Distal Radius Fractures

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Abstract

Distal radius fractures are the most common fractures in the pediatric population, with an incidence of 21–31 % of fractures. They commonly occur as a result of a traumatic fall, more commonly in males than females, and their prevalence is on the rise. The pediatric wrist fracture has excellent remodeling potential, as the distal radius physis contributes approximately 80 % of the longitudinal growth of the forearm. The remodeling potential is especially great in the younger patient with more than 2 years of growth remaining.

Clinical examination and radiographic evaluation of the affected limb will reveal the fracture in question. Distal radius fractures are commonly associated with ulnar fractures, either at the same level or at the ulnar styloid. One must assess the joints above and below to rule out a concomitant injury. The soft tissues may reveal signs of an open fracture, compartment syndrome, or vascular compromise. Growth arrest with displaced physeal injuries of the distal radius occurs in 4–5 % of cases, while an ulnar physeal injury can be present in up to 50 % of fractures involving the distal ulnar physis. It is imperative not to miss associated dislocations, including Galeazzi or Monteggia fracture dislocations.

Treatment options include nonoperative immobilization, closed reduction and percutaneous pinning, and open reduction internal fixation. Most non-displaced fractures, Salter-Harris I and II, greenstick, buckle, complete or plastically deformed fractures, are amenable to first-line nonoperative treatment. Surgical treatment is reserved for open fractures, irreducible fractures, fractures with associated neurovascular compromise, presence of excessive swelling, displaced intra-articular fractures, concomitant elbow fractures, polytrauma, fractures that had loss of their initial reduction, and displaced fractures in children nearing skeletal maturity.

Introduction to Fractures of the Distal Radius

The distal radius is the most common site of fracture in childhood, comprising approximately 21–31 % of all pediatric fractures (Nellans et al. 2012; Randsborg et al. 2013; Ward and Rihn 2006). The majority of distal radius fractures in children occur as a result of falls, either during sports activities or play, with boys sustaining fractures twice as often as girls (Ryan et al. 2010). The incidence peaks around the ages of 8–11 years in girls and 11–14 years in boys (Khosla et al. 2003), coinciding with a dissociation between skeletal expansion and skeletal mineralization that results in a period of relative bone weakness (Faulkner et al. 2006). Lower bone mineral density in children and later menarche in girls has been shown to correlate with an increased fracture risk (Chevalley et al. 2011, 2012).

The incidence of distal radius fractures has increased over the past 40 years (Khosla et al. 2003; de Putter et al. 2011). This rise may be attributable to an increase in sports activities or better access to care and detection (de Putter et al. 2011; Mathison and Agrawal 2010). The rising prevalence of childhood obesity may also contribute, as high adiposity is associated with increased fracture risk (Goulding et al. 2001; Ducher et al. 2009). Studies have found no difference in fracture rates between urban and rural areas or different ethnicities (Nellans et al. 2012; Khosla et al. 2003).

Most pediatric distal radius fractures are treated with closed reduction and immobilization and have an excellent outcome. This chapter discusses nonoperative and operative management of various fracture patterns as well as potential complications.

Pathoanatomy and Applied Anatomy Relating to Fractures of the Distal Radius

Understanding of the functional anatomy and normal growth patterns of the forearm may assist in the diagnosis and treatment of distal radius fractures. While the ulna is a nearly straight bone, the radial shaft has a lateral bow. During pronation and supination, this bow allows the radius to rotate around the relatively stationary ulna. The radial (sigmoid) notch of the proximal ulna and the ulnar (sigmoid) notch of the distal radius facilitate this rotation, stabilized proximally by the annular ligament and distally by the triangular fibrocartilage complex (TFCC). The diaphyses are additionally stabilized by the interosseous membrane, of which the majority of fibers are oriented obliquely such that they travel distally from the radius to the ulna and tighten during pronation. This ligamentous complex normally allows for up to 155–165° of forearm rotation: 75–80° of pronation achieved by the pronator teres and pronator quadratus and 80–85° of supination achieved by the biceps and supinator. The biceps and supinator insert on the proximal radius; the pronator teres inserts near the midshaft of the radius; and the pronator quadratus inserts on the distal third of the radius. Accordingly, in complete distal radius fractures, the proximal fragment is held in neutral position or supination, and the distal fragment is typically pulled into pronation by the unopposed action of the pronator quadratus (Noonan and Price 1998).

In addition to the distal radioulnar joint (DRUJ), the articular surface of the distal radius is formed by two concavities, the scaphoid and lunate fossae, separated by the scapholunate ridge. The radiocarpal and ulnocarpal joints are stabilized by the extrinsic ligaments of the wrist, of which the volar ligaments are stronger than the dorsal ligaments (Waters and Bae 2010). The primary volar stabilizers of the radiocarpal joint are the radioscaphocapitate (radial collateral) and the long and short radiolunate ligaments; the radiolunotriquetral (dorsal radiocarpal) ligament is the main dorsal stabilizer. The ulnocarpal joint is stabilized volarly by the ulnocapitate, ulnolunate, and ulnotriquetral ligaments, which originate from the TFCC. Additionally, the extensor carpi ulnaris (ECU) tendon sheath provides ulnar collateral support. The ligaments of the wrist normally permit 80° of flexion, 75° of extension, 15–25° of radial deviation, and 30–45° of ulnar deviation (Thompson 2010).

Ulnocarpal joint axial loads are transmitted across the triangular fibrocartilage complex (TFCC), which also stabilizes the DRUJ. The TFCC originates at the ulnar notch of the radius and inserts at the base of the ulnar styloid. It includes the avascular central triangular fibrocartilage disc and its bordering dorsal and volar radioulnar ligaments, as well as the ECU tendon sheath and the meniscal homologue, which originates at the dorsal radius, arcs to the ulnar styloid, and inserts on the volar triquetrum. The dorsal and volar radioulnar ligaments tighten in pronation and supination, respectively. Some also consider the ulnolunate and ulnotriquetral ligaments to be part of the TFCC (Bae and Waters 2006).

Familiarity with epiphyseal ossification patterns may enable detection of subtle physeal injuries and recognition of normal development. The distal radial epiphysis is normally sufficiently ossified to be seen on plain radiographs between the ages of 5–21 months in girls and 6–27 months in boys. Rarely, a separate radial styloid ossification center is present. The epiphysis progresses from a transverse appearance to a triangular morphology as the styloid lengthens. At skeletal maturity, there is an average of 22° of radial inclination, which is the angle on a posteroanterior radiograph between the distal articular surface of the radius and a line perpendicular to the radial shaft. Also, throughout growth there is typically 11° of palmar tilt, the angle measured on a lateral radiograph between the distal radial articular surface and the line perpendicular to the radial shaft (Fig. 1) (Waters and Bae 2010). The distal ulnar epiphysis is apparent at approximately age 6–7 years; two distinct secondary ossification centers are often observed. The ulnar styloid projects from the posteromedial aspect of the epiphysis. It is seen during the adolescent growth spurt and elongates until physeal closure (Bae and Waters 2006).

The developmental variation in epiphyseal morphology precludes accurate direct radiographic measurement of the distal radioulnar length relationship, termed the ulnar variance, maintenance of which is important for force transmission across the wrist. The radiocarpal joint and ulnocarpal joint bear approximately 80 % and 20 %, respectively, of the axial load in a normal wrist, and changes in ulnar variance alter this load-bearing pattern (Waters and Bae 2010). It is known that even small changes in ulnar variance can cause alterations in TFCC axial loads of significant magnitude (Bae and Waters 2006). In skeletally mature patients, the articular surfaces of the radius and ulna at the distal radioulnar joint

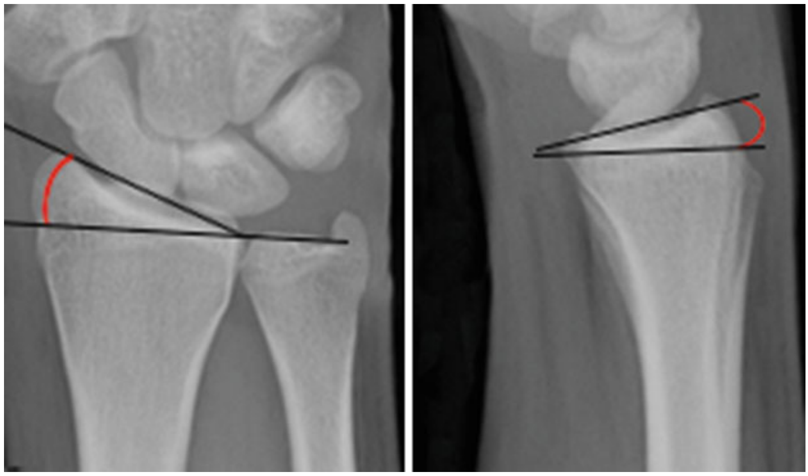


Fig. 1 (**a**) PA radiograph measuring radial inclination and (**b**) Lateral radiograph measuring palmar tilt

are compared on a posteroanterior (PA) radiograph. By convention, if the ulna projects distal to the radius, there is positive ulnar variance; if the radius projects distally, there is negative ulnar variance; and if the two extend equally, there is neutral ulnar variance. In skeletally immature patients, the radial and ulnar metaphyses are compared rather than the articular surfaces (Hafner et al. 1989). This indirect method reduces inaccuracies related to epiphyseal morphology.

Remodeling potential after fracture is directly related to the remaining growth potential. Growth at the distal radial and ulnar physes constitutes approximately 75–80 % of longitudinal growth of the forearm. Ulnar physeal closure occurs on average at age 16 years in girls and 17 years in boys. Radial physeal closure typically follows 6 months later (Waters and Bae 2010). Thus, childhood distal forearm fractures have excellent remodeling potential. This potential is enhanced by elevation of the periosteum, which is thicker and more osteogenic in children than it is in adults (Noonan and Price 1998). Moreover, deformities in the plane of adjacent joint motion have better remodeling compared to other deformities. With continued growth, as much as 10° per year of dorsal-volar angulation may remodel. Hence, 20° of dorsal-volar angulation in patients with at least 2 years of remaining growth has been the traditional standard of acceptable reduction (Bae and Waters 2006).

Assessment of Fractures of the Distal Radius

Signs and Symptoms of Fractures of the Distal Radius

Patients typically present after a fall onto an outstretched hand with wrist pain, tenderness over the fracture site, swelling, and limited motion of the forearm and wrist. Deformity may be present and indicates displacement, angulation, or dislocation. In one series, a 20 % or more decrease in grip strength compared to the uninjured side was predictive of fracture (Pershad et al. 2000). Examination should be performed not only of the wrist but also of the entire upper extremity to detect any associated injuries, and the affected and contralateral extremities should be compared. The skin and soft tissues should be inspected and palpated to assess for the possibility of an open fracture, compartment syndrome, or vascular compromise. Careful neurologic examination should be performed to identify median, ulnar, or posterior interosseous neuropathies, which if present usually resolve within 2–3 weeks. In patients under the age of 3 years, the possibility of non-accidental injury must be considered (Noonan and Price 1998; Waters and Bae 2010; Bae and Waters 2006).

Fractures of the Distal Radius Imaging and Other Diagnostic Studies

Posteroanterior (PA) and lateral radiographs of the forearm should be obtained in cases of a suspected distal forearm or wrist fracture. The upper extremity should be positioned such that the radiograph will be obtained perpendicular to the distal humerus. Comparison films of the contralateral forearm may assist to distinguish subtle physeal injuries; these should be acquired with the forearm in the same rotational position. Dedicated views of the wrist and elbow are helpful to assess for associated injuries such as dislocations of the proximal or distal radioulnar joints. The optimal lateral view of the distal radius is achieved on wrist imaging by aiming the x-ray beam 15° proximally, following the palmar tilt of the distal radius. To measure ulnar variance, PA views of the wrist should be obtained with the shoulder abducted 90°, the elbow flexed 90°, and the forearm pronated.

Knowledge of anatomic landmarks may aid in the interpretation of forearm radiographs. The radial head and the capitellum normally align on all views. The radial tuberosity is normally opposite the radial styloid; thus, it faces toward the ulna in supination, faces away from the ulna in pronation, and is obscured by the radial shaft in the neutral position. The coronoid process and ulnar styloid can be used to evaluate ulnar rotation.

Distal radius fractures are among the more common fractures that pediatric emergency medicine physicians fail to detect while reviewing plain radiographs (Mounts et al. 2011); however, plain radiographs interpreted by radiologists have been shown to be as sensitive for distal radius fractures as computed tomography (Welling et al. 2008). Although they are not routinely utilized for this purpose, computed tomography and magnetic resonance imaging (MRI) may assist in the detection of injuries associated with distal radius fractures (Zimmermann et al. 2007).

Injuries Associated with Fractures of the Distal Radius

Although distal radius fractures typically present as isolated injuries, the presence of associated injuries should be determined. Bilateral distal radius fractures are rare, and while their occurrence in skeletally mature patients is usually due to a high-energy mechanism of injury, in skeletally immature patients the mechanism and fracture patterns are typically the same as those for unilateral fractures (Ehsan and Stevanovic 2010). A distal radius fracture associated with a distal radial-ulnar joint (DRUJ) dislocation is termed a Galeazzi fracture dislocation. More commonly children have an associated ulnar physeal fracture, known as a pediatric Galeazzi equivalent. Fracture of the ulna associated with dislocation of the radial head, termed a Monteggia fracture dislocation, rarely presents concomitantly with a distal radius fracture (Sen et al. 2011). The combination of Monteggia and Galeazzi fracture dislocations in the same child's arm has also been described (Maeda et al. 2003). Monteggia and Galeazzi injuries are discussed in separate chapters in this book.

An ulnar styloid fracture commonly presents in association with a distal radius fracture, although the true incidence is difficult to determine due to the variable ossification pattern of the ulnar styloid. Traditionally, this injury has not been treated, and nonunion, which occurs in approximately 80 % of untreated cases, is usually asymptomatic. However, nonunion has been associated with painful TFCC tears and DRUJ instability. Thus, some advocate reduction of displaced ulnar styloid fractures by casting the wrist in ulnar inclination (Abid et al. 2008).

A scaphoid fracture is occasionally associated with a distal radius fracture. While the site of an isolated scaphoid fracture is usually the distal third, when concomitant with a distal radius fracture, the scaphoid fracture is typically of the waist and non-displaced. Although uncommon, the presence of a scaphoid fracture should be identified because there is a risk of displacing the fractured scaphoid during manipulation of the radius. Other carpal fractures and dislocations are similarly uncommon and tend to occur after high-energy mechanisms (Pretell-Mazzini and Carrigan 2011; Smida et al. 2003). Scaphoid and other carpal fractures can be identified on plain radiographs of the wrist; however, MRI enables early definitive diagnosis (Zimmermann et al. 2007).

Plastic deformation, also known as traumatic bowing, is a diaphyseal deformity due to multiple microfractures. Distal radius fractures are sometimes associated with plastic deformation of the ulna, but bowing of the radius has also been described in association with distal radial metaphyseal fractures (Vorlat and De Boeck 2001). Depending on the age of the child and the degree of angulation, the presence of plastic deformation may alter the course of treatment. Reduction, if indicated, is accomplished by application of constant pressure for several minutes (Sanders and Heckman 1984).

Displaced fractures of both the distal forearm (radius and/or ulna) and distal humerus is termed a "floating elbow" and is caused by a high-energy mechanism. Additive swelling and hemorrhage makes these injuries prone to forearm compartment syndrome, which occurs in approximately 15–33 % of patients (Hwang et al. 2009; Blakemore et al. 2000). Circumferential cast immobilization can increase the risk of compartment syndrome, which may be reduced by treating both fractures with closed reduction and percutaneous Kirschner (K-) wire fixation followed by immobilization in a "bivalved" cast (Ring et al. 2001; Tabak et al. 2003). Prophylactic fasciotomies may be appropriate for patients who are unable to communicate symptoms of compartment syndrome. There is disagreement regarding whether to first stabilize the humerus or the forearm, and published series of each approach have demonstrated similar results (Harrington et al. 2000; Dhoju et al. 2011).

Several forms of acute median nerve injury are associated with distal radius fractures. While carpal tunnel syndrome is a common complication of distal radius fractures in adults (Niver and Ilyas 2012), in children median neuropathy occurs less frequently and is associated with closed Salter-Harris type II fractures. Acute carpal and volar compartment syndromes present similarly with rapid progression of pain and paresthesias in the median nerve distribution and are relieved by decompression. In contrast, median neuropathy due to tenting by fracture fragments should resolve with prompt reduction. However, neuropathy due to stretching or contusion of the nerve at the time of injury may require several weeks to recover. Thus, if neuropathy is present on the initial examination, immediate reduction should be performed. If neuropathy persists and there is a strong clinical suspicion for compartment syndrome, then compartment pressures should be measured and decompression performed if warranted. Nonetheless, all neuropathy patients should be admitted and monitored closely (Waters et al. 1994).

Fractures of the Distal Radius Classification

Distal radius fractures are classified according to location, pattern, displacement, angulation, rotation, stability, and the presence of associated injuries. The AO Pediatric Comprehensive Classification of Long-Bone Fractures may also be used (Slongo et al. 2006). Distal radius fractures usually occur with wrist extension injuries, resulting in dorsal displacement and apex-volar angulation. Occasionally, palmar flexion injuries and resulting volar displacement and apex-dorsal angulation are seen. An unstable fracture is one in which closed reduction cannot be maintained (Waters and Bae 2010). Associated ulnar fractures are classified as styloid avulsions, physeal injuries, and complete or incomplete metaphyseal disruptions.

The location is typically the physis or metaphysis. Physeal fractures are described according to the Salter-Harris classification. Rare triplane fractures have been reported and may be at increased risk for growth arrest (Garcia-Mata and Hidalgo-Ovejero 2006). Metaphyseal fractures may be complete, greenstick, or torus fractures. Disruption of both the volar and dorsal cortices constitutes a complete fracture, which may result from bending, rotational, or shear forces (Fig. 2). Complete fractures are usually unstable and dorsally displaced, and the fracture fragments are often in bayonet apposition. Greenstick, or incomplete, fractures entail disruption of one cortex and compression of the other.

Fig. 2 (**a**) AP and Lat pre-reduction, and (**b**) Post-reduction and casting of displaced unstable diametaphyseal fractures of the distal radius and ulna

The mechanism is a combination of compressive and rotational forces, typically dorsiflexion and supination, leading to failure of the volar cortex in tension and compression of the dorsal cortex. Torus, or buckle, fractures occur with compression of a diametaphyseal cortex in axial loading. By definition, the opposite cortex is intact, and significant angulation and distraction are not present. Classically, there is not an associated ulnar fracture. Torus fractures are inherently stable, partly as a result of the intact surrounding periosteum.

Fractures of the Distal Radius Outcome Tools

Distal radius fracture outcomes may be assessed clinically by measuring range of motion and grip strength and by tracking the incidence of complications and the need for repeat manipulation. Radiographic parameters followed include degree of angulation and cast index. The cast index is the ratio of the inner diameter of the cast in the sagittal plane to that in the coronal plane and is associated with the need for repeat manipulation (Fig. 3) (Chess et al. 1994). The Activities Scale for Kids performance (ASKp) version contains 30 items and is validated for self-reporting of physical activity by children ages 5–15 years (Young et al. 1995). The visual analog scale (VAS) is a validated instrument for the assessment of pain (Bijur et al. 2001). Both of these scales have been utilized in studies of pediatric distal radius fractures (Plint et al. 2006).

Fractures of the Distal Radius Treatment Options

The treatment options for distal radius fractures include splint immobilization, cast immobilization, closed reduction and cast immobilization, closed reduction and percutaneous pinning, and open reduction. The indications and contraindications for, and the techniques, outcomes, and complications of nonoperative and operative management are described below.

Fig. 3 The cast index is measurement of the inner diameter of the cast in the sagittal plane (**a**) divided by that in the coronal plane (**b**) ideally being less than 0.8

Table 1 Nonoperative management

Indications	Contraindications
Most non-displaced fractures	Open fractures
Most Salter-Harris type I or II fractures	Irreducible fractures
Most greenstick fractures	Neurovascular compromise
Most torus fractures	Excessive swelling
Most complete fractures	Displaced Salter-Harris type III or IV fractures
Plastic deformation injuries	Triplane fractures or equivalents
	Ipsilateral humerus fractures
	Polytrauma
	Loss of initial reduction
	Refractures with displacement
	Displaced fractures and less than 2 years until skeletal maturity

Nonoperative Management of Fractures of the Distal Radius

Most distal radius fractures are managed nonoperatively. Contraindications to nonoperative management are the same as indications for operative management and are summarized in Table 1. These include open fractures, irreducible fractures, excessive swelling, and risk for or presence of neurovascular compromise. Additionally, displaced Salter-Harris type III or IV patterns and triplane fractures or equivalents require surgical management for anatomic reduction. Nonoperative management is contraindicated in the presence of polytrauma or ipsilateral humerus fracture due to the risk of compartment syndrome. Furthermore, fractures which lose their initial reduction and refractures with displacement often have poor outcomes when managed nonoperatively. Finally, internal fixation for all displaced fractures in patients with less than 2 years remaining until skeletal maturity can be considered due to their reduced capacity for remodeling compared to younger patients.

Nonoperative management for distal radius fractures entails immobilization with or without closed reduction. Traditionally, immobilization is accomplished with fiberglass or plaster of Paris casting or splinting; however, prefabricated splints and bandage therapy are also used. Both short-arm and long-arm casts are in widespread use. The decision between long-arm and short-arm cast immobilization depends on the displacement of the fracture and age of the patient. This is further discussed in the following sections. Closed reduction is performed with adequate analgesia, usually in the emergency room under conscious sedation. Portable fluoroscopy may be used for guidance and assessment of the reduction. While reduction is typically performed by an orthopedic surgeon where available, many emergency medicine physicians and family practitioners are also trained to evaluate and provide nonoperative management of distal radius fractures.

Non-displaced fractures of the physis and metaphysis with acceptable angulation and rotation may be amenable to immobilization without reduction. Metaphyseal fractures have excellent remodeling potential and up to 10° per year of dorsal-volar angulation may correct with continued growth. The range of angular deformity

Table 2 Acceptable angular deformity for metaphyseal fractures (degrees)

Age (year)	Dorsal-volar Boys	Dorsal-volar Girls	Radial-ulnar Boys and girls
4–9	20	15	15
9–11	15	10	5
11–13	10	10	0
>13	5	0	0

Table 3 Immobilization without reduction

Indications	Contraindications
Most torus fractures	Excessive angular deformity (see Table 2)
Consider for S-H II, <40 % displacement, <20° angulation, child <10 years old	Most displaced physeal fractures
Consider for complete fractures with bayonet apposition in very young child	Most complete fractures
Some greenstick fractures	Rotational deformity
	Plastic deformation

accepted in practice varies and is clinician dependent. As a general guide, the traditional tolerances are provided in Table 2, adapted from the Rockwood and Wilkins text (Waters and Bae 2010).

In contrast, rotational deformity will not remodel and is an indication for reduction. Malrotation is often present when both the radius and ulna are fractured and the fracture sites are at two different levels, proximal and distal to each other. Apex-volar angulation is often associated with supination of the distal fragment; apex-dorsal angulation, with pronation. Failure to recognize and reduce rotational deformity is a common pitfall in the treatment of greenstick fractures. The indications and contraindications for immobilization without reduction for distal radius fractures are summarized in Table 3.

Discussion: Nonoperative Management of Physeal Fractures

Salter-Harris type I and II fractures of the distal radius are typically the result of an extension mechanism and consequently displace dorsally with apex-volar angulation (Fig. 4). Alignment of the fragments is traditionally acceptable with less than 50 % displacement and no angular or rotational deformity (Egol et al. 2010); however, some advocate immobilization without reduction for Salter-Harris type II fractures with less than 20° of angulation and less than 40 % displacement in children under age 10 (Houshian et al. 2004). Physical and occupational therapy are not usually required for pediatric distal radius fractures.

Technique: Closed Reduction of Physeal Fractures

In Salter-Harris type I and II fractures, the dorsal periosteum is usually intact and can be used as a tension band to aid reduction. Although the thickness of the periosteum limits the utility of pulley-weight traction, finger traps with less than 10 lb of counterweight or an assistant are helpful to support and stabilize the extremity for reduction and casting. The fracture may reduce with traction alone; otherwise, gentle thumb pressure applied at the fracture site in a distal and volar direction facilitates atraumatic flexion of the distal epiphysis (Fig. 5). Alignment of the fragments is traditionally acceptable with less than 50 % displacement and no angular or rotational deformity. Multiple reduction attempts may increase the risk of growth arrest due to increased shear forces across the physis. Immobilization in the neutral position or pronation is recommended. Portable fluoroscopy, if available, could be used to immediately assess the reduction before immobilization. Irreducibility is most often due to entrapment of the periosteum or pronator quadratus.

Discussion: Nonoperative Management of Torus Fractures

The traditional standard of care for torus fractures is immobilization in a short-arm cast for 3–4 weeks. The theoretical benefits of casting are protection against pain, displacement, and refracture.

Fig. 4 (**a**) AP and Lat of a Salter-Harris II fracture of the distal radius with dorsal displacement and mild angulation (**b**) AP and Lat at 6 weeks and (**c**) at 4 months

Fig. 5 Example of gentle thumb pressure in a distal and volar direction to reduce dorsally-displaced non-shortened physeal injury

Torus fractures usually do not require reduction, are inherently stable, and have little risk of late displacement; accordingly, alternatives to cast immobilization have been studied (Bae and Howard 2012). Treatment with removable splints may reduce the amount of clinic visits required, enables easier bathing, and avoids cast-saw-related anxiety. Several prospective, randomized controlled trials have compared removable wrist splints to casts. Davidson et al. reported successful healing with no complications in all patients treated with splinting or casting (Davidson et al. 2001). In addition, Plint et al. found no difference in pain on the VAS between the two groups. The splint group had significantly better ASKp scores at one of four time points assessed, suggesting that children have less difficulty with activities while in splints compared to while in casts (Plint et al. 2006). In contrast, Oakley et al. found that patients treated with a volar slab splint had longer durations of pain and longer times until resumption of normal activity (Oakley et al. 2008). Splint management has been found to reduce total cost per patient by approximately \$73–82, with the majority of savings due to attending one fewer clinic visit for cast or splint removal (Davidson et al. 2001; von Keyserlingk et al. 2011).

Soft casts are the preferred treatment in some institutions. Trials by Khan et al. and Witney-Lagen et al. reported full recovery, according to parental evaluation, in both soft cast and rigid cast treatment groups (Khan et al. 2007; Witney-Lagen et al. 2013). Parents may safely remove precut plaster back slabs (Symons et al. 2001) and soft casts (Khan et al. 2007) at home after 3 weeks if adequate explanation of removal is provided during the initial treatment. Most families prefer removal at home rather than in the clinic and prefer soft casts to rigid casts. Thus, although soft cast material is more expensive than rigid cast material, removal at home contributes to decreased total cost of care for both soft casts and splints.

Studies have also demonstrated satisfactory outcomes in the management of torus fractures with bandage therapy. West et al. randomized patients to either casting or treatment with a layer of orthopedic wool covered by crepe bandage and held in place with tape. They reported a decreased incidence of pain and decreased duration of pain in the bandage group; however, a validated pain scale was not used. Fracture healing was universal, and the bandage group had significantly greater range of motion compared to the cast group, as measured on the day of cast removal at 4 weeks (West et al. 2005). Kropman et al. performed a similar trial, and there were no complications in either group. In contrast to the findings of West et al., they reported that VAS pain scores were significantly increased in the bandage group during the first week of treatment. The cast group experienced more discomfort (i.e., itching). Range of motion was reduced in the casting group on the day of cast removal; however, there was no significant difference 2 weeks later. In one center, bandage therapy was made the standard of care for torus fractures, and no secondary angulation or refractures occurred in 49 consecutively treated patients (Vernooij et al. 2012).

In conclusion, there are several treatment options for torus fractures, which are inherently stable injuries. Although the traditional standard of care is rigid immobilization in a short-arm cast for 3–4 weeks, the literature supports treatment in a wrist splint or soft cast that can be removed at home after 3 weeks with no radiographic follow-up. Additionally, a growing body of evidence suggests that bandage therapy is safe and effective. The use of splints, soft casts, and bandages decreases the workload of the fracture clinic and reduces the cost of care. While most parents of children treated with splints, soft casts, and bandages would prefer them to rigid casts, many parents may be hesitant to forego traditional rigid immobilization and radiographic follow-up. Thus, treatment of torus fractures should be the result of a shared decision-making process involving the patient, parents, and physician and should consider any special needs of the child and the impact on the family of attending a follow-up visit. Finally, it warrants mentioning that errors in torus fracture diagnosis are not uncommon and are typically due to failure to recognize a greenstick fracture (Fig. 6). Therefore, review of the radiographs by an experienced physician is mandatory.

Discussion: Nonoperative Management of Greenstick Fractures

Greenstick fractures typically present as failure of the volar cortex in tension and the dorsal cortex in compression. Radial displacement and apex ulnar angulation are often present. Traditional tolerances for angular deformity are shown in Table 2. Fractures which are minimally angulated on presentation may be immobilized without reduction (Al-Ansari et al. 2007; Do et al. 2003). However, excessive angulation presents a risk of lost forearm rotation and should be corrected to maintain the interosseous space.

Rotational deformity is also common, especially when there is an associated ulna fracture, and correction of malrotation is essential to achieving anatomic alignment. However, rotational correction often fractures the intact cortex, thus completing the fracture. Intentional completion of the fracture is controversial, and little data is available to evaluate this practice. Some argue that fracture completion decreases the risk of redisplacement; however, some evidence suggests

Fig. 6 (**a**) AP, (**b**) Lateral, and (**c**) Oblique of a greenstick fracture of the distal radius

that the opposite may be true (Waters and Bae 2010; Schmuck et al. 2010). Nevertheless, fracture completion appears to be useful when primary angulation exceeds remodeling capacity.

Clinical practice varies regarding the position and type of forearm immobilization. Some advocate for immobilization in supination to minimize the deforming effect of the brachioradialis; in the neutral position, to maintain the interosseous space and rotational range of motion; and in pronation, to reduce the common supination deformity (Waters and Bae 2010). Boyer et al. found no difference in angulation in patients randomized to supination, neutral position, or pronation (Boyer et al. 2002). Local practice determines the choice of long-arm cast, short-arm cast, or splint (Bae and Howard 2012). Classically, a long-arm cast is applied for 3–4 weeks, followed by a short-arm cast for 1–3 weeks. Elbow immobilization is thought to decrease the risk of displacement by limiting the child's activities and reducing the deforming effect of the brachioradialis (as in supination). However, in trials by Bohm et al. and Webb et al., there was no difference in the rate of lost reduction between patients randomized to short-arm casts or long-arm casts after closed reduction (Bohm et al. 2006; Webb et al. 2006). Moreover, patients treated with a long-arm cast were more likely to require assistance with activities of daily living and missed, on average, one more day of school than those treated with a short-arm cast. Additionally, Boutis et al. found no significant difference between patients randomized to short-arm casts or prefabricated wrist splints in complication rate, ASK scores, grip strength, range of motion, and radiographic measurement of angulation (Boutis et al. 2010).

In conclusion, most greenstick fractures are treated with closed reduction and rigid immobilization, but the acceptable angulation, position, and type of immobilization vary in clinical practice. Failure to recognize and reduce rotational deformity is a common pitfall in the treatment of greenstick fractures. While long-arm casts are the traditional standard of care, the literature supports the use of well-molded short-arm casts. Redisplacement is common, and weekly radiographic follow-up is indicated until there is evidence of sufficient callus formation.

Technique: Closed Reduction of Greenstick Fractures

Correction of malrotation is essential to achieving anatomic alignment in greenstick fractures. Finger traps are not used. While pressure is applied to the apex of deformity, the patient's thumb should be rotated toward the apex of angulation. In other words, apex-volar fractures require pronation of the distal fragment and apex-dorsal, supination. Fracture of the intact cortex during this maneuver may occur but is not necessary. Angular deformity should be corrected to fewer than 10°. Maintenance of alignment may be aided by immobilizing the forearm in the rotational position used to achieve the reduction. While portable fluoroscopy, if available, should be used to assess the reduction, postreduction radiographs should include the entire forearm to facilitate evaluation of malrotation.

Discussion: Management of Complete Fractures

Complete fractures of the distal radius often present with associated ulna fractures, are usually dorsally displaced, and are frequently in bayonet apposition. In other words, the distal fragment frequently lies in a side-to-side rather than end-to-end relationship to the proximal fragment. The traditional standard of care is closed reduction and cast immobilization. Regardless of the presence of an associated ulna fracture, reduction is difficult to maintain. The rate of redisplacement following an initial, acceptable closed reduction has been reported between 21 % and 91 %, but in most studies, it is approximately 25 %. The greatest risk factors for redisplacement are initial angulation greater than 30°, incomplete reduction, and complete displacement, although displacement greater than 50 % also increases this risk (Zamzam and Khoshhal 2005; Alemdaroglu et al. 2008; McQuinn and Jaarsma 2012).

Loss of reduction may lead to a malunion, which has excellent potential for remodeling in the dorsal-volar plane (see "Pathoanatomy and Applied Anatomy Relating to Fractures of the Distal Radius" section). However, deformity in the radial-ulnar plane has less potential for remodeling (see Table 2). Repeat manipulation may be indicated following loss of reduction to avoid a malunion. One should use caution not re-manipulate a physeal fracture after 7–10 days of injury as this carries a higher risk of arrest. For their study, Alemdaroglu et al. (2008) defined redisplacement as dorsovolar angulation of 10° or greater, radioulnar angulation of 5° or greater, translation of 3 mm or greater, or the combination of dorsovolar angulation of 5° or greater and translation of 2 mm or greater. The authors remanipulated fractures that had dorsovolar angulation of greater than 20°, radioulnar angulation of greater than 10°, translation of greater than 4 mm, or any combination of two of the following: dorsovolar angulation of greater than 10°, radioulnar angulation of greater than 5°, and translation of greater than 3 mm (see Table 4).

Some surgeons advocate conservative management to take advantage of the tremendous remodeling potential of the distal radius. Do et al. (2003) found that fractures with less than 15° of dorsovolar or radioulnar angulation and less than 1 cm of shortening heal without deformity or clinical sequelae. The average time to bony healing and cast removal was 6 weeks, and remodeling was complete after an average of 4 months (up to 13 months in older children). Moreover, Crawford et al. (2012) reported excellent results in 51 consecutive children with fractures in bayonet apposition treated with no attempt at anatomic reduction. Within 72 h of injury, in an outpatient clinic with no analgesia or sedation, short-arm casts were applied and gently molded to correct angulation, leaving the fractures overriding and shortened. The average dorsovolar and radioulnar angulation after reduction were 4.0° and 3.2°, respectively, (range 0–13, 0–10) and at follow-up after 1 year were 2.2° and 0.75° (range 0–10, 0–5). All patients progressed to union and full range of wrist motion, there were no complications, and "only a few patients had a minimally noticeable clinical deformity." The cost of care for this approach was approximately one-fifth that of closed reduction with conscious sedation and approximately one-eighth that of

Table 4 Criteria for redisplacement and remanipulation (Alemdaroglu et al. 2008)

	Redisplacement	Remanipulation
Dorsovolar angulation (degrees)	≥10 isolated, ≥5 in combination	>20 isolated, >10 in combination
Radioulnar angulation (degrees)	≥5 isolated	>10 isolated, >5 in combination
Translation (mm)	≥3 isolated, ≥2 in combination	>4 isolated, >3 in combination

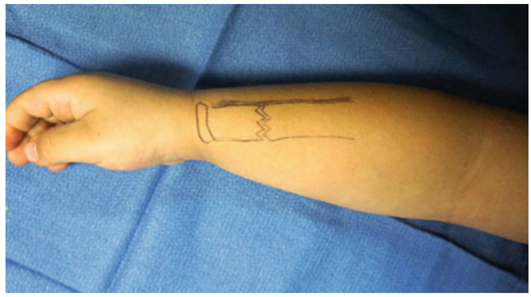
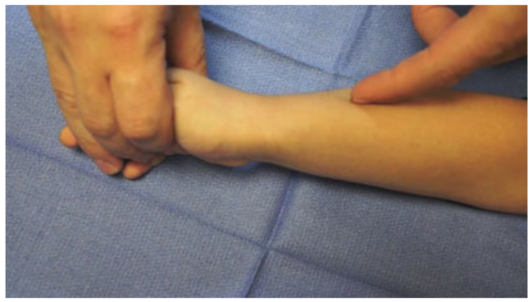


Fig. 7 Depiction of intact dorsal periosteum in a pediatric distal radius fracture



Video 1

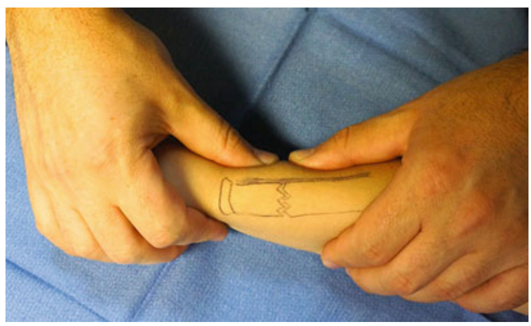


Fig. 8 Demonstration of placement of thumb pressure to distract a shortened displaced fracture with intact dorsal periosteum

percutaneous pin fixation with general anesthesia. The authors advocate for this approach as first-line treatment, noting that it avoids the risks of anesthesia, lessens the time required by the treating physician, and reduces the cost of care.

In conclusion, the traditional standard of care for complete fractures of the distal radius is closed reduction and cast immobilization with close radiographic follow-up until there is evidence of healing (typically 6 weeks). Loss of reduction is common, and repeat manipulation may be indicated to avoid a malunion. The literature supports primary percutaneous pin fixation as an alternative for fractures at high risk of displacement or when excessive swelling is present to reduce the risk of neurovascular compromise. However, these fractures have excellent remodeling potential, and good results have been obtained by correcting angular deformity with gentle cast molding and allowing healing to occur in an overriding, shortened position. Thus, treatment should be guided by a shared decision-making process involving the patient, parents, and physician with consideration of the risk of loss of reduction based on the patient's age and fracture characteristics.

Technique: Closed Reduction of Complete Fractures

Finger traps with weight of less than 10 lb may be useful to stabilize the hand during casting, but the intact periosteum will not usually stretch to permit reduction through traction, and the tense periosteum may hinder reduction (Fig. 7). Eichinger et al. (2011) described a traction technique designed to provide greater mechanical advantage by securing the patient's arm beneath the surgeon's thigh. Regardless of the traction technique employed, the key to anatomic reduction is initial exaggeration of the deformity (usually dorsal displacement and apex-volar angulation of the distal fragment) [see Video 1]. The dorsum of the hand is often brought to an acute angle with the dorsum of the forearm. Thumb pressure is then applied to distract the distal fragment (Fig. 8). Next, the distal fragment is flexed volarly to obtain reduction, and at the same time, malrotation is corrected if present. Finally, residual translation is corrected through “toggling” the distal fragment by slight dorsiflexion and volarly directed thumb pressure. Portable fluoroscopy, if available, should be used to immediately assess the reduction before immobilization.

Technique: Splint Immobilization

Prefabricated splints have been studied as definitive therapy for torus and greenstick fractures. Additionally, sugar-tong splints, often used as a temporizing measure, are reportedly effective for maintaining reduction of complete fractures (Denes et al. 2007). Successfully applied splints limit flexion and extension of the wrist and pronation and supination of the forearm. Following the placement of well-fitted stockinette, the elbow should be flexed to 90° and the forearm held in neutral rotation. Cotton padding should be rolled with 50 % overlap from the proximal interphalangeal joints to three centimeters proximal to the antecubital fossa, with extra padding for bony prominences. Measure a length of plaster to extend just proximal to the dorsal metacarpophalangeal (MCP) joints around the elbow in a U-shape to the fracture site on the volar surface (Egol et al. 2010). Ten layers of two- to four-inch-wide plaster should be submerged in room temperature water and then pressed together to bond the layers and remove excess water. The plaster should be held in place by an assistant or by a cooperative patient’s contralateral hand, while an elastic bandage is wrapped with gentle tension and 50 % overlap from distal to proximal along the length of the plaster. As the splint starts to dry, carefully apply a three-point mold or a “banana-shaped” mold, applying pressure with the base of the palm. To correct apex-volar angulation, the middle pressure point should be on the volar aspect just proximal to the fracture, and the proximal and distal points should be on the dorsal aspect (Fig. 9). The opposite placement will help correct apex-dorsal angulation. After the splint dries, a neurovascular exam of the affected extremity should be performed. It is important to keep the MCP joints free for unhindered finger motion to be permitted.

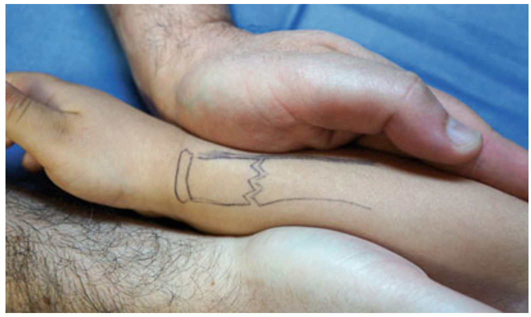


Fig. 9 Demonstration of the 3-point mold to hold the reduction in cast

Technique: Cast Immobilization

Stockinette and cotton padding should be applied and the extremity positioned as described above, with the exception for smaller children of extending the elbow to approximately 90° of flexion. This allows for better forearm molding. The plaster or fiberglass should extend from the proximal palmar crease to either 3 cm distal to the antecubital fossa (for a short-arm cast) or to the mid-humerus (for a long-arm cast). The MCP joints should move freely. The thumb should be able to touch the small finger unless an elbow-extension cast is applied, in which case the thumb should be included in extension to prevent distal migration of the cast. A three-point mold should be applied around the fracture site as described above (Fig. 9). Additionally, an oval-shaped mold helps maintain the interosseous space, and a straight ulnar mold and posterior humeral mold help prevent migration. In anticipation of swelling, the cast should be bivalved and over-wrapped with an elastic bandage. A neurovascular exam should be performed and final radiographs should be obtained.

Several cast parameters have been developed to measure the quality of reduction and molding. The cast index is the ratio of the inner cast diameters (sagittal divided by coronal) at the fracture site, and higher values have been associated with loss of reduction. Better outcomes are traditionally associated with values of 0.7 or less, and evidence suggests that values of 0.81 or greater are associated with an increased risk of loss of reduction (Chess et al. 1994; Ortega Vadillo et al. 2010; Kamat et al. 2012). Additionally, Edmonds et al. (2009) identified an association between the second metacarpal-radius angle and better outcomes, noting that fractures were more likely to have an ideal outcome if molded in ulnar deviation. Finally, the three-point index is found by calculating the ratio of the sum of the "critical gap" distances and the length of contact area between the two fracture fragments on PA and lateral radiographs and then taking the sum of these two ratios. The "critical gaps" are the distances between the skin and cast at approximately the sites where three-point molding should be applied (see section "Technique: Splint Immobilization"). In a prospective study by Alemdraglu et al. (2008), a three-point index value of 0.8 or greater was 95 % sensitive and 95 % specific for redisplacement. Thus, the three-point index may be used to assess the quality of cast molding and to predict redisplacement.

Operative Treatment of Fractures of the Distal Radius

Indications/Contraindications

The main indications for operative treatment of distal radius fractures include those with associated neurovascular injuries, especially median neuropathy, open fractures, a large amount of volar swelling, irreducible fractures, and loss of reduction after initial closed treatment. Median neuropathy can be seen with injuries, which cause a direct contusion to the nerve, stretch neuropraxia, laceration from the fracture fragment, and/or imminent compartment syndrome with a large hematoma causing direct pressure. Closed reduction with a circumferential cast, especially with a large volar amount of swelling, can potentially worsen symptoms. Fractures with an open injury to the soft tissue envelope warrant surgical irrigation and debridement to prevent infection, osteomyelitis, and delayed union. Irreducible fractures are likely due to entrapment of the periosteum and less often the pronator quadratus.

Table 5 Preoperative planning

OR table: A standard OR table is utilized
Position: Supine, no bumps required
Fluoroscopy location: Placement of image intensifier flipped upside down, on affected side, parallel to bed and can be used as the operative table itself. Alternatively, a radiolucent arm table can be attached to the side of the table and fluoroscopy can enter from underneath
Equipment: Basic ortho-tray, power wire driver, smooth Steinmann pins, cast cart
Tourniquet: A nonsterile tourniquet is placed on the upper arm

Surgical Procedure

Closed Reduction Percutaneous Pin Fixation

Preoperative planning (see Table 5).

Positioning

The patient is placed in the supine position on the operative table and shifted to the edge of the bed on the affected side, without any bumps necessary. The table is rotated in the room as needed to allow for the necessary room for the image intensifier.

Surgical Approaches/Technique

An anesthetic is delivered, and a nonsterile tourniquet is placed on the upper arm. The upper extremity is prepped and draped in the usual sterile manner. It remains a surgeon's choice whether to utilize a tourniquet during this minimally invasive procedure. Closed reduction of the fracture is performed first with an adequate amount of traction. For metaphyseal and diametaphyseal fractures, subsequent exaggeration of the fracture will allow the surgeon to unhinge the fragments and ease in the reduction. To minimize the risk of growth arrest in physeal injuries, it is imperative

Fig. 10 Skin landmarks of typical pattern of the superficial sensory branch of the radial nerve

to utilize an adequate amount of traction. This alone can aid in reduction, with or without the need for volarly or dorsally based digital pressure over the epiphysis as indicated. Once the fracture is confirmed to be adequately reduced on image intensification, skeletal stabilization is ensued.

The radial styloid is palpated along with Lister's tubercle. For metaphyseal fractures where the distal fragment cannot be captured without crossing the physis of the distal radius or physeal injuries, a small centimeter-length linear incision is made distal to the radial styloid. This incision is made sharply through skin and subcutaneous tissue, and then a hemostat is utilized to bluntly dissect down to bone to prevent iatrogenic injury to the superficial sensory branch of the radial nerve and the extensor tendons (Fig. 10). Then, a 1.6-mm smooth Steinmann pin is selected and is driven through the epiphysis radial styloid tip with the greatest attempt to remain perpendicular to and central in the physis (1.1-mm Kirschner wires are utilized in patients under the age of 6). This is advanced into the proximal ulnar-sided cortex of the radius (Fig. 11). It is preferable to engage the cortex of the metaphyseal fragment just proximal to the distal radial physis. The stability is checked with fluoroscopy, and if needed a secondary pin is utilized in a crossing fashion or parallel to the first pin. Once stability is confirmed, the pin is prebent and cut outside of the skin. Passive motion of the wrist and digits is checked to rule out any tethering of the tendons. If a tourniquet was utilized, it is then deflated and pulses are palpated. Sterile nonadherent dressings are placed around the pin, and then the extremity is immobilized in either a long-arm posterior splint or a bivalved fiberglass cast.

The postoperative course includes a follow-up appointment in 1 week to assess radiographic alignment. Pins are maintained for a total of 3–4 weeks and then removed in the outpatient office. The length of immobilization is a total of 6 weeks on average. Once radiographic and clinical healing is confirmed, the patient is eased back into range of motion and subsequent strengthening, with or without the need for formal physical therapy, which is determined on a case-by-case basis.

Open Reduction of Irreducible Fractures

Irreducible fractures are most likely due to entrapped periosteum and/or the pronator quadratus itself. Preoperative planning and patient positioning is the same as above for the percutaneous technique. These fractures are accessed traditionally via an open volar approach to gain access to the entrapped tissue/muscle. Once the fracture is reduced, it can be stabilized with plate osteosynthesis or K-wire fixation. It is recommended that 4–6 cortices are captured in the metaphyseal (i.e., distal) fragment for stable fixation. The wound is then closed and a volar plaster splint is applied or a bivalved cast (Table 6).

Treatment-Specific Outcomes of Percutaneous Pinning of Distal Radius Fractures

Percutaneous pin fixation has been shown to be successful for the treatment of patients with excessive swelling in order to reduce the risk of neurovascular compromise and is often used as alternative to repeat manipulation to correct late redisplacement. Due to the risk of redisplacement, some surgeons prefer closed reduction and immediate percutaneous pinning.

Fig. 11 (**a**) AP and Lat of completely displaced distal radius physeal fracture with associated moderate soft tissue swelling and sensory changes warranting (**b**) K-wire fixation to hold reduction (**c**) 1 month post-op (**d**) 6 weeks post-op

McLauchlan et al. (2002) and Miller et al. (2005) randomized children to either closed reduction and cast immobilization or the additional insertion of a percutaneous K-wire (McLauchlan) or Concept (C-) wire(s) (Miller), which was/were removed three (McLauchlan) or four (Miller) weeks later. Miller et al. studied fractures at high risk for loss of reduction, including only children older than age 10 years with either complete displacement or angulation greater than 30°. To minimize the effects of poor reduction and casting technique, these patients were treated by an attending pediatric orthopedic surgeon. In the control groups, 21 % (McLauchlan) and 39 % (Miller) of patients underwent a second procedure to correct unacceptable deformity. Miller et al. used complete displacement or angulation greater than 25° as criteria for remanipulation. In the pin groups, there was no loss of reduction; however, the rates of pin-related complications (pain, prominent scarring, and wire migration) were 11 % (McLauchlan) and 38 % (Miller). Pin-related complications included hyperesthesia, prominent scarring, wire migration, pin-site infections, and tendon irritation, all of which resolved following pin removal. Both studies reported no significant differences between the groups in long-term outcomes including wrist range of motion and strength. Additionally, Miller et al. reported that the cost of care was not significantly different between groups. Thus, primary percutaneous pin fixation is a safe and effective alternative for fractures at high risk of displacement.

Table 6 Surgical pitfalls and prevention

Potential pitfall	Pearls for prevention
Injury to the superficial branch of the radial nerve	Blunt dissection after initial skin and subcutaneous incision utilizing hemostat "nick and spread" technique
	Utilization of a drill guide during insertion of K-wire
Tendon irritation/wire migration	As above for nerve protection
	Prebending the wire outside the skin with adequate padding
Infection	Placement of wire under sterile technique
	Prompt removal once adequate callus formation
	Patient/parental education on cast care and maintenance of clean/dry dressings
Pain associated with pin removal/scarring	Wires can be prebent and cut underneath skin for later removal in operative setting

Preferred Treatment

Distal radius fractures are for the most part managed by closed means. A closed displaced and/or angulated fracture with parameters outside the abovementioned tolerances is closed reduced and immobilized in the emergency room setting under conscious sedation. The authors' immobilization of choice in the acute setting is a bivalved fiberglass long-arm cast for the highly unstable fractures, physeal injuries, and the younger patient where a short-arm cast is at risk for falling off. Diametaphyseal, torus, and greenstick fractures, which are otherwise more inherently stable, can be managed in a bivalved short-arm fiberglass cast. Follow-up radiographs and clinical evaluation are done at the 1-week mark to assess alignment and stability. This may require multiple 1-week clinical visits to assess stability. The typical period of immobilization is 6 weeks total. Stable torus fractures are seen in 3–4 weeks for repeat imaging out of cast.

As for the distal radius fractures associated with neurovascular injuries, median neuropathy, open fractures, a large amount of volar swelling, irreducible fractures, and a loss of reduction after initial closed treatment, the authors prefer skeletal stabilization via percutaneous pinning. Pins are generally removed in 3–4 weeks postoperatively. The fracture is then protected for another 2 weeks in a short-arm cast.

Summary and Future Directions

Distal radius fractures are the most common fractures in the pediatric population, with an incidence of 21–31 % of all pediatric fractures. They commonly occur as a result of a traumatic fall, are more common in males than females, and their prevalence is on the rise. The pediatric wrist fracture has excellent remodeling potential, as the distal radius physis contributes to approximately 80 % of the longitudinal growth of the forearm. This is especially true in the younger patient with more than 2 years of growth remaining.

Clinical examination and radiographic evaluation of the affected limb will reveal the fracture in question. This could include a diametaphyseal fracture of variable displacement and angular instability, physeal injuries, most commonly of the Salter-Harris I and II patterns, torus (buckle) type, or greenstick fractures. These fractures are commonly associated with ulnar fractures, either at the same level or at the ulnar styloid. The rate of growth arrest with displaced physeal injuries of the distal radius is on average 4–5 %, while an ulnar physeal injury can be present in up to 50 % of cases. It is imperative not to miss associated dislocations, such as Galeazzi or Monteggia fracture dislocations, or more proximal fractures at the elbow.

Treatment options include nonoperative immobilization, closed reduction and percutaneous pinning, and open reduction internal fixation. Most non-displaced fractures, Salter-Harris I and II, greenstick, buckle, complete, or plastically deformed fractures, are amenable to first-line nonoperative treatment. The orthopedic surgeon, the emergency physician, as well as the primary care physician will continue to frequently address wrist injuries in children. The appropriate diagnosis of a fracture and the ability to follow a prescribed treatment algorithm is imperative to restore function, motion, and a symptom-free wrist.

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