization with standard short-arm splinting, which is more accepted by patients. The adequacy of reduction and the ability to retain the initial reduction, as well as the degree of intra-articular displacement, dictates the need for surgical fixation. Limits of accepted reduction are generally seen critically in younger patients (Table). Guidelines from the American Academy of Orthopaedic Surgeons (AAOS) recommend surgical fixation if postreduction radial shortening greater than 3 mm, dorsal tilt greater than 10°, or intra-articular displacement or stepoff greater than 2 mm are observed. However, evidence shows good outcomes even in displaced articular fractures in elderly patients. When assessing surgical indications in elderly patients, levels of activities of daily living, presence of degenerative changes, and prior wrist pathologies must be accounted for. Although surgical fixation in high-functioning retirees may be appropriate, the presence of preexisting arthritis may limit the expected benefit of surgical fixation for elderly patients.

Unless urgent or emergent surgery is needed, as mentioned above, surgical fixation of distal radial fractures should be performed as soon as soft tissue conditions allow or when the

**Figure 6:** Preoperative posteroanterior (A) and lateral (B) radiographs of a radiocarpal fracture dislocation caused by a shear mechanism taken after a reduction attempt failed to show the extensive capsuloligamentous injury; a radial styloid avulsion and dorsal carpal subluxation are also observed. Intraoperative photograph showing avulsion of the radial styloid and scaphoid fossa with disrupted dorsal capsular attachments (C); the lunate fossa and adjacent ulnar head are also visible. Due to extensive soft tissue injury, minimal instrumentation with combined screw and K-wire fixation was chosen, along with distal radioulnar joint and radiocarpal transfixation. Posteroanterior (D) and lateral (E) radiographs 6 weeks postoperatively showing maintained alignment and a broken distal radioulnar joint K-wire.
indication for fixation arises, such as in instances of secondary fracture displacement. Weekly radiographic monitoring of conservatively treated fractures for the first 3 weeks is recommended per AAOS guidelines. Early correction of pending malunions allows for faster rehabilitation and may avoid secondary joint injury.

**SURGICAL TECHNIQUES**

Surgical fixation techniques can be divided into closed, minimally invasive, and open. Fracture pattern, soft tissue status, patient factors, and available resources dictate the indication for each method.

**Closed Reduction and Fixation Techniques**

Closed Reduction and Percutaneous Pinning. Percutaneous wire fixation may be indicated for unstable extra-articular fractures with dorsal metaphyseal comminution and injuries with noted soft tissue damage. This technique is still widely used for intra-articular fractures in low-resource facilities around the world. Various extrafocal techniques (eg, Lambotte and Depalma) have been described in which K-wires serve to retain the closed reduction until union is achieved. This must be differentiated from intrafocal techniques, as introduced by K-pandji, in which direct fracture manipulation and reduction are performed by inserting percutaneous wires into the fracture itself. Closed reduction and percutaneous pinning techniques have led to good outcomes when clinically indicated and performed with technical expertise. External Fixation. Indications for external fixation include open or highly comminuted fractures and wrist injuries in polytrauma patients. Joint-spanning assemblies are commonly used and rely on ligamentotaxis for reduction. Excessive long-term traction is associated with stiffness and poorer outcomes. Unilateral constructs spanning only the injury side of the wrist can avoid these concerns and may be used for direct fracture reduction using the external fixator pins as a joystick. This form of instrumentation is suitable for more proximal fractures with an intact distal radius rim. External fixators can be an adjunct to arthroscopic fracture reduction and serve as a neutralization device with minimal traction.

**Minimally Invasive Fixation**

Apart from direct open visualization, arthroscopy is the only way to gain a direct overview of the joint surface in surgical fixation of the distal radius. This can be of significant importance when dealing with central joint depressions (Figure 7). Several studies suggest improved outcomes given the precision of reduction. Arthroscopy plays an important role in searching for and addressing associated injuries seen in distal radial fractures, such as cartilage injuries, loose intra-articular bodies, and ligament injuries (Figure 2).

**Internal Wrist-spanning Plates.** These temporary implants are used as internal fixators and have shown good results in elderly patients or in selected indications, such as in severely comminuted wrist fractures. Using minimally invasive approaches, internal wrist-spanning plates help maintain distal radial and radiocarpal alignment until bony union is achieved. They are typically removed after 3 to 4 months. Despite the longer immobilization of the wrist with this static device, mid-term recovery of functional wrist range of motion has been observed. These findings may be seen as a challenge to the traditional paradigm of fixation and early mobilization and should be kept in mind when considering postoperative immobilization of complex injuries.

**Endomedullary Fixed-angle Devices.** A recently introduced fixation concept allows the introduction of a fixed-angle internal fixation device through a mini-open technique. Although evidence on outcomes using this technique is still limited, a recent study suggests improved 1-year outcomes when compared with casting.

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**Table**

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<th>Posteroanterior View</th>
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<td>Radial height, &lt;2 mm shorter</td>
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**Figure 7:** Arthroscopic detection of occult intra-articular pathologies in distal radial fractures showing a loose osteocartilaginous fragment (A), a cartilage defect of the lunate (B), and a scapholunate ligament rupture (C).
Open Fixation

In the past 2 decades, the introduction of locking plate systems and an improved understanding of fracture patterns and associated injuries have changed the practice of fracture fixation in distal radial fractures. Volar approaches have gained great acceptance and permit standardized fixation for many fracture patterns.

The Henry-type approach using the plane of the flexor carpi radialis is the most commonly used access point to the volar carpus and stays clear of the median nerve and the radial artery. Medial extensile volar approaches can be used to access lunate facet fragments. Dorsal approaches, usually elevating the third and fourth extensor compartments, are indicated when addressing dorsal fragments or irreducible depressions. Current evidence suggests that soft tissue–protecting dissection techniques combined with shorter screw lengths and low-profile plates can limit extensor tendon complication rates.

Surgical approaches must be selected individually to address key fragments and restore articular congruity, radiocarpal stability, and alignment as used in fragment-specific fixation.

Since their introduction, the use of locking plates for fixation of distal radial fractures has surged in all age groups, especially in elderly patients.

This may be explained by the initial impression of having a solid technique at the hand offering reliably good reduction and retention capabilities, which was perceived as leading to improved patient outcomes. Locking technology offers a fixed-angle support to the joint surface and strong retention, even in osteopenic bone (Figure 3). In addition to fracture retention, locked plates can serve as reduction devices and are helpful in reducing dorsal displacement against the shaft fragment.

Earlier locking T-plates were followed by anatomic-shaped plates and variable locked-angled plates, allowing more individualized plate and screw positioning. Current evidence shows good short-term results comparing these implants with other forms of fixation, and complication rates appear to be low. Results appear similar when looking at mid-term outcomes comparing volar locking plates with external fixation. No comparative long-term results are available given the recent introduction of these implants.

Ongoing dynamic development in plate design provides a steady inflow of new implants on the market, which may challenge comparative long-term studies. Available data show that volar and dorsal tendon injuries are possible using the originally presumed safe volar approach and that fracture retention is not warranted using these implants. Success depends on the surgeon’s experience and diligent planning.

Complications

Although malunions and associated carpal instabilities combined with stiffness and tendon ruptures rank among the more commonly seen complications in conservative treatment, surgical therapy can expose patients to various added risks. Of the many factors influencing potential adverse results, few are preventable, such as a loss of reduction and tendon injuries due to suboptimal plate and screw positioning. Proper training can minimize the learning curve when using newer implants. Exact intraoperative radiographic visualization of reduction and hardware placement is mandatory.

OUTCOMES

Although ample literature supports good short-term outcomes, higher-level evidence examining the outcomes of surgical fixation in distal radial fractures stresses the importance of age and socioeconomic status. No evidence supports one surgical technique over the other in younger patients, and no consensus exists regarding the best treatment for these fractures in elderly patients. The call for prospective, multicenter outcomes studies in distal radial fractures remains the same as it was years ago.

CONCLUSION

Distal radial fractures are the most commonly seen upper-extremity fractures. With the epidemiologic growth of the elderly population, a continued increase will be seen in the incidence of this fracture. Despite the growing trend of operative treatment in the past decade, no Level I evidence indicates whether operative treatment leads to improved outcomes in elderly patients. The enthusiastic reception of locking plate systems needs long-term outcome data to support its extensive current use.

REFERENCES