### 6.3.3 Distal radius and wrist

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1 Assessment

1.1 Biomechanics

The three-column concept (Fig 6.3.3-1) [1] is a helpful biomechanical model for understanding the pathomechanics of wrist fractures. The radial column includes the radial styloid and scaphoid fossa, the intermediate column consists of the lunate fossa and sigmoid notch (distal radioulnar joint, DRUJ), and the ulnar column comprises the distal ulna (DRUJ) with the triangular fibrocartilaginous complex (TFCC).

The radial styloid is an important stabilizer of the wrist providing a bony buttress and attachment for the extrinsic carpal ligaments. Under normal physiological conditions, only a minor amount of load is transmitted along the radial column. A large proportion of load is transmitted across the lunate fossa to the intermediate column. The ulna is the stable partner in forearm rotation. The radius swings around the ulna and the two bones are firmly linked together by ligaments, at the level of the proximal and distal radioulnar joint, and by the interosseous membrane. The ulnar column represents the distal end of this stable pivot. The TFCC allows independent flexion/extension, radial/ulnar deviation, and pronation/supination of the wrist. It therefore plays a crucial role in the stability of the carpus and forearm. Significant forces are transmitted across the ulnar column, especially while making a tight fist.

1.2 Pathomechanics and classification

Virtually all types of distal radial fractures, with the exception of dorsal rim avulsion fractures, can be produced by hyperextension forces [2]. Various forces act on the wrist depending on the position of the hand at the time of impact. In a low-energy fall, bending forces lead to dorsally displaced extra- or intraarticular fractures. Shear forces lead to partial displacement of the palmar joint surface and produce unstable injuries. Compression forces are predominant in high-energy, axial loading injuries and lead to impaction of articular fragments. Avulsion is the main mechanism in fracture dislocations and the avulsed fragments often represent the bony attachments of a ligament.

Numerous classification systems are available for wrist fractures. These include the Müller AO Classification (Fig 6.3.3-2),
Specific fractures

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<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>I</td>
<td>Bending fracture of the metaphysis</td>
</tr>
<tr>
<td>II</td>
<td>Shearing fracture of the joint surface</td>
</tr>
<tr>
<td>III</td>
<td>Compression fracture of the joint surface</td>
</tr>
<tr>
<td>IV</td>
<td>Avulsion fractures, radiocarpal fracture, dislocation</td>
</tr>
<tr>
<td>V</td>
<td>Combined fractures (I, II, III, IV); high-velocity injury</td>
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</tbody>
</table>

Tab 6.3.3-1 The Fernandez classification. which has an anatomical basis and the Fernandez classification [3] that is based upon the pathomechanics described above (Tab 6.3.3-1).

1.3 Imaging

Radiological investigations allow a more precise understanding of the fracture pattern and associated injuries.

Plain x-rays

Plain anteroposterior (AP) and lateral x-rays must be taken for all radial fractures. Oblique views may be helpful. Normal radiological parameters should be known and a comparative view of the other wrist can be helpful.

Areas of collapse of metaphyseal bone (and therefore effective bone loss) can be predicted from the position of fracture fragments, particularly on the lateral view. This indicates potential instability, which is the single most important radiological guide to treatment.

- The important criteria for the radiographic assessment of instability [4] are:
  - significant comminution;
  - angular deformity > 10°;
  - shortening > 5 mm;
  - articular displacement > 2 mm.

Most of the information required for planning treatment can be obtained from plain x-rays. However, CT scan is helpful in more complex cases.

Computed tomography (CT)

- CT scans provide extremely accurate information about fracture fragment position and size and articular congruity.
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The sigmoid notch is especially well visualized by CT scan (Fig. 6.3.3-3). This information is almost impossible to gain by any other mode. 3-D reconstruction CT, with digital subtraction of the carpus and ulna (Fig. 6.3.3-4), can give an uninterrupted view of the fracture pattern and may be helpful in some cases.

1.4 Associated lesions

All wrist fractures must be assessed for open wounds (usually on the ulna side) and injury to the median or ulnar nerve. Compartment syndrome may develop in high-energy injuries.

Lesions of the proximal carpal row and TFCC

Distal radial fractures may be associated with injuries to the TFCC and carpal ligaments, particularly the scapholunate or lunotriquetral. These injuries are seen in extraarticular fractures but are more common with articular fractures [5]. X-rays (and CT scans) should carefully be reviewed for widening of the scapholunate interval (Fig. 6.3.3-5), interruption of Gilula’s lines, fractures that separate the scaphoid and lunate fossa, and evidence of carpal instability with dorsal angulation of the scaphoid. High-energy injuries may have associated fractures of the scaphoid waist.

1.5 Decision making

Decision making depends upon the “personality” of the injury, including patient, soft-tissue and fracture factors. A distal radial compression fracture in the osteopenic elderly behaves very differently from the high-energy fracture dislocation seen in young adults. It is crucial to educate the patient on their responsibilities prior to surgery and to stress that the outcome depends upon a team: the surgeon, the physical therapist, and—most importantly—the patient. If all members of the team are motivated and dedicated, the best possible outcome will be achieved.
Clear goals must be set prior to devising a plan of treatment. It must be established whether the fragments already are in an acceptable position. This decision will vary with the personal situation of the patient, although certain guidelines exist. For instance, the presence of an intraarticular step greater than 2 mm demands reduction—unless the patient already has established radiocarpal arthrosis. Radial length is thought to be another important radiological parameter and this should form a keystone in decision making.

2 Surgical anatomy

2.1 Anatomy

A thorough knowledge of the anatomy around the wrist and carpus is essential if surgical intervention is planned. The following sections describe the anatomy relevant to both radiography and surgical approaches.

2.2 Radiographic anatomy

Standard radiographic parameters are used to assess the distal radius.

AP view (Fig 6.3.3-6)

- **Radial height**: the distance between two parallel lines drawn perpendicular to the long axis of the radial shaft—one from the tip of the radial styloid and the other from the ulnar corner of the lunate fossa.
  
  Average = 12 mm.

- **Radial inclination**: the angle between two lines—one drawn perpendicular to the long axis of the radius at the ulnar corner of the lunate fossa and the other between that point in the lunate fossa and the tip of the radial styloid.
  
  Average = 23°.

- **Ulnar variance**: a measurement of the relative lengths of radius and ulna at the wrist. The distance between two parallel lines drawn perpendicular to the long axis of the radius at the distal articular surface of the ulna and the ulnar corner of the sigmoid notch of the radius.
  
  60% of the population are ulnar neutral.

Lateral view (Fig 6.3.3-7)

- **Palmar inclination**: the angle between two lines—one drawn perpendicular to the long axis of the radius and the other between the dorsal and palmar lips of the distal radial articular surface.
  
  Average = 12°.

- **Scapholunate angle**: the angle between the axis of the scaphoid (a line joining palmar limits of proximal and distal poles) and the axis of the lunate (a line perpendicular to the line joining dorsal and palmar lips of the lunate).
  
  Average = 30–80°. This will vary depending on the position of the wrist.

Fig 6.3.3-6 Normal x-ray anatomy. AP view. Measurement of radial height and inclination plus ulnar variance.
2.3 Preoperative planning

The aims of treatment are to restore anatomy (radial length and angles, articular surface congruity, DRUJ) and to regain function. In simple cases, standard AP and lateral x-rays of the injured wrist provide all the necessary information for planning. In articular and partial articular fractures, additional CT scan investigation is usually recommended. Key articular fragments are identified: dorsoulnar, palmarulnar, hyperextended palmar fragment, radial styloid, and impacted articular fragments (Fig 6.3.3-8). The three column concept helps in developing an operative strategy for reduction and stable fixation of the respective articular fragments. The intermediate column is the key to the radiocarpal joint surface. If impacted fragments have to be addressed directly, a dorsal approach to the intermediate column with a limited arthrotomy is indicated. If the CT scan or traction x-rays suggest an important ligament tear, intraoperative arthroscopy or extended dorsal arthrotomy (for direct inspection) is indicated.

External fixation can be of great value, either as a temporary intraoperative reduction device, or as an escape route if stable fixation cannot be achieved. Intraoperative image intensification should be available to check reduction, implant positioning, stability of the final construct, and carpal kinematics during operation.

Fig 6.3.3-8 Common articular fragments of the radius.
I Radial styloid.
II Palmarulnar.
III Dorsoulnar.
2.4 Surgical approaches

2.4.1 Dorsal approach
A straight skin incision is placed over Lister’s tubercle (Fig 6.3.3-9a). Distally, it extends over the radiocarpal joint line to about 1 cm proximal to the base of the second carpo-metacarpal joint. Proximally, the incision is continued 3–4 cm along the radial shaft. The intermediate column is approached through the floor of the third extensor compartment (Fig 6.3.3-9b). The extensor retinaculum is divided along the line of the extensor pollicis longus (EPL) tendon, which is freed and protected. The distal end of the retinacular incision is V-shaped so that the distal part of the tendon maintains its course. The V can be used later as a flap to cover the plate. The intermediate column is now visualized by subperiosteal dissection (Fig 6.3.3-9c). The second compartment can be elevated subperiosteally to expose the dorsal aspect of the distal radius. This exposure is useful for standard dorsal plating. If, however, a double plating technique is chosen, the exposure of the radial column is better achieved by passing superficially to the second compartment and opening the first compartment. The radial (buttress) plate can then be passed underneath the tendons of the abductor pollicis longus (APL) and extensor pollicis brevis (EPB) muscles. The superficial radial nerve lies in the skin flap and must be protected. The second and fourth compartments are not opened. A limited transverse arthroscopy along the dorsal radial rim is performed for open reduction of articular fragments and to inspect the proximal carpal row for associated ligament injuries. After reconstruction of the joint surface, the intermediate column is stabilized with a dorsal plate which can either be contoured or, if the palmar cortex is intact, applied in buttress mode. For closure, the EPL tendon is partially transposed subcutaneously using the V-flap of the retinaculum.

In B1.1 and B1.2 fractures, a direct approach to the radial styloid may be chosen. A straight incision in the anatomical snuff-box centered over the tip of the radial styloid is performed. The superficial radial nerve and branch of the radial artery are vulnerable and must be protected. The styloid process is approached between the first and second extensor compartments.

2.4.2 Palmar approach
The skin is incised longitudinally along the course of the flexor carpi radialis (FCR) tendon (Fig 6.3.3-10a). The FCR sheath is opened and the tendon retracted to the radial side to expose the radial styloid and scaphoid fossa. Great care must be taken to avoid pressure on the median nerve (Fig 6.3.3-10b).

Underneath the FCR sheath lies the flexor pollicis longus (FPL) tendon. This must be retracted ulnarly revealing the pronator quadratus (PQ) muscle. The pronator quadratus muscle is elevated from its radial origin and reflected ulnarly to expose the distal radius (Fig 6.3.3-10c). If the fracture is very distal, it is not necessary to completely elevate this muscle. The palmar extrinsic radiocarpal ligaments should not be detached from the radius to expose the joint surface as this may destabilize the wrist. Palmar fragments are rarely single and comminuted. Each fragment must be identified, disimpacted, and reduced. The palmar surface of the distal radius is flat. Application of a flat implant on to this surface will automatically correct any malrotation of the fracture fragments.
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Fig 6.3.3-9a–c  Dorsal approach to the wrist.

a  The incision is centered on Lister’s tubercle.
b  After skin incision, the radius can be exposed between the extensor tendon compartments I and II, II and III, or III and IV.
c  The approach between the extensor tendon compartments depends on the fracture pattern and must be carefully planned after assessing the x-rays and CT.

I  Abductor pollicis longus and extensor pollicis brevis.
II  Extensor carpi radialis longus and brevis.
III  Extensor pollicis longus.
IV  Extensor digitorum longus and extensor indicis.
V  Extensor digiti minimi.
VI  Extensor carpi ulnaris.
1  Superficial radial nerve.
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Fig 6.3.3-10a–c  Palmar approach to the radius.
a  Approach through the bed of the flexor carpi radialis (FCR) tendon.
b  The approach is between the FCR tendon and the radial artery. Pressure on the median nerve must be avoided.
c  Distal radius exposed by elevation of the pronator quadratus muscle.

1  Radial artery.
2  Flexor carpi radialis tendon.
3  Median nerve.
4  Recurrent motor branch of the median nerve.
5  Pronator quadratus muscle.
The anatomy of the distal radius produces some unique surgical challenges. Dorsally placed implants have little soft-tissue cover and often irritate the overlying extensor tendons. Palmar implants are well covered by the pronator quadratus muscle. The thin cortex around the metaphysis of the distal radius means that the thread pitch of conventional screws gives insufficient purchase for fixation to be achieved with absolute stability, a problem that is enhanced in osteoporotic bone. Because of these limitations, plate fixation was for many years only recommended to buttress palmar, partial articular fractures. External fixation was the treatment of choice using ligamentotaxis and distraction to reduce the fracture. However, complications related to external fixation led to further attempts to develop implants that would allow internal fixation on the dorsum of the wrist. Unfortunately, problems with the overlying soft tissues continued to occur, despite the use of low-profile plates and screw heads.

The recent development of locking head screws and the internal fixator principle, plus further understanding of the biomechanics of the wrist, has led to the introduction of internal fixators. These support specific columns with double plate arrangements for the radial and intermediate columns. The early results are very promising and likely to extend the indications for internal fixation in distal radial fractures in future.

### 3.1 Type A–extraarticular fractures

Stable metaphyseal fractures with minimal shortening or dorsal displacement can be treated by cast immobilization. These injuries (often referred to as Colles’ fractures) are common in the elderly population and respond well to nonoperative management. Similar injuries in young adults require more intensive attempts at achieving and maintaining anatomical reduction. Extraarticular injuries with significant dorsal displacement include dorsal metaphyseal comminution and an area of effective bone loss. These fractures reduce easily with simple disimpaction, but they are unstable and most will redisplace in a cast. Under these circumstances, stabilization with K-wires is usually adequate, either by extrafocal, percutaneous pinning, or by using an intrafocal technique as described by Kapandji (Fig 6.3.3-11a–b). When dorsal comminution is marked (with excessive shortening and/or dorsal inclination), instability and unacceptable redisplacement are likely after simple manipulation. Poor bone stock often makes.
these fractures difficult to treat by pinning. These fractures have traditionally been managed by external fixation (Fig 6.3.3-12a), often supplemented with K-wires and bone graft. If the distal fragments are sufficiently large to accept Schanz screws, the external fixator does not need to be applied across the radiocarpal joint, but can remain entirely within the radius (Fig 6.3.3-12b). However, fracture patterns that are suitable for this nonbridging technique are infrequent.

External fixation remains a popular treatment, but internal fixators may now provide sufficient stability to allow early movement with few of the complications associated with external fixation. In the treatment of dorsally displaced fractures, locking plates may be applied on the anterior surface of the distal radius. Locking head screws are placed into the subchondral bone under radiographic guidance. The offset angle of these screws, which is built into the plate, results in a

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**Fig 6.3.3-12a–c**

a  Bridging external fixation. Indirect reduction using ligmentation, with a tube-to-tube construct.

b–c  Nonbridging external fixation. Direct reduction by manipulation of fragments using the fixator pins.
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normal palmar inclination when the longitudinal part of the plate is applied to the radial shaft (Fig 6.3.3-13). The placement of the plate on the anterior surface reduces plate related problems and the stability of these devices makes bone grafting of the dorsal defect unnecessary [6].

3.2 Type B—partial articular fractures

This group comprises a variety of shear, compression, and avulsion injuries (Fig 6.3.3-2). Conventional x-rays often underestimate the extent of articular involvement and additional CT scans should be obtained. Understanding of the pathomechanics provides the key to the specific treatment of each fracture.

B1.1 and B1.2 (fractures of the radial styloid, B1.1 simple, B1.2 multifragmentary)

If shear forces are involved, the styloid fragment is displaced proximally and the articular surface may be impacted. The fracture may extend towards the palmar rim (which will be seen on CT scan) and requires specific attention. Typically, an associated scapholunate ligament tear will be present [7]. If the radial styloid is displaced distally and ulnarily, the injury is a result of avulsion forces in a fracture dislocation (see below, B2.3). Nondisplaced radial styloid shear fractures are treated with immobilization and cast. Displaced fractures need to be reduced and fixed with (cannulated) screws or K-wires (Fig 6.3.3-14). In injuries with extension towards the palmar rim, a palmar plate may be required.

Fig 6.3.3-13a–b  The LCP 2.4 applied to the anterior surface provides a fixed-angle device that can maintain reduction even if there is dorsal bone loss. The distal screws angles away from the joint to avoid articular penetration.
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B1.3 (isolated dorsoulnar or palmarulnar fragment resulting from compression forces)
Both the radiocarpal and the distal radioulnar joint are involved. The fragment should be anatomically reduced and fixed with screws or a small buttress plate.

B2.1 and B2.2 (B2.1 dorsal shear fractures, B2.2 with involvement of the radial styloid)
These injuries are unstable with dorsal subluxation of the carpus. They should be treated operatively, either with external fixation and K-wires or dorsal plating.

B2.3 (fracture dislocation with avulsion of the dorsal rim, with or without fracture of the radial styloid)
The styloid fragment, if present, is equivalent to an osseous avulsion of the radioscapohapitate and dorsal radiotriquetral ligament. Additional tears or osseous avulsions of palmar radiocarpal and ulnocarpal ligaments including TFCC tears are frequent and should be addressed. These injuries are unstable. As an exception, closed reduction and cast immobilization may be sufficient. More often, external fixation (in neutralizing mode) is advisable, combined with small screws and K-wires to reattach avulsed ligaments, and direct ligament repair is warranted.

B3 (palmar shear fractures)
Extensive impaction of the articular surface may be present (B3.3), either at the level of the palmar shear fragment or at the dorsal articular remnant. These injuries are unstable with palmar subluxation of the carpus. Palmar buttress plate fixation is indicated to stabilize the fracture (Fig 6.3.3-15). Associated ligament tears of the proximal carpal row should be treated specifically.

3.3 Type C—complete articular fractures
This heterogeneous group includes all fractures with complete separation of the radial epiphysis from the shaft and involvement of the articular surface. Extraarticular angles and articular congruity must both be restored. Low-energy injuries mainly involve bending forces, whereas in high-energy injuries shear and compression forces predominate. In these cases preliminary closed reduction and joint-bridging external fixation (ligamentotaxis), as a first step, may be adequate. As a second step, a CT scan (after external fixation) should be performed. After soft-tissue swelling has subsided, definitive treatment is planned as a third step.
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Fig 6.3.3-15a–e  Technique of palmar plating of B3 fracture.

a–b  Reduction by hyperextension of the wrist over a pad.

c–e  A small-fragment T-plate 3.5 is placed in a buttress position. The first screw is placed in the most proximal hole. By tightening the second screw a buttressing effect is obtained. Placement of screw(s) in the most distal hole(s) is optional.
**C1 and C2**
The common feature of this subgroup is extension of the fracture into the radiocarpal joint with a simple coronal or sagittal fracture line. Metaphyseal comminution may also be present (C2). In many instances, the intraarticular fracture is non-displaced. The fracture can be reduced by ligamentotaxis, and—after closed reduction—cast immobilization may be appropriate in cases without signs of instability. With metaphyseal comminution percutaneous pinning or bridging external fixation (with or without percutaneous pinning) may be chosen (Fig 6.3.3-16). Palmar plating with a locking implant allows anatomical restoration of length and rotation and secondary loss of reduction is unlikely. In addition, early mobilization is possible with a more rapid return to function and less

![Diagram of fracture reduction and fixation](image-url)

**Fig 6.3.3-16a–d** Technique of percutaneous reduction and K-wire fixation of a C1 fracture with application of a protecting external fixator. Pin placement must avoid the extensor tendon and its expansion at the metacarpophalangeal joint.
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risk of complex regional pain syndrome. Special attention must be paid to fractures with a dorsoulnar fragment (C1.1). This fragment is part of the radiocarpal and the distal radioulnar joint and must be anatomically reduced. If the fragment does not reduce after attempted closed reduction with ligamentotaxis, percutaneous manipulation with a K-wire or open reduction and internal fixation may be required (Fig 6.3.3-17). In fractures with extension into the diaphysis (C2.3 and C3.3) open treatment with a long, bridging T-plate is preferred since diaphyseal fractures take longer to heal.

**C3 (high-energy trauma with multifragmentary involvement of the radiocarpal joint surface)**

Shear and compression forces lead to marked displacement and depression of articular fragments. Severe soft-tissue injuries may be present. A three-step procedure, as described above, is appropriate in such cases. Often the radial and intermediate column must be stabilized separately (Fig 6.3.3-18). The radial column can be buttressed with a radially placed plate, either from a dorsal or palmar approach. The hyperextended palmar articular fragment (intermediate column) must

![Fig 6.3.3-17a–d](image1) Displaced articular fracture. Open reduction and fixation with a palmar plate LCP 2.4. This avoids tendon problems that are seen with dorsal plates.

![Fig 6.3.3-18a–c](image2) Complex articular fracture (C3) fixed using LCP 2.4. Specific plates are used for the radial styloid and palmpoular fragments.
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be reduced and fixed from a palmar approach. If the intermediate column is additionally split into a dorsoulnar and a palmar ulnar fragment, the dorsoulnar fragment occasionally has to be addressed separately, using a limited dorsal approach to the intermediate column through the third extensor compartment (Fig 6.3.3-19 to 6.3.3-21). Dorsal arthrotomy and inspection of the radiocarpal joint is warranted in cases of impacted articular fragments. Bone graft or substitutes can be useful but are rarely necessary when using locking plates. If stable internal fixation is not achieved, bridging external fixation, in a neutralizing mode, may be left in place for 6 weeks as an escape route.

3.4 Ulnar column lesions

Bony and/or ligamentous disruption of the ulnar column represents a serious injury which merits assessment and specific treatment. Ulnar-sided lesions can be classified according to Fernandez (Tab 6.3.3-2). TFCC lesions are classified according to Palmer.

Fig 6.3.3-19a–f Case of a 50-year-old male with skiing injury.

a–d Referral 3 weeks after the accident.

Due to the hyperextended palmoulnar fragment and the displaced meta-/diaphyseal palmar fragment a palmar approach is necessary. The radial column can be controlled and buttressed separately with an S-plate from the palmar approach. An additional limited dorsal approach will be needed to reduce and buttress the dorsoulnar fragment.
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Fig 6.3.3-20a–e Case of a 50-year-old male with skiing injury (patient of Fig 6.3.3-19). Indirect reduction by a distracting external fixator. Direct reduction of fragments and preliminary fixation with K-wires.

a–b The intermediate column is reconstructed by a palmar as well as a dorsal L- and S-locking plate. The medial column is additionally buttressed by a third LCP.

c–e The postoperative CT scans show anatomical reconstruction of the articular surfaces in different projections.

Fig 6.3.3-21a–f Case of a 50-year-old male with skiing injury (patient of Fig 6.3.3-19 and 6.3.3-20). Early motion was started immediately postoperatively. The plaster splint was changed to a removable velcro splint. The hand is used for unloaded daily activities such as eating, personal hygiene, knotting a tie, holding a paper.

a–b After 6 weeks fracture healing is documented with x-rays and the patient can start with loaded activities.

c–f After 3 months the patient shows good wrist motion.
6 Specific fractures
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3.4.1 Ulnar styloid fractures
One third of distal radial fractures are associated with a fracture of the ulnar styloid process. A variety of fracture patterns exists, ranging from simple avulsion of the tip to a displaced fracture at the base of the entire styloid process. Any fracture type may also involve additional ligament disruption and a fracture at the base of the styloid does not rule out a radial TFCC tear. There is no generally accepted treatment algorithm for ulnar styloid fractures. Decisions on fixation of the ulnar styloid should be based on a clinical assessment of the stability of the DRUJ after fixation of the radial injury. Stable fixation of the ulnar styloid can be achieved either with a single 2 mm screw or a tension band wire.

3.4.2 Ulnar head, neck, and distal shaft fractures
Treatment of these injuries is based on the same principles as other fractures. It is important to recognize that fractures of both bones are not wrist fractures but forearm fractures that happen to be near the wrist: They should be treated in the same way, with reduction and internal fixation. Stable internal fixation of distal ulnar fractures can be difficult to achieve because the distal fragment is small and a large proportion is covered in articular cartilage. The 2.7 or 2.0 mm mini condylar buttress plate has been used successfully to treat these injuries [8]. It has the advantages of being a fixed-angle device with two points of fixation in the small distal fragment and of having an oblique hole to allow placing of an interfragmentary lag screw (Fig 6.3.3-22).

3.5 Postoperative care
All patients must exercise their shoulder, elbow, and fingers. Extraarticular and simple articular fractures treated with percutaneous pinning are immobilized in a cast for an average of 6 weeks. Patients with external fixators require education on pin site care. In most cases, fixators can be removed at 6 weeks, although they should be maintained for longer if the fracture

<table>
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<tr>
<th>Type I</th>
<th>Stable</th>
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<tr>
<td>(Following reduction of the radius the DRUJ is congruous and stable)</td>
<td></td>
</tr>
<tr>
<td><img src="https://example.com/image1.png" alt="Image" /></td>
<td></td>
</tr>
<tr>
<td>A Avulsion fracture tip of the ulnar styloid</td>
<td></td>
</tr>
<tr>
<td>B Stable fracture ulnar neck</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type II</th>
<th>Unstable</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Subluxation or dislocation of the ulnar head)</td>
<td></td>
</tr>
<tr>
<td><img src="https://example.com/image2.png" alt="Image" /></td>
<td></td>
</tr>
<tr>
<td>A TFCC tear +/- capsular ligaments</td>
<td></td>
</tr>
<tr>
<td>B Avulsion fracture base of the ulnar styloid</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type III</th>
<th>Potentially unstable</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Subluxation possible)</td>
<td></td>
</tr>
<tr>
<td><img src="https://example.com/image3.png" alt="Image" /></td>
<td></td>
</tr>
<tr>
<td>A Intraarticular fracture of the sigmoid notch</td>
<td></td>
</tr>
<tr>
<td>B Intraarticular fracture of the ulnar head</td>
<td></td>
</tr>
</tbody>
</table>

Tab 6.3.3-2 Fernandez classification of distal ulnar lesions.
6.3.3 Distal radius and wrist

Fig 6.3.3-22a–g

a–b 40-year-old male, who fell from a ladder. Dorsally impacted intraarticular fracture of the distal radius (23-A3.3). High-energy axial forces led to impaction of articular fragments into the metaphyseal cancellous bone.

c The intermediate column is divided into two main fragments (dorsoulnar, palmoulnar).

d The dorsoulnar fragment is centrally impacted.

e The radial styloid is separated. These articular fragments do not respond to ligamentotaxis. Formal open revision is indicated to reconstruct the radiocarpal joint surface under vision. Additionally, this type of injury may also involve a relevant ligamentous injury of the proximal carpal row. These ligaments can be revised during the dorsal approach with arthrotomy. ORIF was performed with two locking plates 2.4 placed orthogonally onto the distal radius through one straight dorsal radial approach.

f–g At 6 weeks fracture healing has progressed well without secondary displacement, which allows to begin activities, which are more functional.
has been bone grafted or there is delay in union. Fractures treated by internal fixation should be assessed for stability at the time of surgery. The wrist is splinted until the wounds have healed; mobilization and physical therapy can begin as soon as the fracture fixation allows.

### 3.6 Complications

Median nerve irritation is common. Generally, symptoms are mild and disappear with elevation. Persistent paresthesia may be due to median neuropaxia at the site of fracture, or acute carpal tunnel syndrome. Decompression and exploration of both sites of potential injury is necessary.

Compartment syndrome is always a threat, particularly after crush injury, prolonged anesthesia and arthroscopy assisted reduction. If this diagnosis is suspected on clinical grounds, compartment pressures may be measured but urgent decompression needs to be performed.

Stiffness is common after wrist fractures but may not limit function. Elevation and early digital movement, together with surgical stabilization and early movement of the wrist, will help reduce the degree of stiffness.

Arthrosis is more common in articular injuries and is seen more frequently if a residual step of 2 mm or greater remains in the articular surface [9]. The appearance of arthrosis may be a purely radiological phenomenon. There is no association between radiographic appearances and symptoms.

Malunion is common, particularly after nonoperative treatment of displaced fractures. In the elderly, small degrees of malunion are tolerated well and result in minimal disability. Severe malunion may result in reduced grip strength, cosmetic deformity, stiffness, restriction of forearm rotation, and pain. This is usually on the ulnar side due to ulnar abutment.

Nonunion is uncommon and most often seen in distal radial fractures with an associated distal ulna fracture.

External fixation [10] can result in pin-site infection, loss of reduction, and injury to the radial sensory nerve, which can be avoided by using an open technique for pin insertion. Complex regional pain syndrome type 1 (CRPS I) has been associated with external fixation, particularly when the fixator is used for prolonged and forceful distraction. CRPS I is not restricted to those cases treated by external fixation and can occur after any distal radial fracture.

Open reduction and internal fixation is generally safe and infection is rare [1, 11]. Dorsal plates are implicated in tenosynovitis and tendon rupture. Loss of reduction after internal fixation can occur in osteoporotic bone, but the risks are reduced by well planned surgery and the use of locking plates.

### 3.7 Results

Current literature provides no evidence-based recommendation of one specific treatment method. While long-term studies point towards a link between wrist disability and deformity [12–14], the relevance of these studies is uncertain. Most authors agree that the shape of the healed skeleton and the identification and treatment of associated injuries are strong predictors of final functional outcome [15–17]. It seems to be important to concentrate on both extraarticular and intraarticular reduction [9, 18, 19].

External fixation is versatile in managing both intra- and extraarticular fractures with acceptable functional results [20]. Studies on internal fixation have produced comparable results [1], even with predominantly comminuted intraarticular fractures [11]. The current method of treating dorsally displaced fractures by indirect reduction through a palmar approach appears to produce excellent results when using locking plates [21].
6.3.3 Distal radius and wrist

4 Bibliography


5 Acknowledgment

We wish to thank Diego L Fernandez for his contribution to this chapter in the first edition of the AO Principles of Fracture Management.