Radius and Ulna

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Key Points

- Fractures of the shaft of the radius and ulna are less common than distal radius and ulna fractures and are more likely to be unstable.
- Radius and ulna fractures are very common in pediatric patients. They typically heal well, but displacement and angulation may require closed reduction or surgery.
- Radiocarpal dislocations are extremely rare in sports and typically only occur with polytrauma.

Introduction

The radius and the ulna are commonly fractured in sports, often due to falls onto an outstretched hand (FOOSH). The radius and ulna are connected proximally by the annular ligament and elbow capsule. The capsule of the wrist, triangular fibrocartilage complex (TFCC), dorsal radioulnar ligament, and volar radioulnar ligament connect the radius and ulna distally. In between the radius and ulna is the interosseous membrane which provides significant stability between the two bones. The unique nature of the forearm allows the radius to roll over the ulna, allowing for pronation of the wrist. In addition, the radius has an anatomic bow which allows for this movement as well as to allow grip strength.

Midshaft Forearm Fractures

Fracture Classification

Forearm fractures are classified based on a number of descriptors of the fracture: closed vs open, radius vs ulna fracture or both bone fractures, location of the fracture, fracture pattern (e.g., greenstick, oblique, transverse, comminuted), presence or absence of instability at the wrist or elbow, and presence or absence of angulation and displacement [1]. Galeazzi and Monteggia fractures are classified separately as fracture-dislocations (see Chap. 16 for details on Monteggia fractures). Galeazzi fractures, sometimes referred to as reverse Monteggia fractures, are fractures of the radial shaft with disruption of the distal radioulnar joint (DRUJ) [2]. An Essex-Lopresti fracture is a radial head fracture with interosseous membrane rupture and DRUJ dislocation due to proximal migration of the radius [2].

Mechanism of Injury in Sports

Forearm fractures may occur due to an axial compression such as from a FOOSH, bending of the forearm, rotation of the forearm, or from direct trauma [3]. Most forearm fractures are due to a high-energy mechanism, such as a fall from height or motor vehicle accident. In sports, athletes in football and wrestling are most likely to have forearm fractures with an incidence of 0.48 and 0.21 per 10,000 high-school athletic exposures, respectively [4]. Galeazzi fracture-dislocations typically occur due to a fall on an extended wrist with a hyperpronated forearm [5].

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Epidemiology

It is estimated that 10–14% of all fractures occur in the forearm [3]. Diaphyseal forearm fractures are much less common than distal forearm fractures. They are most common in 10–20-year-old males and in females over age 60 years [6]. Galeazzi fracture-dislocations account for 7% of adult forearm fractures [2].

Clinical Presentation

Patients typically present with pain and swelling. Patients with a displaced or angulated fracture may have deformity noted on clinical examination. Clinicians should also evaluate for soft tissue injuries such as lacerations, contusions, neurovascular injury, and open fractures. A patient with an associated DRUJ disruption may have a swollen, tender wrist with limited pronation and supination [2]. If a patient has numbness or tingling along the radial or palmar aspect of the hand, a median nerve injury should be suspected. In comparison, a radial nerve injury will affect the posterior forearm and dorsal aspect of the radial side of the hand. The posterior and anterior interosseous nerves may be injured if the interosseous membrane is disrupted. The posterior interosseous nerve supplies motor innervation for the wrist and finger extensors including the extensor digitorum, extensor indicis, and extensor carpi ulnaris. The anterior interosseous nerve supplies motor function to the flexor pollicis longus, lateral half of the flexor digitorum profundus, and pronator quadratus. With an Essex-Lopresti injury, patients have ulnar-sided wrist pain with a radius fracture. They may also have decreased forearm rotation and DRUJ instability and positive ulnar variance on radiographs.

Imaging

Initial imaging for a suspected forearm fracture includes anteroposterior and lateral radiographic views of the forearm (Fig. 17.1). If the patient has tenderness at the wrist or elbow, radiographs of these joints should also be obtained. Clinicians should closely evaluate the DRUJ in patients with a radial shaft fracture for possible Galeazzi fracture-dislocation. If the patient's radiograph shows an ulnar styloid fracture, widening of the DRUJ on the PA view, dorsal displacement of the ulna on the lateral view, or ulnar positive variance of >5 mm compared to the unaffected side, there should be a high suspicion for injury to the DRUJ [1]. Radial head dislocation indicates a Monteggia fracture-dislocation. MRI is occasionally needed if there is suspicion of damage to the TFCC, interosseous membrane, or to the articular cartilage [1–3]. CT may be needed for surgical planning or to evaluate for nonunion.

Initial Management

On the sideline, the patient's arm should be splinted, taking care to immobilize the elbow at 90°, the forearm in neutral, and the wrist in a neutral or slightly extended position. Neurovascular status should be evaluated. In the clinic or emergency room, forearm fractures without displacement should be initially treated with a sugar-tong or long arm splint. Once swelling has improved after 1–2 weeks, the patient should be placed in a long arm cast with the forearm in neutral or slightly supinated to reduce the forces of the supinator and biceps brachii muscles [7]. Isolated ulnar shaft fractures (Fig. 17.2) can be treated with a long arm posterior splint if there is >50% overlap of the fracture fragments, <10° of angulation, and no radial head dislocation and the fracture is in the distal two-thirds of the ulna [1]. The splint should hold the elbow at 90° with the forearm in neutral. Fractures of the proximal third ulna typically require surgery. A 2012 Cochrane review found that there is insufficient evidence for the best method of treatment for isolated ulnar shaft fractures in adults [7]. Galeazzi fractures require ORIF in adults; however, closed reduction may be attempted in pediatric patients [8]. Patients with isolated radial shaft fractures should be placed in a double sugar-tong splint [1]. Occasionally, both bone forearm fractures can be treated without surgery. Initial treatment should include a well-molded, long arm cast that is bivalved.

Indications for Urgent and Nonurgent Orthopedic Referral

Closed reduction of forearm fractures in adults typically results in poor outcomes as patients may develop improper rotational alignment, DRUJ instability, or unstable fractures even when casted [1, 2]; therefore, many forearm fractures including isolated ulnar shaft and radial shaft fractures as well as both bone forearm fractures require referral to orthopedics [3, 9]. Pediatric patients, however, can frequently be managed with nonoperative care (see Pediatric Considerations). Patients with an open fracture or signs of vascular insufficiency require emergent orthopedic referral. Neurologic symptoms also require urgent referral to orthopedics. Adults who have Galeazzi or Essex-Lopresti fracture-dislocations displaced fractures, or fractures with >10° of angulation will likely need surgical fixation with an urgent referral to orthopedics. Plates, screws, nails, bone

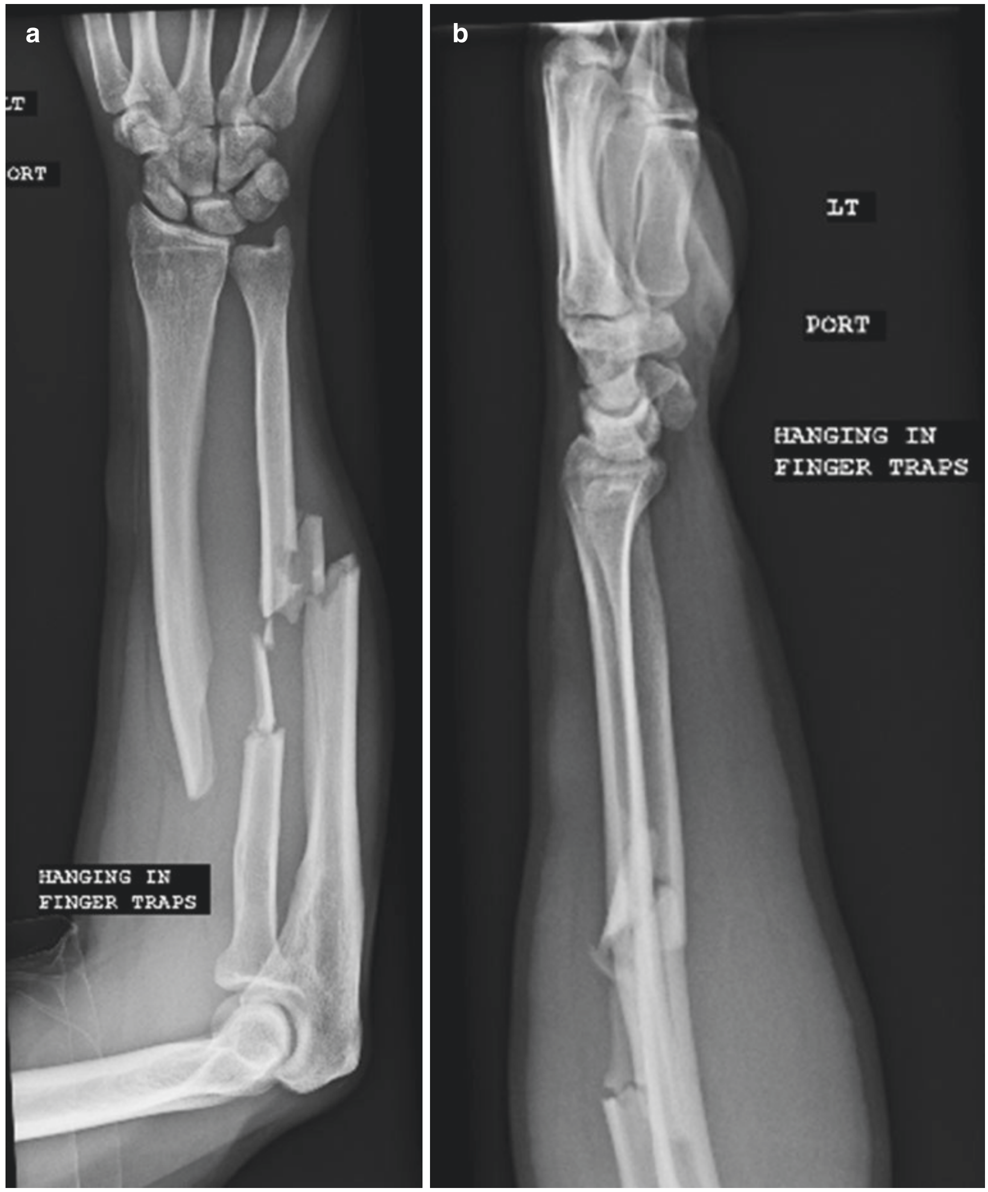

Fig. 17.1 Both bone forearm fractures (**a**, **b**) in a 49-year-old male after hitting a tree while skiing

grafting, and external fixators may be used, but the specific methods for surgical fixation are beyond the scope of this text [3, 8].

Follow-Up Care

Adult patients with forearm fractures who are able to be managed without surgery should be followed with weekly X-rays, especially in the first 2–4 weeks, to ensure stable position of the fracture [3]. Patients should be splinted for 7–10 days. They should then be transitioned to a long arm cast that extends from the deltoid insertion on the humerus to the MCP joints for 2–4 weeks. Sometimes, a bivalve cast is needed for the first 2 weeks if the patient has significant swelling [3]. The patient should then be transitioned to a functional long arm or forearm brace for 4–6 weeks (for a total of 8 weeks) or until radiographic healing is achieved (Table 17.1) which may take 12–16 weeks [1, 10]. The brace should allow full flexion and extension of the elbow and wrist as well as full pronation and supination. Adult patients typically will require PT to regain full motion and strength, as well as to progress back to sports. PT should start once they are in the brace. Patients who develop increased angulation or displacement during their care should be referred to orthopedics.

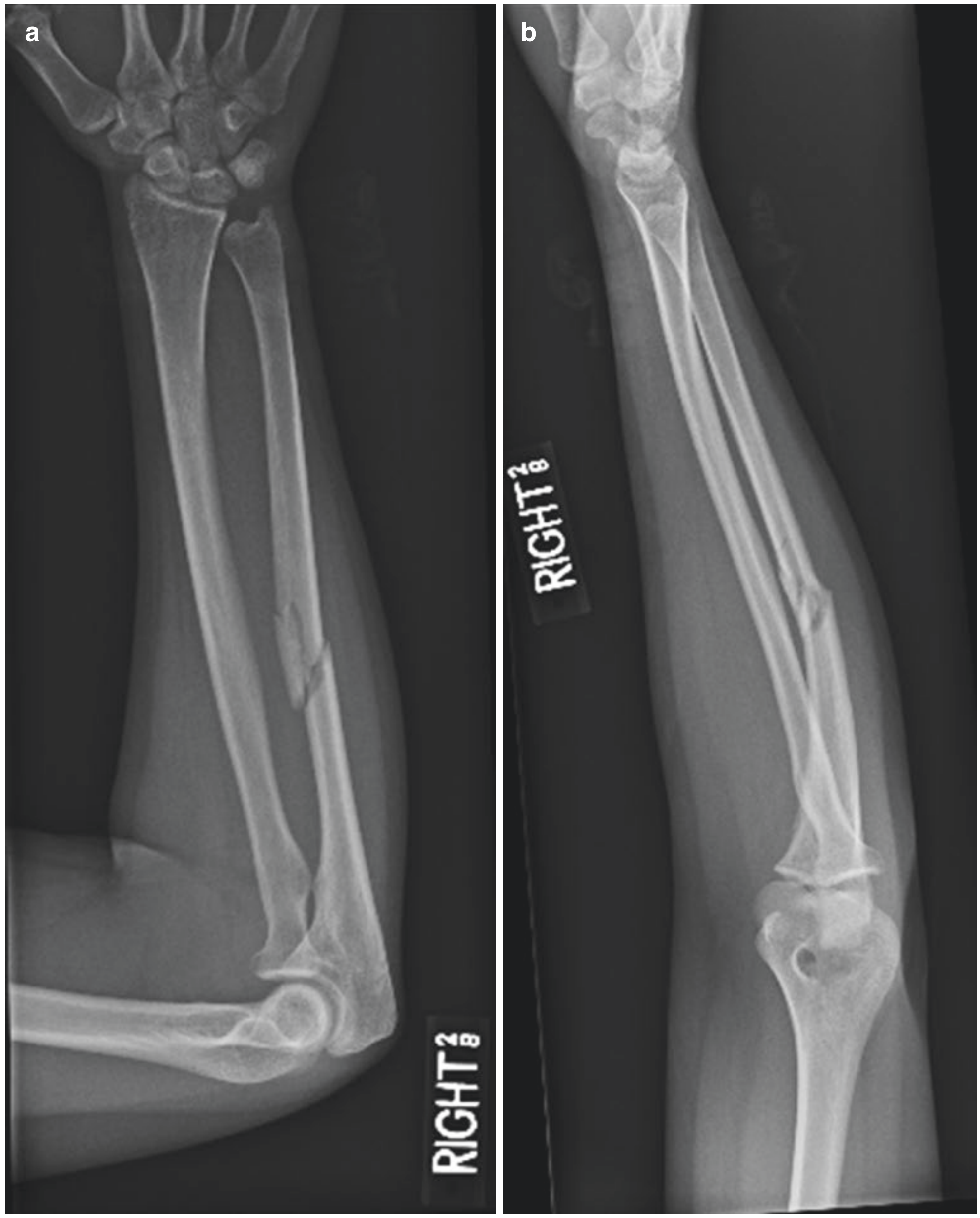

Fig. 17.2 Ulnar shaft fracture (**a**, **b**) with angulation in a 24-year-old female who fell while skiing

Table 17.1 Treatment of radius and ulna fractures

Fracture type	Initial treatment	Further treatment	Total length of immobilization	Return to sport
Isolated radial or ulnar shaft fracture	Sugar-tong or long arm splint	Long arm cast/splint for 2–4 weeks, then functional brace	8–12 weeks	8–16 weeks
Both bone forearm fractures	Sugar-tong or long arm splint	Long arm cast/splint for 2–4 weeks, then functional brace	8–12 weeks	8–16 weeks
Distal radius and ulna fractures	Sugar-tong splint	Short arm cast for 4–6 weeks followed by removable brace	6–8 weeks	8–12 weeks

Return to Sports

After casting is complete, adult patients with forearm fractures will require physical therapy (PT) to regain range of motion and strength of the arm. Return to sport typically requires 12–16 weeks; however, athletes who do not require excessive upper extremity strength (e.g., cross-country) can often return in 8–12 weeks. The specific time to return to sports often depends on the type of injury, specific sport, and evidence of radiographic healing [3]. Pediatric patients typically heal faster and return to sports faster than adults with forearm fractures.

Complications

Disruption of the distal radioulnar, proximal radioulnar, or radiocapitellar joints may occur in forearm fractures. If not addressed, patients typically have poor outcomes [2]. It is important to ensure the radius maintains its anatomic bow as more than a 5% change can result in a loss of forearm rotation and grip strength [8]. DRUJ instability is a common complication after forearm injuries. Nerve laceration or entrapment sometimes occurs days to weeks after the injury and, if suspected, should be evaluated by MRI or US [1, 11]. Other complications include myositis ossificans, malunion and nonunion (2–10%), and radioulnar synostosis (1–6%) [1, 3]. Joint stiffness is a common complication, especially with prolonged immobilization of the elbow.

Pediatric Considerations

Midshaft forearm fractures are common in children and are very often associated with significant deformity. Just like distal forearm fractures, these fractures can often be reduced in a closed fashion. However, angulation is not as well tolerated in the midshaft as the remodeling potential is less as the fracture is farther away from the physis. In addition, these fractures are often very unstable and difficult to keep aligned even in a long arm cast. They should be monitored weekly with X-rays until callous becomes visible. If alignment cannot be maintained in a long arm cast, they may require internal fixation (Fig. 17.3). Often these fractures take longer to heal than those of the distal radius and can take up to 3–4 months. Galeazzi fractures are rare in children. Closed reduction of the fracture usually leads to reduction of the corresponding joint dislocation. If closed reduction is not successful, then open reduction with internal fixation is indicated. PT is usually not required after treatment as pediatric patients regain motion and strength pretty quickly. Occasionally pediatric patients will get elbow stiffness and require PT and dynamic bracing.

Distal Radius and Ulna Fractures

Classification

Multiple methods have been used to categorize distal radius fractures. Classifications such as the Melone, Fernandez, and Frykman systems have all been proposed. The Melone system (Table 17.2) describes injury patterns of intra-articular distal radius fractures by their mechanism and severity of injury [12]. The Fernandez classification scheme (Table 17.3) recognizes five different patterns of injury based on their mechanism of injury and radiographic fracture pattern produced [13–15]. Lastly, the commonly cited Frykman classification (Table 17.4) describes wrist fractures based on the radiographic appearance of the radius and the presence or absence of an associated distal ulna fracture [14, 15]. This comprehensive classification system includes extra-articular and intra-articular fractures (Fig. 17.4) [15].

In addition to formal classification systems, there are numerous eponyms that have historically been used to describe various fracture patterns. A Smith's fracture describes an extra-articular distal radius fracture with volar displacement of the distal fragment and apex dorsal angulation [13, 14]. Barton fractures (Fig. 17.5) are a related injury where there is extension of the fracture line into the articular surface [13, 14]. In this injury pattern, there is also volar displacement of the distal fracture fragment. The carpus tends to displace volarly along with the fracture fragment and is characteristically an unstable fracture pattern. Chauffer fractures are intra-articular distal radius fractures where the primary fracture fragment is composed of the radial styloid [13, 14]. This term was initially used to describe a unique fracture that occurred in individuals injured while handling a car starter that backfired [14]. Chauffer fractures are also known for their association with concomitant injuries of the scapholunate ligament [2]. Perhaps the most well-known eponym for wrist injuries is the Colles' fracture (Fig. 17.6). The term is classically used to describe an extra-articular distal radius fracture with dorsal tilt or apex volar angulation. Despite the number of eponyms and classification systems that have been described here, many others remain important and are used to define the nature of distal radius and ulna fractures in clinical practice.

Mechanism of Injury

The predominant mechanism of injury that produces a distal radius or ulna fracture is a FOOSH from a standing position. With the wrist often held in an extended position, the distal radius is then forcefully driven into a hyperextended position producing a dorsally displaced fracture with apex volar angulation most frequently [16]. In the older adult, this is sometimes the result of postural instability while ambulating or standing [16]. This low-energy mechanism produces a fracture secondary to underlying osteopenia or osteoporosis. In the adolescent or young adult, distal radius fractures are frequently the result of high-energy injuries such as a motor vehicle accident or in the setting of athletics [13, 16, 17].

Epidemiology

In the United States, annually greater than 640,000 distal radius fractures are diagnosed [14]. A bimodal distribution is

Fig. 17.3 An 11-year-old male who had a FOOSH injury when he fell from the top of a slide (**a**, **b**). After closed reduction, he had good alignment of his fractures (**c**, **d**). However, 1 week later, the reduction was lost (**e**, **f**). He eventually had surgical reduction with fixation

Table 17.2 Melone fracture classification of intra-articular distal radius fractures [12]

	Description of radius fracture
Type I	Stable fracture, no displacement
Type II	"Die punch" fracture, unstable IIA: reducible IIB: irreducible
Type III	"Spike" fracture with radial shaft projecting or spiked into the flexor compartment, unstable
Type IV	"Split" fracture with severe disruption of radial articular surface, unstable, severely comminuted
Type V	Explosion injury due to compression and crush injury leading to severe comminution

Table 17.3 Fernandez fracture classification [13–15]

	Description	Treatment options
Type I	Bending fracture of metaphysis	Cast if fracture is stable, percutaneous pinning or external fixation if unstable
Type II	Shearing fracture that extends to radiocarpal joint	Open reduction or screw fixation
Type III	Compression fracture that extends to radiocarpal joint	Typically require surgery with percutaneous pinning
Type IV	Avulsion fracture that extends to radiocarpal joint with dislocation	Closed or open reduction, may require pin or screw fixation
Type V	Combination of above types	Surgery based on fracture appearance

Table 17.4 Frykman fracture classification [15]

	Radius	Ulna
Frykman I	Extra-articular radius fracture	No ulna fracture
Frykman II	Extra-articular radius fracture	Distal ulna fracture
Frykman III	Intra-articular radius fracture of radiocarpal joint	No ulna fracture
Frykman IV	Intra-articular radius fracture of radiocarpal joint	Distal ulna fracture
Frykman V	Fracture extends to radioulnar joint	No distal ulna fracture
Frykman VI	Fracture extends to radioulnar joint	Distal ulna fracture
Frykman VII	Fracture extends to radiocarpal and radioulnar joint	No distal ulna fracture
Frykman VIII	Fracture extends to radiocarpal and radioulnar joint	Distal ulna fracture

found, with the initial peak in the young male demographic, often secondary to injuries sustained during sports. The average age for those injured during an athletic activity has been reported to be less than 40 years of age, with 72% of distal radius fractures occurring in males [17]. A second peak is seen in the elderly female population and are often considered fragility fractures. Wood et al. reported on a large series of 408 adolescent patients who sustained various upper and lower extremity fractures [18]. In their review, 23.9% of adolescent fractures occurred during a sporting event. Of

Fig. 17.4 Frykman II distal radius fracture

these, 83.6% of injuries were isolated to the upper extremity, with 23% of the total injuries accounted for by distal radius and or ulna fractures [18]. In a similar review of 5953 adult fractures, a 12.8% prevalence of sports-related injuries was found [19]. In this same review, distal radius fractures occurred during a variety of sporting activities including soccer, rugby, skiing, and basketball most frequently [19].

Fig. 17.5 Barton's fracture with volar displacement of the distal fracture fragment

Fig. 17.6 Colles' fracture with dorsal tilt on lateral X-ray

Clinical Presentation

After a distal radius fracture, the patient typically presents with the acute onset of pain following an identifiable traumatic event. Injuries can be produced from a low-energy mechanism such as a fall from a standing position or low height. Alternatively, a high injury mechanism such as a collision during a sporting event or a fall onto an outstretched arm while running at high speed can produce wrist injuries (Fig. 17.7). In patients with marked displacement of a fracture fragment, an obvious extension or flexion deformity may be visible (Fig. 17.8). A comprehensive physical examination including an assessment of the soft tissues for abrasions or lacerations should be undertaken. The soft tissues should be carefully inspected circumferentially to rule out of the possibility of an open fracture, particularly in high-energy injuries. A thorough skin examination is critical as some open injuries including distal ulna fractures may present with only a poke hole with subtle venous bleeding [14]. A vascular examination should be performed to assess the perfusion of the hand including an evaluation of the radial and ulnar pulses as well as capillary refill in the fingers. A neurologic examination should be performed to assess for a sensory or motor deficit in the hand. Compartment syndrome is rare in the setting of a distal radius fracture and can be diagnosed with a detailed physical examination. Acute carpal tunnel syndrome is an uncommon occurrence, but is an important consideration in the clinical evaluation of a patient with a distal radius fracture. The acute onset of paresthesias in the thumb, index, long, and ring finger can alert the clinician to the potential of median nerve compression secondary to fracture displacement or a hematoma [14]. If symptoms are not immediately improved following a bedside reduction, an urgent orthopedic evaluation is warranted. Suspicion for compartment syndrome or median nerve compression is particularly relevant in the evaluation of wrist fractures secondary to a high-energy mechanism.

Imaging

Plain radiography is an essential component in the evaluation of distal radius and ulna fractures. In patients with point tenderness or clinical deformity evident on examination, three views of the affected wrist should be obtained [20]. A quality anterior posterior (AP), oblique, and lateral view all are necessary for the accurate assessment of distal radius fractures. Dedicated imaging of the hand should be considered if point tenderness is present within the hand or fingers. Similarly, proximal imaging is warranted to evaluate the forearm or elbow if clinical concern exists for an associated injury. X-rays are usually the only imaging modality

Fig. 17.7 Mild swelling in the distal dorsum of the radius (**a**, **b**) in a 36-year-old male as a result of an injury (FOOSH) while mountain biking. X-rays reveal intra-articular and non-displaced distal radius fracture (**c**–**e**)

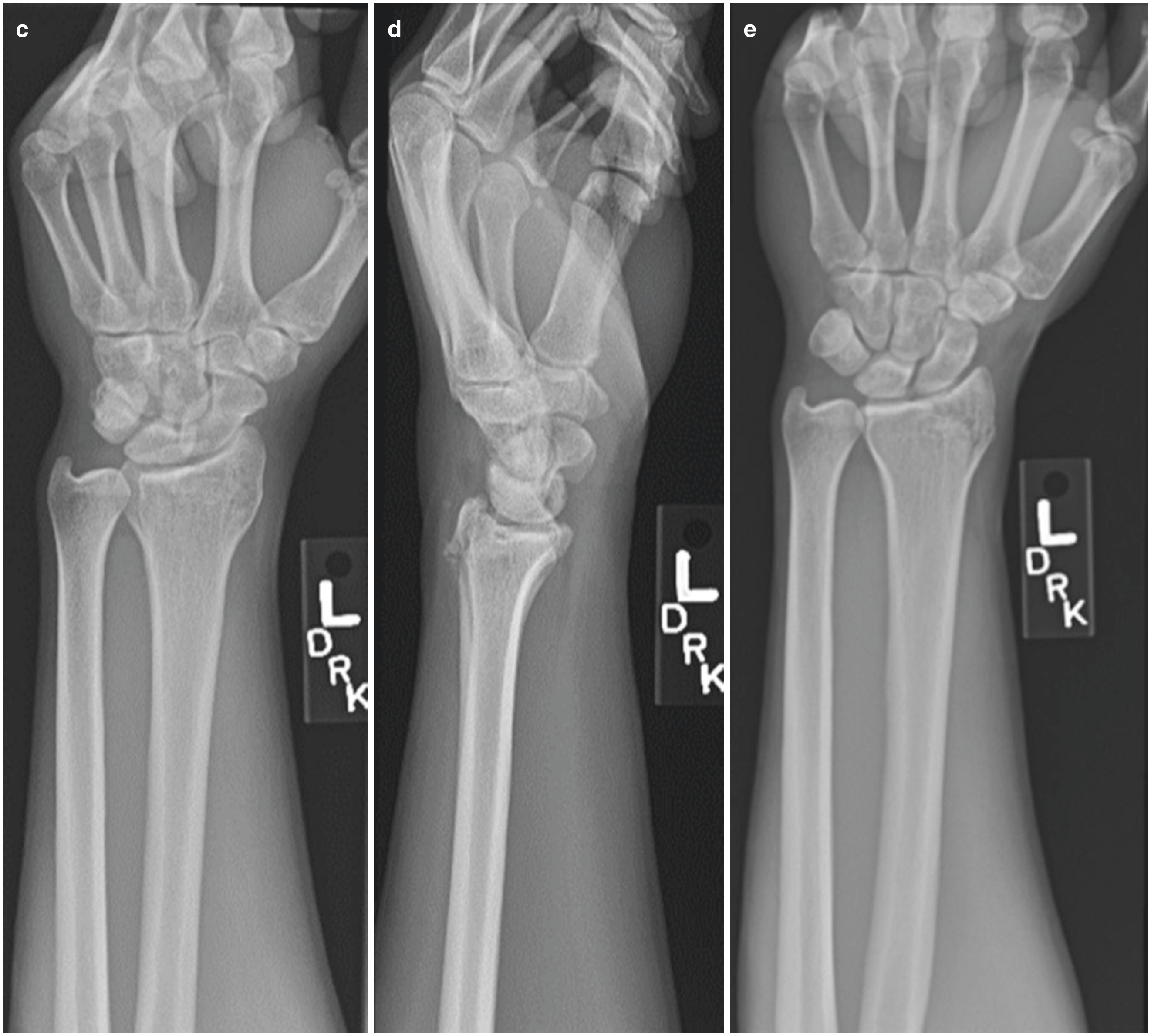

Fig. 17.7 (continued)

necessary for the evaluation of distal radius or ulna fractures. Quality radiographs allow for the evaluation of articular involvement and radiocarpal joint congruity, as well as displacement in both the coronal and sagittal planes (Fig. 17.9).

While distal ulna fractures rarely occur in isolation in the adult patient, distal ulna fractures including ulnar styloid avulsions are commonly associated with distal radius fractures [21]. Ulnar styloid fractures (Fig. 17.10) may represent underlying instability of the distal radioulnar joint or associated triangular fibrocartilage complex injuries [21].

Occasionally, CT is utilized to better define articular involvement; however, this is rarely needed prior to orthopedic referral [13]. MRI can be a useful adjunct in select scenarios, such as the evaluation of suspected scapholunate ligament injuries in radial styloid fractures if clinical concern exists.

The role of ultrasound is evolving in the diagnosis and treatment of distal radius and ulna fractures. The use of portable ultrasound has been reported with a 100% sensitivity and 90–95% specificity for the diagnosis of distal radius fractures [22]. A proposed benefit of ultrasound is the portability of devices outside of the hospital setting, potentially expanding its role to sideline use in the screening of athletes for fractures [22]. An additional utility of ultrasound is its role in assisting with the confirmation of fracture reduction. Lau et al. reported 76–93% sensitivity and 93–94% specificity in the identification of successful closed reduction of distal radius fractures when compared to conventional

Fig. 17.8 A dinner-fork deformity (**a**) in a 29-year-old male as a result of an injury (FOOSH) while skiing. X-rays reveal distal radius fracture with posterior displacement (**b**, **c**). His alignment seems to be acceptable after a closed reduction (**d**, **e**)

Fig. 17.9 AP wrist X-ray with distal radius and ulna fractures

Fig. 17.10 AP X-ray demonstrating a distal radius fracture and associated ulnar styloid fracture

radiography [22]. Comparison of fluoroscopic-assisted reduction and ultrasound-assisted closed reduction of distal radius fractures has demonstrated no difference in radiographic outcomes including restoration of volar tilt, radial height, and radial shortening [23].

Initial Management

In the setting of an athletic event, suspected distal radius and ulna fractures can be initially treated with splint application with the forearm and wrist in a neutral position. Obvious deformities can be reduced with gentle traction to restore overall limb alignment. A sugar-tong splint with the elbow in 90° of flexion can be applied. Alternatively, a dorsal and ulnar volar slab splint can be applied (Fig. 17.11).

Prior to splint application, a comprehensive clinical evaluation including an assessment for open fractures and neurovascular injury should be performed. Athletes with suspected wrist fractures should be removed from play until radiographs and a formal clinical examination are completed. After initial splinting or sling application, patients can be evaluated in the emergency room or clinic setting depending on the initial severity of their injury.

In the clinic or emergency room setting, orthogonal radiographs out of splint material should be obtained. If an open fracture is suspected, intravenous antibiotics and indicated tetanus prophylaxis should be promptly administered. Pediatric or adolescent patients with closed fractures should undergo attempted closed reduction maneuvers. In the hospital or urgent care setting, this can be performed after the administration of a hematoma block or light sedation if available. Traction is often needed prior to an attempt for reduction (Fig. 17.12). Immobilization with a fiberglass splint or in some cases with a cast should be applied. If a fiberglass cast is applied in the acute setting, the cast should be valved to accommodate soft tissue swelling. In the adult population,

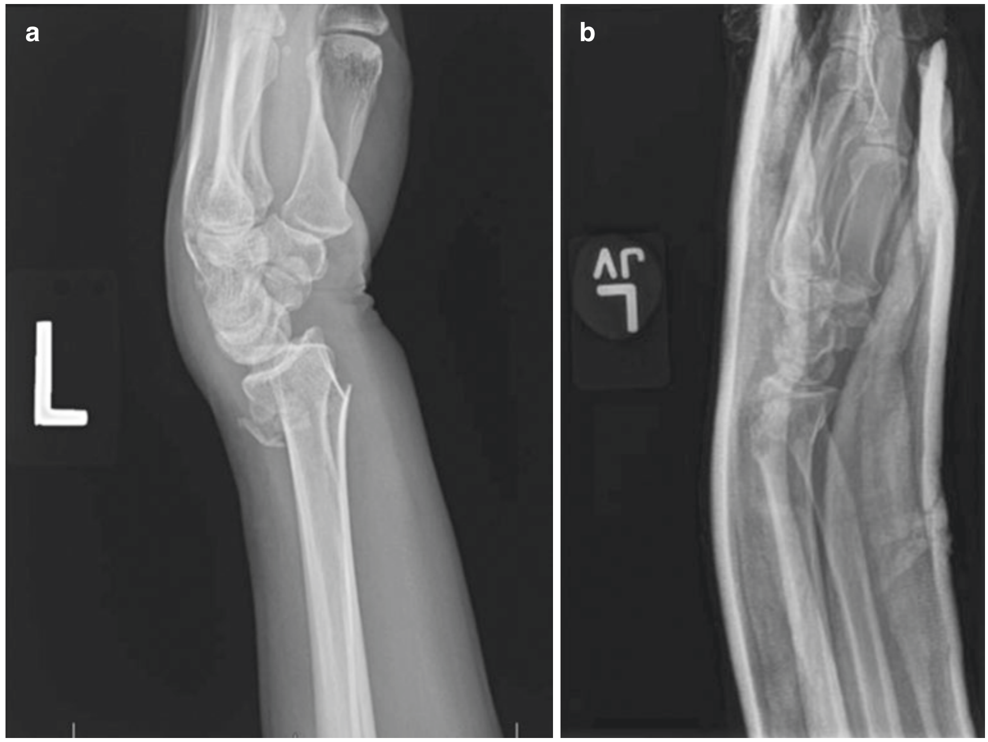

Fig. 17.11 Dorsally displaced distal radius fracture before (**a**) and after (**b**) closed reduction and splint application

initial immobilization is typically accomplished using splints after a closed reduction is performed.

Indications for Urgent and Nonurgent Orthopedic Referral

Non-displaced fractures without articular extension can often be treated nonsurgically with cast immobilization [20]. Although protocols vary, many clinicians treat distal radius fractures amenable to nonoperative treatment with a total of 6 weeks of cast or splint immobilization [20]. Fractures that demonstrate displacement at the time of injury and undergo closed reduction maneuvers are at risk for subsequent displacement with closed treatment. Early orthopedic evaluation within 1 week of injury may be essential to identify patients that would benefit from operative treatment. Certain non-displaced fracture patterns including radial styloid fractures are at particularly high risk of subsequent loss of reduction. Additionally, because of their association with scapholunate interosseous ligament injuries, consideration should be given to early referral of radial styloid fractures. Numerous risk factors have been reported to aid in identifying patients at higher risk for loss of radiographic reduction. These include the initial degree of fracture displacement, the presence of dorsal comminution, and increasing age [13, 14, 20, 24]. Consideration should be given to the presence of these factors when determining if an early orthopedic referral is warranted. Multiple prospective studies have demonstrated improved outcomes with surgical treatment of fractures in non-elderly patients who do not have acceptable radiographic outcomes after a closed reduction attempt [25]. Surgical treatment may be warranted if there is greater than 3 mm of loss of radial height, greater than 2 mm of articular incongruity (Fig. 17.13), or greater than 10° of dorsal tilt on lateral imaging following closed reduction [25]. These patients should be promptly referred for orthopedic evaluation. The evidence for this recommendation is "moderate" based on AAOS guidelines, indicating the benefits exceed the potential risks, but the strength of the supporting evidence is weak [25].

Occasionally an urgent orthopedic consultation is warranted for immediate evaluation. The suspected presence of an open fracture, compartment syndrome, or acute carpal tunnel syndrome is an indication for immediate evaluation by an orthopedic surgeon in the emergency department setting. Additionally, significant fracture displacement with skin tenting and impending soft tissue compromise may warrant urgent orthopedic evaluation if a satisfactory closed reduction cannot be performed.

Follow-Up Care

Patients with distal radius fractures that are amenable to nonsurgical treatment should be followed with weekly X-rays for the first 3 weeks following an injury; however, this evidence is based solely on expert opinion [13, 16, 25]. If a closed

Fig. 17.12 Traction with finger traps and 5–10 kg of weight is often required before close reduction of a displaced distal radius fracture

reduction was initially required, follow-up imaging can be obtained without removal of a splint or cast in order to help prevent loss of reduction. If quality images cannot be obtained through the splint or cast material, it should be removed and X-rays should be repeated. Imaging should be critically assessed to ensure there is no loss of reduction while immobilized. In patients where a gradual or complete loss of reduction is noted, prompt orthopedic referral should be considered to evaluate whether surgical reduction and fixation are warranted. In those initially treated with sugar-tong splint placement, a transition into a short arm cast at 2–3 weeks can be made after swelling has improved. A short arm cast with the wrist in neutral or slight extension should be applied up to the metacarpophalangeal joints. The fingers and thumb should remain free and early finger motion should be encouraged to

Fig. 17.13 AP X-ray of an intra-articular distal radius fracture with articular incongruity

prevent stiffness [14]. A total of 6 weeks of immobilization is commonly recommended (Table 17.1) [16]. Following the completion of immobilization, an examination should be performed to clinically assess for fracture healing by ensuring that tenderness over the fracture has resolved. When the fracture is clinically healed, immobilization is discontinued and the patient is transitioned into a removable brace. Brace wear is discontinued as tolerated by the patient and activity is slowly increased. Those that do not quickly recover wrist and finger motion or strength may be referred for occupational hand therapy to aid in their progress.

Return to Sports

Following nonsurgical treatment of a distal radius fracture, patients are typically advised to avoid contact sports for a minimum of 8–12 weeks after their injury [16]. Patients should demonstrate restoration of near-normal wrist motion and strength, as well as clinical and radiographic evidence of fracture healing prior to return to sports. The specific time to return to sports is dependent on the initial nature of the injury and the sport in which the athlete participates. In contact sports such as football, consideration should be given to delayed return to sport or the transient use of protective braces. A period of 8–9 weeks after initial injury has been reported as an average time period for return to play of athletes following distal radius fractures [26].

Complications

Distal radius fractures treated nonsurgically typically heal, and nonunion of closed distal radius fractures is uncommon [14]. In fractures where loss of reduction is unrecognized or remains untreated, malunion can occur [14, 20]. Fracture malunion most commonly results in a loss of normal volar tilt in the sagittal plane, which clinically can result in the loss of normal wrist flexion. Additionally, radius fractures that heal in a shortened position can develop ulnar positive variance, where the ulna becomes long relative to the radius at the level of the wrist. This may lead to ulnocarpal impingement over time and warrants evaluation in individuals with ulnar-sided wrist pain with a history of a distal radius fracture [16]. If symptomatic malunion occurs, an orthopedic referral may be warranted for consideration of a corrective osteotomy. Articular incongruity may predispose the patient to developing post-traumatic radiocarpal arthrosis. Additionally, long-term adaptive changes can occur in the midcarpal joint as a result of a distal radius malunion.

Transient stiffness is a common complication of both surgical and nonoperative treatment of distal radius fractures. This can be addressed during the treatment period by encouraging early finger motion. After discontinuation of immobilization, individuals may benefit from formal therapy sessions if wrist or finger stiffness is a concern. Tendon rupture is a rare complication, but has been described after nonsurgical treatment of distal radius fractures. Immediate or delayed rupture of the extensor pollicis longus tendon can be seen after a non-displaced distal radius fracture and warrants orthopedic referral for evaluation and treatment [13]. This is addressed most often with an extensor indicis proprius transfer for reconstruction. Ruptures of additional flexor and extensor tendons have been described, but typically occur as the iatrogenic sequela of surgical treatment with plate fixation [14].

Pediatric Considerations

Children are more likely to fracture bones than adults because of their softer bone and the presence of growth plates. Forearm fractures are one of the most common fractures in pediatrics. Fracture patterns in children are different than those in adults. Buckle (torus), greenstick, and physeal fractures are unique to children and are often subtle. Providers must be aware of these patterns and look for them on x-ray.

A buckle fracture (Fig. 17.14) is a compression fracture of one cortex (usually dorsal) at the junction of the metaphyseal and diaphyseal bone. These are very common and heal quickly. A greenstick fracture is a combination of a buckle fracture on one cortex and a break through the opposite cortex (usually volar). This creates a hinge of periosteum that is still intact and stabilizes the fracture (Fig. 17.15). A physeal fracture is a fracture through the physis at the end of the long bone. There are several patterns of physeal fracture that can involve the physis alone or with part of the metaphysis, epiphysis, or both (please refer to the Salter-Harris classification system). Physeal fractures are of particular concern as they can lead to problems of growth with early physeal closure or bridging.

As in adults, a FOOSH is the most common mechanism for sustaining a distal radius or ulna fracture. A child will complain of pain at the distal forearm and will limit use of the arm. Swelling and bruising may not be present. They may have limited supination or flexion and will be tender to palpation on the distal radius and/or ulna. Navicular or scaphoid fractures can happen in children but are less common than adults (see Chap. 18 – Carpus). They should still be considered in the physical examination and appropriate imaging ordered.

As with adults, any child with obvious wrist deformity should be reduced closed and splinted or casted (Fig. 17.16). If closed reduction is not successful or the reduction is lost, open reduction with internal fixation is indicated. In general, it is less common to require open reduction in children because some angulation of the distal radius is acceptable because of the process of remodeling. As the bone lengthens with growth, it straightens itself out. This is more effective with younger age, close proximity to the physis, and angulation in the flexion/extension plane. Angulation of the distal radius up to 25° in children less than ten years old is considered acceptable, whereas angulation over 10° in children over 10 years old is unlikely to correct. Displacement is tolerated much better than angulation. Bayonet apposition

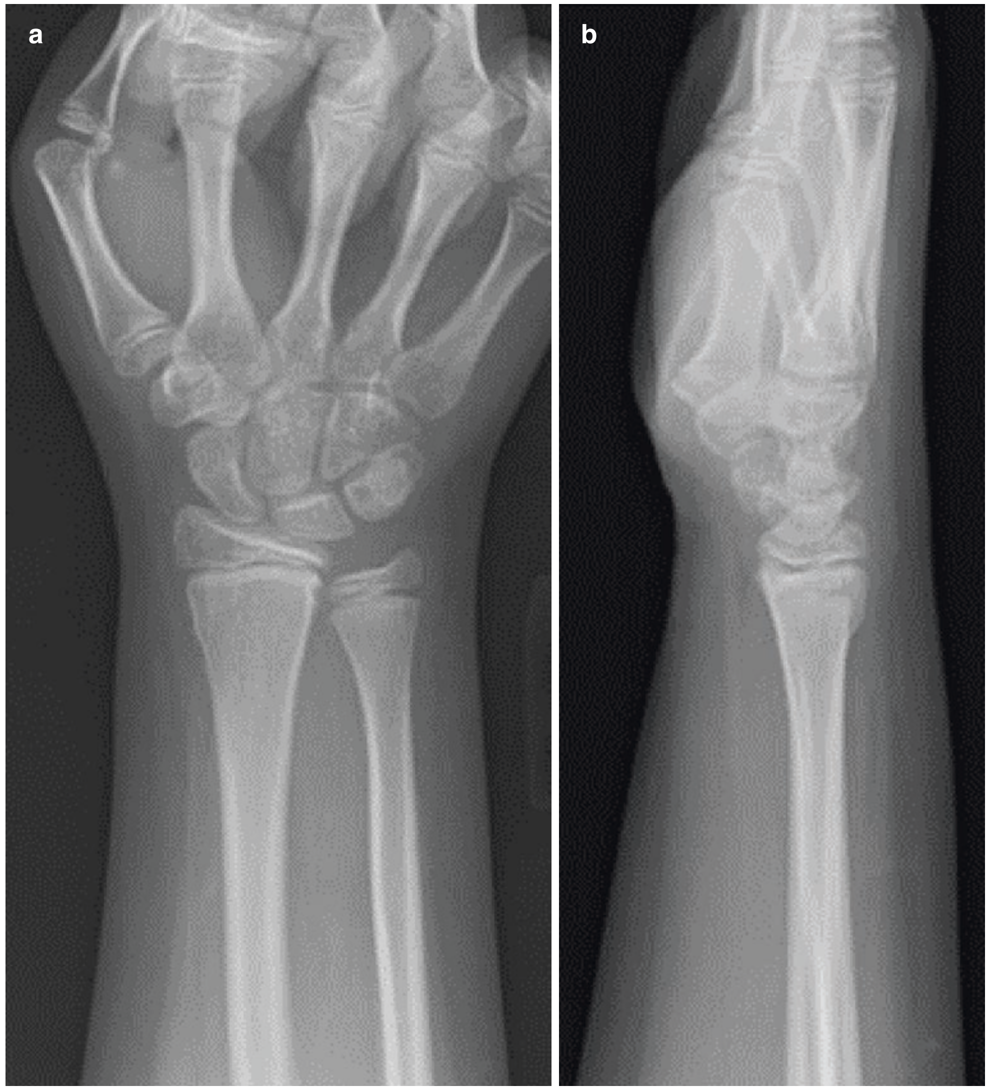

Fig. 17.14 Buckle fracture of the distal radius (**a**, **b**) in a 9-year-old female who tripped and had a FOOSH

(100% displacement with no angulation) is well tolerated and does not require surgery. All deformed distal radius fractures should be evaluated for compartment syndrome and posterior interosseous nerve injury. Distal forearm fractures that are not reduced usually heal in 4–6 weeks, while reduced fractures often take an additional 2 weeks to heal. Traditionally these reduced fractures have been treated in a long arm cast to limit supination and pronation, but there is some evidence that they can be managed successfully in a short arm cast. There is high-level evidence to demonstrate that buckle fractures of the distal radius can be treated successfully in a volar wrist splint for 3–4 weeks instead of a short arm cast. Physeal fractures should be treated in a short arm cast and then followed serially with X-rays for a year to monitor for physeal closure and positive ulnar variance.

Radiocarpal and Ulnocarpal Joint Dislocations

Mechanism of Injury

Radiocarpal and ulnocarpal dislocations occur when compressive, rotational, and shearing forces cause the carpus to dislocate in relation to the distal radius and ulna. These injuries are uncommon and are often due to high-energy injuries such as falls from a height or motor vehicle accidents [27]. In sports, these are more likely to occur in pole vault and motocross events (Fig. 17.17). Radioulnar joint dislocations often occur in a Galeazzi fracture as described above. They typically occur in a FOOSH with a hyperpronated forearm [5].

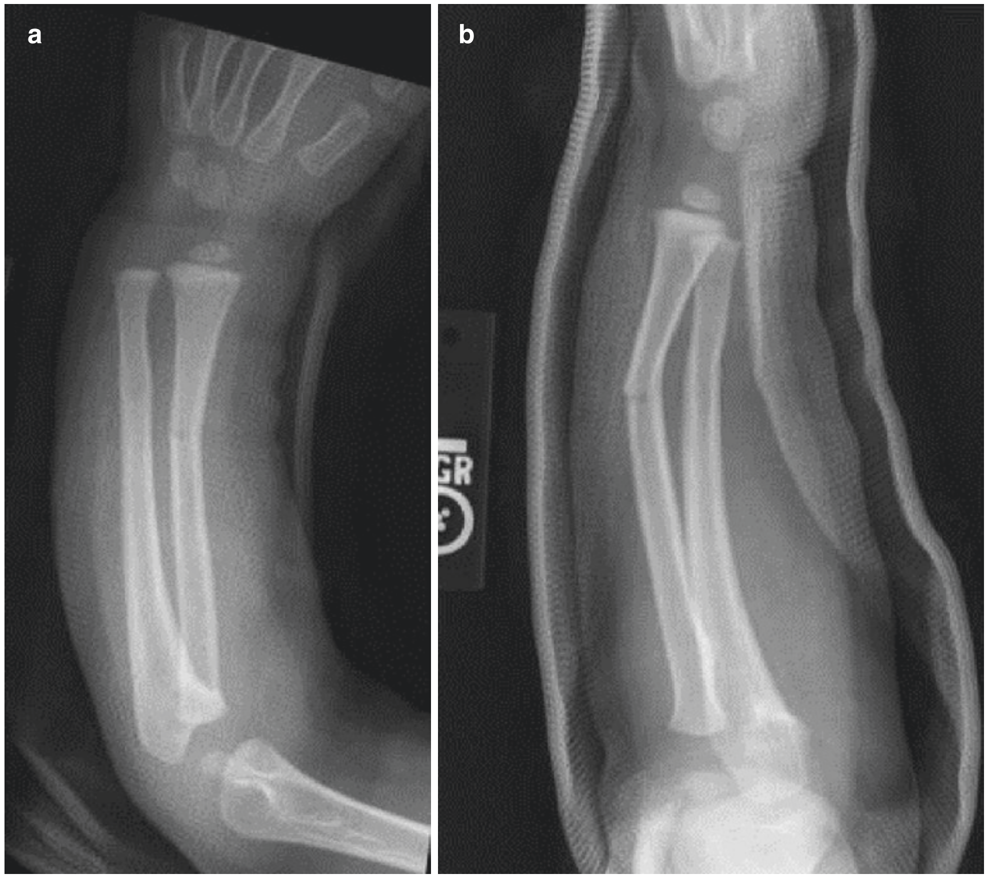

Fig. 17.15 Greenstick fracture of the radius and buckle fracture of the ulna (**a**, **b**) in a 2-year-old male who fell while playing

Epidemiology

Radiocarpal and ulnocarpal dislocations more commonly occur in men age 20–40 years old. They are very rare and account for 0.2% of all dislocations and 0.2% of all wrist injuries [27, 28].

Fracture Classification

There are two types of classification systems for radiocarpal dislocations. The Moneim classification is based on the presence or absence of injury to the intercarpal articulations. In type 1, the carpus dislocates as a unit from distal radius in a dorsal or volar direction. In addition, there may be an associated radial styloid fracture, but the intercarpal anatomy is intact. Type 2 is more complex and has an associated intercarpal fracture with ligamentous injuries [27, 28]. The second classification system is described by Dumontier and involves two groups [28]. Group 1 is a purely ligamentous dislocation with no radial fracture or only a small cortical avulsion fracture of the radius. Group 2 dislocations include a radial styloid fracture that involves at least one-third of the scaphoid fossa of the radius. Radioulnar dislocations are classified by the position of the distal radius: type 1 is dorsal displacement and type 2 is volar displacement [5].

Clinical Presentation

Patients with a radiocarpal dislocation typically present with pain, swelling, and a deformed appearing wrist. Dorsal dislocations are more common, but volar dislocations are more severe [29]. Because of the high-energy mechanism that typically causes the dislocation, patients often have open wounds and other injuries [28]. Patients may also have neurologic deficits, typically involving the median nerve, though occasionally the ulnar nerve is also injured [28]. They may also have vascular insufficiency due to arterial occlusion. The vascular insufficiency should be corrected by reduction as quickly as possible. Patients with a radioulnar dislocation almost always have a diaphyseal forearm fracture. Thus, closed attention should be paid to the DRUJ in any patient with a forearm fracture [5].

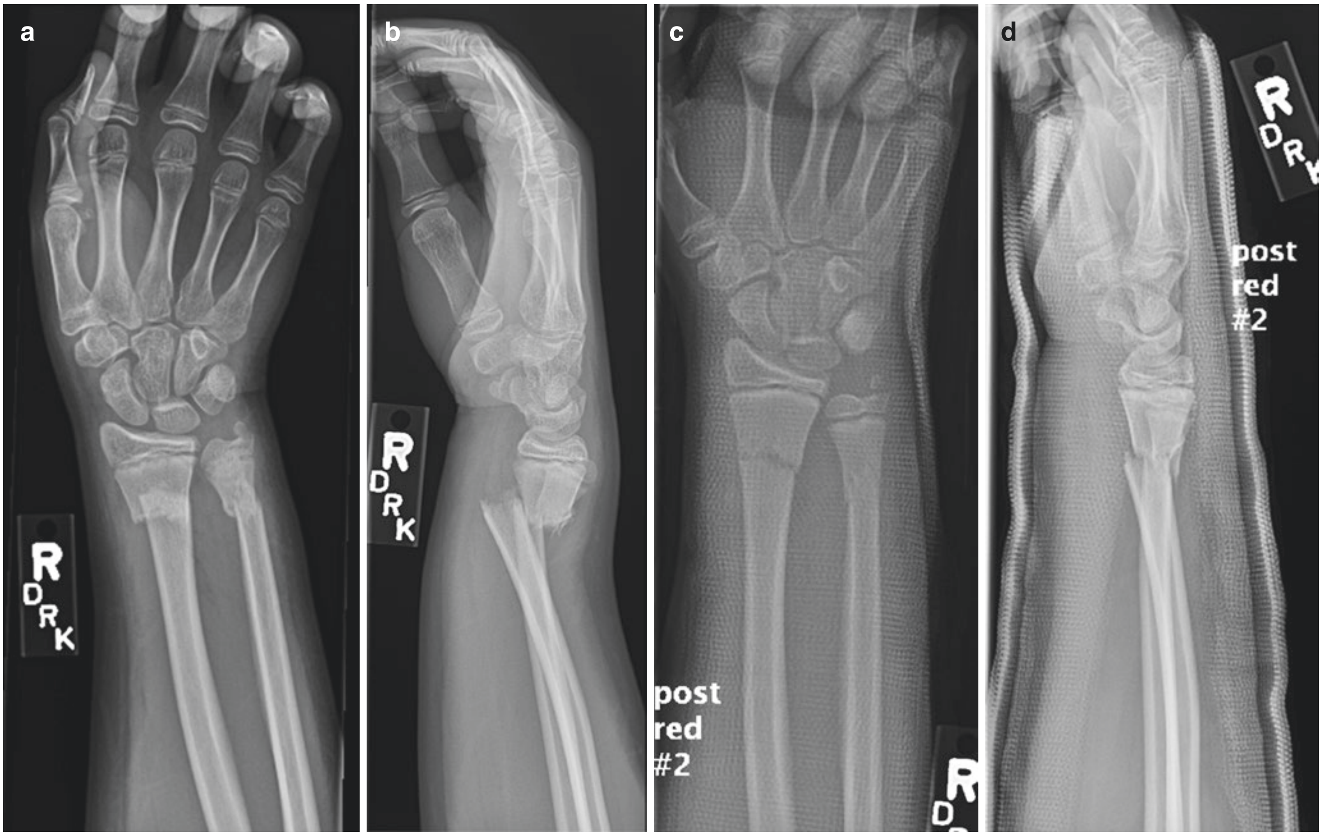

Fig. 17.16 A 13-year-old male who sustained a FOOSH injury while skiing (**a**, **b**). After closed reduction, he has improved alignment (**c**, **d**)

Imaging

Standard wrist X-rays including posteroanterior, lateral, and oblique views should be obtained in a suspected radiocarpal dislocation. The position of the lunate in relation to the radius on the lateral view determines the direction of dislocation [28]. Occasionally, stress radiographs are obtained to evaluate for stability; however, this is not routinely performed. Comparison views of the unaffected wrist can be useful in determining if the fractured arm has DRUJ disruption. A 2 mm widening of the DRUJ can suggest disruption of the joint [30]. CT typically is used for preoperative planning and can aid in evaluation of subtle fractures [28]. In addition, an MRI may be obtained to evaluate for ligamentous injuries, specifically the scapholunate and lunotriquetral ligaments [27, 29].

Initial Management

On the sideline, closed reduction may be attempted for radiocarpal or ulnocarpal dislocations if the medical facility is far, especially if there is neurovascular compromise. Reduction is performed by applying longitudinal traction to the wrist [28]. Because of the high-energy mechanism required to cause radiocarpal and ulnocarpal dislocations, patients typically have severe associated injuries that require a full evaluation in the emergency department (see Chap. 8 – Fracture Types and Definitions). Once the patient is stable and life-threatening injuries are addressed, closer evaluation of the stability of the wrist can be evaluated. If the bony alignment is normal and the wrist appears stable, a short arm cast can be placed for 6 weeks [29]. Patients with a radioulnar dislocation and Galeazzi fracture should be placed in a sugar-tong splint initially. They will typically need to be referred to orthopedics [5]; however, pediatric patients may be able to be treated without surgery.

Indications for Urgent and Nonurgent Orthopedic Referral

Although some patients have been treated with closed reduction and casting, there is a high risk for instability long term [28]. Therefore, both radiocarpal and ulnocarpal dislocations almost always require surgical fixation to restore wrist stability [27]. Specifically, patients with irreducible dislocations, an accompanying fracture, neurovascular involvement, or open injuries should be referred urgently to orthopedics [27].

Fig. 17.17 A 59-year-old male injured while mountain biking (FOOSH) and suffered an open ulnocarpal dislocation with distal radius fracture (**a**–**d**). After reduction (**e**–**g**), patient was urgently referred for a surgical fixation

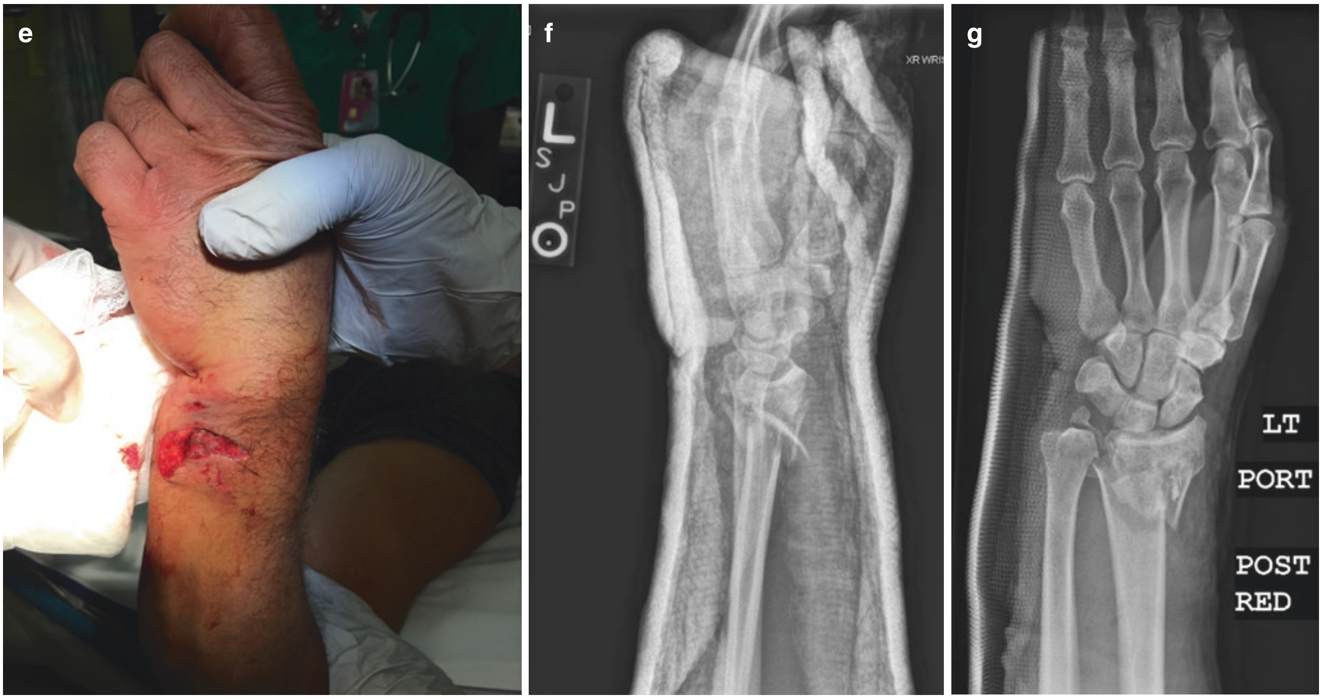

Fig. 17.17 (continued)

Follow-Up Care

If the patient is treated with nonoperative care, the patient should be placed in a short arm cast for 6 weeks. If the wrist is unstable after 6 weeks of immobilization, then the patient should be referred to orthopedics for surgical consultation. For patients who undergo surgery, follow-up depends on the type of surgery performed and the associated injuries.

Return to Sports

Full return to wrist function after radiocarpal and ulnocarpal dislocations typically takes 6 months. Because these injuries are so uncommon, there is very little evidence on return to sports. It should be noted that range of motion is often somewhat limited after radiocarpal dislocation, so aggressive PT is necessary to progress athletes back to sports.

Complications

For those patients who undergo conservative management, they still may have instability and radiocarpal collapse long term. If this occurs, surgical fixation is typically necessary. After radiocarpal dislocation, patients typically have a 30–40% decrease in the total of arc wrist flexion and extension [28]. This loss of wrist motion may occur due to prolonged immobilization and due to tightening of the intercarpal ligaments. This loss of motion is more common with open dislocations and those with nerve damage [27]. Arthritis may also develop over time and may require wrist fusion [27]. In three small case series, 11–66% of patients developed radiocarpal arthritis after radiocarpal dislocation [28]. Patients with open dislocation, complete radiocarpal ligamentous injuries, or nerve or intercarpal ligamentous injuries typically have worse outcomes [28]. If a DRUJ dislocation is not treated, patients may have chronic pain, weakness, and poor range of motion [5]. In addition, muscle-tendon entrapment can occur with more significant injuries [5].

Pediatric Considerations

It is unusual for children to have an isolated radiocarpal or ulnocarpal dislocation. It is much more common to break both the radius and the ulna or break one of the bones and dislocate the other. These patterns can be subtle and require a high index of suspicion. Galeazzi fracture with radioulnar dislocations can occur in children and can often be treated with conservative management, unlike in adults [5].

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