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# Management of High Energy Distal Radius Injuries

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**Abstract**

**Purpose of Review** High energy distal radius are commonly multi-fragmentary with significant comminution and/or bone loss. They can also be associated with ligamentous and soft tissue injury and neurovascular compromise. As such, reconstruction of these injuries can be challenging. This paper will review the relevant anatomy, different methods of fixation, and present techniques for difficult fractures.

**Recent Findings** Volar locked plating is a successful, very common method of treatment for distal radius fractures, but dorsal plating, fragment specific fixation, spanning bridge plating, and external fixation are sometimes necessary, particularly in higher energy injuries characterized by metaphyseal comminution, small volar fragments, intra-articular free fragments or lunate facet subsidence. Extended flexor carpi radialis (FCR), dorsal, and flexor carpi ulnaris (FCU) exposures can assist in visualizing the fracture site.

**Summary** There are many different modes of fixation for distal radius fractures, and successful outcome depends on selection of appropriate fixation based on the fracture pattern and status of the soft tissues.

**Keywords** Distal radius · Hand trauma · Comminuted fracture · Articular fracture · Open reduction internal fixation

## Introduction

Distal radius fractures have a bimodal distribution with low energy fractures occurring in the elderly population. These can often be treated either closed or when indicated, with common techniques, now most frequently with a volar locked plate. However, high energy distal radius injuries usually occur in younger, higher-demand patients. They often present a therapeutic challenge due to the fracture comminution, bone loss, and concomitant soft tissue injury. While some of these may be amenable to treatment with a volar locked plate via the classic volar Henry or FCR approach, many may require additional fixation and/or alternative exposures to successfully reduce and fix the various fracture fragments. Successful treatment of complex distal radius fractures requires knowledge of wrist anatomy, facility with the various options for exposure and fixation, and careful soft tissue management.

This article is part of the Topical Collection on *Distal Radius and Wrist Fractures*

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## Anatomy and Column Theory

The distal radius has three articular surfaces: the scaphoid fossa, the lunate fossa, and the sigmoid notch. The scaphoid and lunate fossa form a platform on which the carpus rests and are separated by the dorsal-volar ridge. The lateral aspect of the distal radius extends to form the radial styloid. The dorsal lip of the distal radius is convex and acts as a fulcrum for the extensor tendons, whereas the volar surface is concave. The medial aspect of the distal radius forms the sigmoid notch. The radius—with the carpus and hand by extension—articulates with the ulna at the sigmoid notch and move as a unit around the ulnar head. The relationship between the distal radius, carpus, and ulna is maintained by the extrinsic wrist ligaments.

When treating comminuted fractures, it may be beneficial to think of these structures in terms of three columns—radial, intermediate, and ulnar—supported by the shaft or pedestal (Figs. 1 and 2) [1].

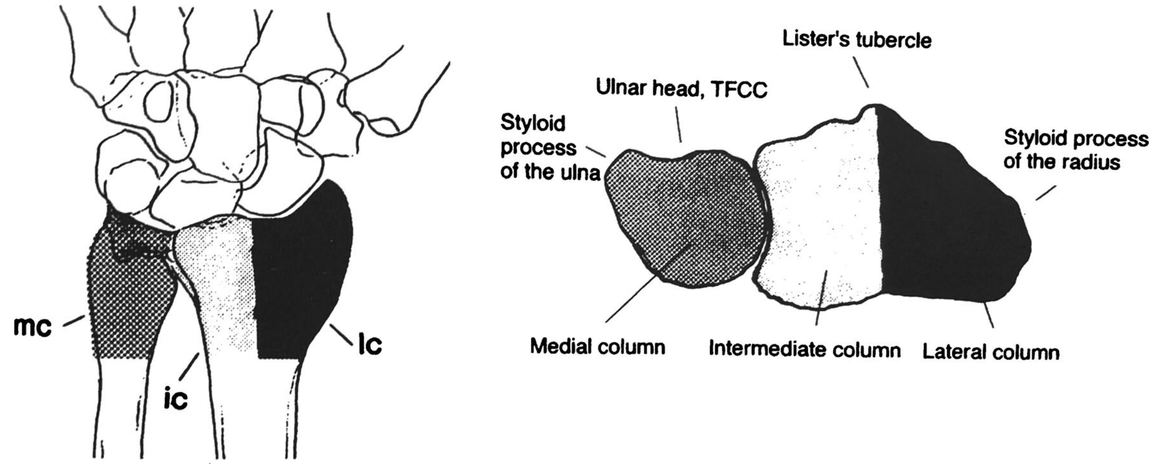


**Fig. 1** This illustrates the column model of the wrist, which consists of the radial, intermediate, and ulnar columns

## Radial Column

The radial column consists of the radial styloid and scaphoid fossa. Restoring this column re-establishes length of the distal radius. This column also provides stability against both radial translation of the carpus directly and against ulnar translation of the carpal elements via the attachment site for the radioscaphocapitate ligament. The radial column also represents the insertion site of the brachioradialis, which is an important deforming force for radial fragments in certain distal radius fractures.

## Intermediate Column

The intermediate column consists of the lunate facet and represents the primary load bearing column of the radius. The dorsal-ulnar corner is the attachment site of the dorsal distal radioulnar ligaments, and injury to this area can lead to distal radioulnar joint (DRUJ) instability. The dorsal wall serves as a buttress against dorsal subluxation of the carpus. The volar rim, or the "critical corner," is the attachment site of the short radiolunate ligament and volar distal radioulnar ligaments, which serves to prevent volar translation of the carpus (Fig. 4c).

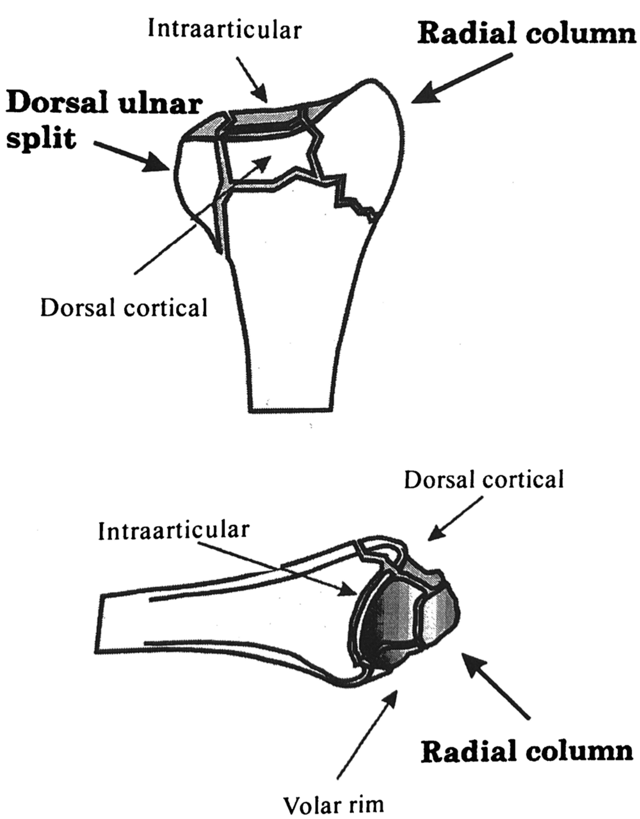


**Fig. 2** The commonly seen articular fragments in intra-articular distal radius fractures

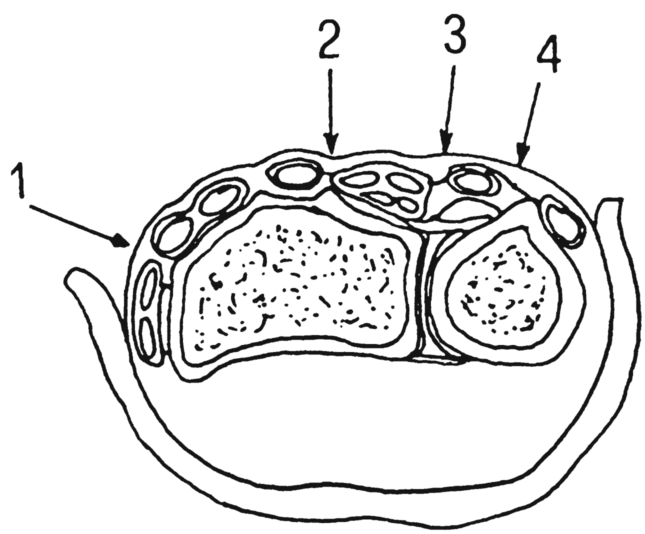


**Fig. 3** The intervals labeled 1–4 show the possible intervals between extensor compartments which could be utilized to visualize the fracture and to instrument

### Ulnar Column

The ulnar column serves as the rotational column of the wrist and consists of the ulna, the triangular fibrocartilage complex (TFCC), and the dorsal and volar radioulnar ligaments. Assessing this column is important to restore normal forearm rotation. While this column least commonly requires surgical treatment in distal radius fractures, in high energy fractures, disruption of the ulnar head/styloid or TFCC may lead to persistent DRUJ instability and/or forearm dysfunction unless it is addressed at the time of surgery.

### Pedestal

The pedestal is composed of the metadiaphyseal region. This area is typically intact in low energy fractures but may also be a site of comminution and bone loss in higher energy injuries.

## Fixation Techniques

### Volar Locked Plating

Volar locked plating has become a mainstay in the treatment of distal radius fractures. It is an attractive option since:

(1). the volar cortex is frequently less comminuted facilitating reduction,
(2). avoidance of dorsal dissection helps preserve the vascular supply of the dorsal fragments,
(3). there is lower risk of tendon rupture compared to dorsal plating, and
(4). the distal pegs or screws provide good control when placed into the subchondral bone by preventing shortening and late displacement [2,3].

The advent of variable angle constructs has also provided surgeons with more versatility in plate and screw placement depending on the fracture pattern and the ability to place screws into specific intra-articular fragments. Volar locked plates can be used for fractures which have enough distal bone for screw fixation through the distal row of the plate. For fragments too small or too distal to be captured by the distal row, an alternative form of fixation should be used. For example, fractures with small volar lunate facet fragments with less than 15 mm of bone available for fixation or initial subsidence > 5 mm have a higher probability of loss of reduction and may benefit from fragment specific fixation (Fig. 4a) [4••].

### Dorsal Monoblock Plating

A dorsal approach may be preferred over a volar one as

(1). it provides excellent exposure of the articular surface (which is not seen directly from volar) and
(2). dorsal buttress plates may provide improved stability against dorsal collapse seen in highly comminuted fractures and dorsal shearing fracture patterns [5].

a dorsal approach may also be beneficial as it provides better visualization of intra-articular free fragments. Depending on the fracture pattern, it may be helpful to use dorsal plating alone or in conjunction with other forms of fixation. Due to less soft tissue on the dorsal side of the wrist, there may be higher likelihood of tendon irritation and need for hardware removal, although new lower profile plates may help mitigate this problem. Farhan et al., in their retrospective series of 24 patients with AO C3 distal radius fractures treated with combined volar and dorsal plating, 4 patients required plate removal [6].

### Fragment Specific Fixation

Fragment specific fixation aims to independently reconstruct and stabilize each fracture fragment. Each fracture component is fixed using individualized implants, which when used in combination creates a load sharing construct with the added benefit of increased rigidity from multi-planar fixation [3]. Implants which may be used include headless and headed compression screws, column specific plates—including specialized pin plates and rim plates—and tension band constructs. These implants may be placed via dorsal, volar, radial, or combined approaches depending on the fracture pattern and the need for dorsal fixation. Many authors advocate working "inside out," focusing first on the intermediate column and then the radial column. A typical order of operations entails fixation of the volar rim, dorsal ulnar corner, free articular fragments, dorsal wall, and then radial column. The wrist is then typically tested for instability to determine if ulnar column fixation is necessary. In instances of frank instability of the DRUJ after radial and intermediate column fixation, ulnar styloid fixation or TFCC repair is indicated. Specific ulnar styloid plates or a tension band construct may be used to fix ulnar styloid fractures.

### Dorsal Spanning Fixation

Dorsal distraction bridge plating can be used for

(1). intra-articular fracture too comminuted to be amenable to the other techniques discussed,
(2). metaphyseal comminution, and
(3). concomitant radiocarpal instability.

It may also be used in combination with volar plating for additional fixation, such as when early weight bearing is necessary for polytrauma patients (Fig. 4b).

The bridge plate may be secured distally to either the index or long finger metacarpal. It can be placed using two incisions centered over the metacarpal and over the dorsoradial aspect of the radial diaphysis. The plate is passed bluntly beneath the extensor tendons and should lie at the floor of the fourth dorsal compartment. An additional incision can be made over the distal radius, and many dorsal spanning plates also have options for screw fixation in the distal radius.

### External Fixation

External fixation can be used to maintain length, alignment, and rotation. Current indications include fractures with contaminated soft tissues or to augment internal fixation. However, an external fixator can be cumbersome for patients and can be associated with complications such as pin tract infection and complex regional pain syndrome. In recent studies of closed fractures, including several randomized control trials and meta-analyses, external fixation and volar locked plating have similar outcomes in terms of patient function and re-operation rate [7,8•,9,10].

## Exposure and Plate Positioning

The volar Henry or FCR approach is the most commonly used approach for distal radius fixation. However, it may not provide adequate exposure for complex fractures. Multiple exposures of the distal radius are possible and they may be combined when necessary, although the surgeon must be cognizant of incision length and skin bridge width to prevent skin necrosis. The skin around the distal radius, especially on the dorsal aspect, is very mobile and incisions can be moved slightly in either direction to maximize skin bridge size.

### Extended FCR

Volar plates are typically placed via a volar Henry or FCR approach in the internervous plane between the brachioradialis and FCR. The radial artery, which lies within this interval, can be mobilized radially or ulnarly. The flexor pollicis longus is exposed and retracted ulnarly, thereby exposing the pronator quadratus. The pronator quadratus is then incised using an L-shaped incision and elevated off the radius to expose the fracture. To maximize the exposure, this incision can be extended distally via zig-zag, first up to the wrist crease towards the scaphoid tubercle and then back ulnarly across the wrist crease. This provides improved exposure for very distal fractures. From this incision, it is also possible to dissect radially under the first dorsal compartment to visualize the radial styloid and to release the brachioradialis. In complex fracture patterns, it may be beneficial to release the brachioradialis routinely as it aids reduction. From this approach, it is also possible to use a clamp to rotate and deliver the proximal fragment out of the wound in order to visualize the dorsal cortex.

This incision can be used for volar monoblock plates as well as for fragment specific fixation that captures the radial styloid and/or volar rim fragments. When placing plates on the volar surface, care must be taken to ensure placement proximal to the transverse radial ridge (“watershed line”). When positioned more distally, the lip of any volar implants may come in direct contact with the adjacent flexor tendons, placing them at risk of rupture [11]. Some surgeons advocate closing the pronator quadratus over the plate to provide coverage to minimize flexor pollicis longus tendon irritation. In most instances, screws should be left a few millimeters short of the dorsal cortex to avoid extensor tendon irritation and/or rupture. Assessment of the distal implants under fluoroscopy in multiple planes is essential to assess for any intra-articular or dorsal cortical screw penetration. A sigmoid notch view can be helpful in detecting DRUJ penetration [12•]. Horizon views can aid in detecting dorsal cortical penetration, which can ultimately lead to extensor tendon rupture [13].

For radial styloid fixation, it is often useful to dissect radially under the first dorsal compartment. A radial plate may be placed on the floor of the first compartment. In situations where direct fracture visualization is necessary and the radial column or volar rim are not easily seen through this approach, an ulnar palmar approach or radial approach may be necessary.

### Ulnar Palmar

In some instances, it may be difficult to visualize the ulnar volar rim fragment via a traditional FCR approach. A more ulnar approach can be taken, utilizing an incision over the flexor carpi ulnaris (FCU) and using the interval between the ulnar neurovascular bundle and the FCU. The flexor tendons and median nerve are then retracted radially and the ulnar neurovascular bundle gently retracted ulnarly to expose the pronator quadratus, which is incised and then elevated off the bone to visualize the fracture. This approach provides excellent exposure to the volar rim fragment and can be used for fragment specific plating.

### Radial

A straight radial incision can also be utilized to expose the radial styloid fragment and for fragment specific fixation. An incision is made on the radial side of the wrist directly over the radial styloid. The brachioradialis is easily released from this approach. The radial sensory nerve will be in the center of the surgical field and must be identified and protected. When placing radial plates through this approach, they can be placed on the floor of the first dorsal compartment, similarly as with a volar Henry approach, or radial column plates can easily be placed on the bone between the first and second dorsal compartments.

## Dorsal Bicolumnar

A midline dorsal incision can be used to visualize both the radial styloid fragment, dorsal ulnar corner fragment, and free intra-articular fragments. An incision is made just ulnar to Lister's tubercle. The extensor pollicis longus is identified and translocated radially. Incision(s) can then be made through the extensor retinaculum either through or between compartments depending on what components of the radius the surgeon is trying to expose. When performing this exposure, it is important to preserve the dorsal extrinsic ligaments, as accidental release will result in radiocarpal instability. Depending on the amount of radial and ulnar dissection, the radial and ulnar sensory nerves may be in the field.

Various intervals may be used between different dorsal compartments. A commonly used approach is to incise the third dorsal compartment and then elevate the second, fourth, and possibly fifth compartments off the bone. This provides adequate room for dorsal monoblock plating. In this circumstance, it may be beneficial to remove Lister's tubercle to facilitate plate positioning. The surgeon can also dissect radially in the subcutaneous tissues and make an incision in the retinaculum between the first and second compartments for radial styloid plating. The extensor retinaculum is repaired,

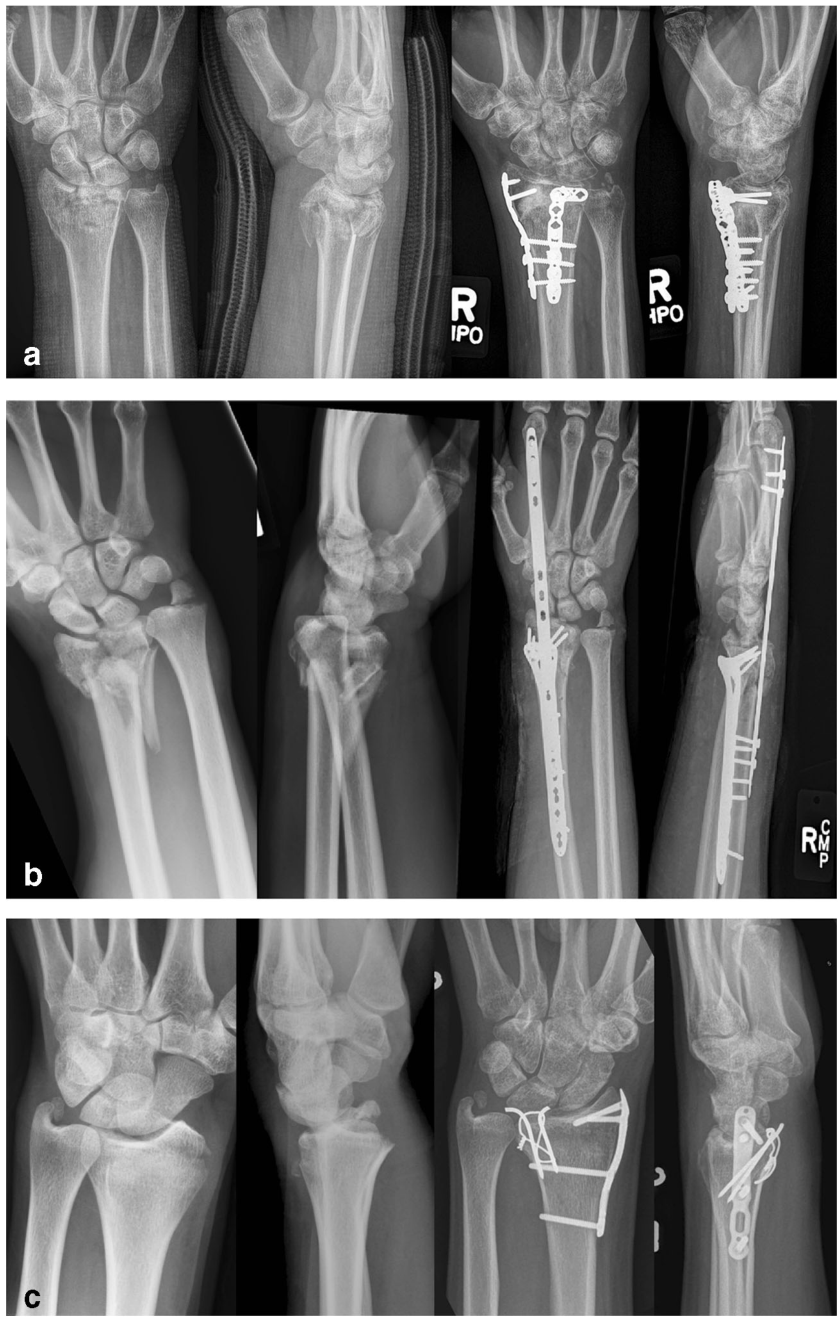


**Fig. 4** **a** The use of fragment specific fixation in setting of very distal fracture with intra-articular split (case courtesy of Chaitanya Mudgal). **b** The use of external fixation to augment volar locked plating in the setting of highly comminuted distal radial fracture with long metaphyseal fracture (case courtesy of Nishant Suneja). **c** Fragment specific fixation of the "critical corner," or volar ulnar rim using tension band construct

and the extensor pollicis longus tendon is typically translated and transposed. Through this same skin incision, more limited approaches can be done to reach particular areas of the radius, leaving the remainder of the extensor retinaculum intact. The radial styloid can be accessed between the first and second compartments and dorsal ulnar corner and sigmoid notch can be accessed through the fifth compartment (Fig. 4).

### Ulnar

The ulna is most frequently exposed using the plane between the FCU and extensor carpi ulnaris (ECU). The bone is subcutaneous in this location and the FCU and ECU easily elevated to provide exposure to the ulna. When dissecting around the ulnar styloid, care must be taken to identify and protect the ulnar sensory nerve and to avoid destabilizing the ECU tendon.

## Soft Tissue Management and Concomitant Injuries

### Open Fractures

The size of defect and the degree of gross contamination are both predictive of risk of infection [14,15]. Adequate debridement is essential in preventing infection. Although randomized studies would be difficult to perform, large cohort studies have shown that timing to debridement—up to 24 h from time of injury—is not associated with risk of infection [16,17] and that upper extremity fractures have a lower risk of infection compared to lower extremity fractures [16]. As such, in addition to updating tetanus vaccination and intravenous antibiotics, it is very important to adequately debride the fracture within 24 h of injury. For patients with highly contaminated fractures requiring serial debridement, either temporizing or definitive external fixation may be a good option for fixation.

### Triangular Fibrocartilage Complex Tear

In high energy distal radius injuries, there is frequently an ulnar styloid fracture or a triangular fibrocartilage complex (TFCC) injury [18–21]. Certain peripheral tears may be associated with DRUJ instability, even after bony fixation of the radial and intermediate columns. Instability of the DRUJ does seem to be related to the quality of the reduction of the distal radius so in this instance, residual deformity, particularly in the coronal plane, must be corrected. In instances of a hypermobile DRUJ without frank instability, it may be beneficial to immobilize the patient's forearm in the position of stability, i.e., either pronated or supinated, after surgery. In instances of dislocating DRUJ after bony fixation, acute repair—either open or arthroscopic—is indicated. Repair can be achieved using suture anchors or transosseous sutures through the ulna.

### Scapholunate Ligament Injury

There is a high rate of concomitant scapholunate interosseous ligament injury with high energy distal radius fractures [6]. Diagnosis relies on either radiographic SL distance and SL angle or intraoperative fluoroscopic or arthroscopic assessment. Acute repair may be indicated in high-grade injuries. However, the majority of injuries do not require repair.

### Acute Carpal Tunnel Syndrome

Acute median neuropathy can be a sequela of edema and hemorrhage from distal radius fracture, and much less commonly from direct pressure from the fracture fragments. In an older population, patients with pre-existing CTS may have worsening symptoms after distal radius fracture. In both of these cases, timely carpal tunnel release is important to prevent long-term sequelae.

## Summary

Management of complex distal radius fractures can be challenging especially in situations of multiple intra-articular fragments and/or volar and dorsal comminution. Successful management relies on detailed knowledge of anatomy, understanding the different fixation options and approaches, and careful preoperative planning.

### Compliance with Ethical Standards

**Conflict of Interest** The authors declare that they have no conflict of interest.

**Human and Animal Rights and Informed Consent** This article does not contain any studies with human or animal subjects performed by any of the authors.

## References

Papers of particular interest, published recently, have been highlighted as:
• Of importance
•• Of major importance

1. Medoff RJ. Essential radiographic evaluation for distal radius fractures. Hand Clin. 2005;21(3):279–88.
2. Chen NC, Jupiter JB. Management of Distal Radial Fractures. JBJS. 2007;89:2051–62.

3. Martineau PA, Berry GK, Harvey E. Plating for distal radius fractures. Orthop Clin N Am. 2007;38:193–201.
4.•• Beck JD, Harness NG, Spencer HT. Volar plate fixation failure for volar shearing distal radius fractures with small lunate facet fragments. J Hand Surg [Am]. 2014;39:670–8 **This prospective study followed the outcomes of patients with AO B3 distal radius fractures fixed with volar locking plates and consequently identified risk factors of implant failure. This is important as it concretely identified situations in which fragment specific fixation should be considered over volar locked plating.**
5. Lutsky K, Boyer M, Goldfarb C. Dorsal locked plate fixation of distal radius fractures. J Hand Surg [Am]. 2013;38:1414–22.
6. Farhan MF, Wong JH, Sreedharan S, Yong FC, Teoh LC. Combined volar and dorsal plating for complex comminuted distal radial fractures. J Orthop Surg (Hong Kong). 2015;23:19–23.
7. Wang D, Shan L, Jun-Lin Z. Locking plate versus external fixation for type C distal radius fractures: a meta-analysis of randomized control trials. Chin J Traumatol. 2018;21:113–7.
8.• Saving J, Enocson A, Ponzer S, Mellstrand Navarro C. External fixation versus volar locking plate for unstable dorsally displaced distal radius fractures: a 3-year follow up of a randomized control study. J Hand Surg [Am]. 2019;44:18–26 **Popularity for external fixation has waxed and waned and has recently been less popular due to concerns about complications. However, this study shows that 3 year results between external fixation and volar locked plating are comparable.**
9. Roh YH, Lee BK, Baek JR, Noh JH, Gong HS, Baek GH. A randomized comparison of volar plate and external fixation for intra-articular distal radius fractures. J Hand Surg. 2015;40:34–41.
10. Wei DH, Poolman RW, Bhandari M, Wolfe VM, Rosenwasser MP. External fixation versus internal fixation for unstable distal radius fractures: a systematic review and meta-analysis of comparative clinical trials. J Orthop Trauma. 2012;26:386–94.
11. Cross AW, Schmidt CC. Flexor tendon injuries following locked volar plating of distal radius fractures. J Hand Surg [Am]. 2008;33:164–7.
12.• Kamal RN, LEversedge F, Ruch DS, Mithani SK, Cotterell IHF, Richard MJ. The Sigmoid Notch View for Distal Radius Fractures. J Hand Surg [Am]. 2018;43:1038 **This study describes the sigmoid notch view, which can be one method of ensuring there is no intra-articular screw penetration.**
13. Kitay A, Swanstrom M, Schreiber JJ, Carlson MG, Nguyen JT, Weiland AJ, et al. Volar plate position and flexor tendon rupture following distal radius fracture fixation. J Hand Surg [Am]. 2013;38:1091–6.
14. Kurylo JC, Axelrad TW, Tornetta P, Jawa A. Open fractures of the distal radius: the effect of delayed debridement and immediate internal fixation on infection rates and the need for secondary procedures. J Hand Surg [Am]. 2011;36:1131–4.
15. Glueck DA, Charoglu CP, Lawton JN. Factors associated with infection following open distal radius fractures. Hand. 2009;4:330–4.
16. Weber D, Dulai SK, Bergman J. Time to initial operative treatment following open fracture does not impact development of deep infection: a prospective cohort study. J Orthop Trauma. 2014;28:613–9.
17. Srour M, Inaba K, Okoye O. Prospective evaluation of treatment of open fractures: effect of time to irrigation and debridement. JAMA Surg. 2015;150:332–6.
18. Roberts RS, Bennett JD, Roth JH, Milne K. Arthroscopic diagnosis of intra-articular soft tissue injuries associated with distal radius fractures. J Hand Surg [Am]. 1997;22:772–6.
19. Lundau T, Arner M, Hagberg L. Intraarticular lesions in distal radius fractures in young adults: a descriptive arthroscopic study in 50 patients. J Hand Surg (Br). 1997;22:638–43.
20. Geissler WB, Freelane AE, Savoie FH, McIntyre LW, Whipple TL. Intracarpal soft tissue lesions associated with an intra-articular fracture of the distal end of the radius. J Bone Joint Surg Am. 1996;78:357–65.
21. Kordaziewicz B, Podgorski A, Kilch M, Michalik D, Chaberek S, Pomianowski S. Arthroscopic assessment of intra-articular distal radius fractures-results of minimally invasive fixation. Orthop Traumatol Rehabil. 2011;13:369–86.