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Emergency Medicine Management of Distal Radius and Ulna Fractures: Narrative Review

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Importance: Distal radius fractures and distal ulna fractures are common orthopedic injuries treated in emergency departments (ED). Our goal in this narrative review was to present emergency physicians with a single source that covers the evaluation and treatment of distal radius fractures and distal ulna fractures across the lifetime of our patients. There are differences in the treatment algorithms for distal radius fractures between pediatric, young adult, and geriatric patients.

Observations: Pediatric distal radius fractures are defined by their relation to the growth plate and are influenced by the gradual calcification of the developing bone. Some pediatric distal radius fractures can heal through significant displacement, while others require anatomical reduction to limit the risk of growth arrest. For adult patients with a distal radius fracture, there are established guidelines for both appropriate reduction goals and for when operative treatment is indicated. For geriatric patients, management strategies have evolved over the last decade after multiple studies demonstrated no functional difference between operative and nonoperative management. Given this, most geriatric distal radius fractures are managed nonsurgically, which makes effective reduction in the ED important to optimize long-term wrist function.

Conclusion and Relevance: Emergency physicians need to be well versed at both identifying fracture patterns and be knowledgeable about radiographic fracture-reduction goals. This emergency medicine-focused and illustrated narrative review will assist physicians, nurse practitioners, and physician assistants in meeting those goals. We also summarize pain management, splint molding, possible complications and follow-up considerations for emergency physicians treating patients with distal radius fractures. [West J Emerg Med. 2026;27(4)1090–1104.]

INTRODUCTION

Distal radius fractures and distal ulna fractures are common orthopedic injuries treated in emergency departments (ED). Distal radius fractures account for between 0.66-2.5% of all ED visits.¹ They represent approximately one sixth of all fractures seen in the ED, > 25% of all pediatric fractures, and 18% of geriatric fractures (patients > 65).^{2,3} These fractures peak in a bimodal distribution; boys < 18 and women > 65 years of age have the highest prevalence. The risk of distal radius fractures in older women is so pronounced that there is a 15% chance that a woman > 50 years of age will have a distal radius fracture in her lifetime.^{4,5} The prevalence of distal radius fractures has

increased in proportion to the increase in the geriatric population, with a Danish study showing a 20% increase in incidence between 1997 and 2018.⁶ Most pediatric distal radius fractures occur from high energy falls or during sporting events. Torus fractures are the most common fracture pattern, followed by bicortical fractures and physeal fractures. Salter Harris II fractures comprise the majority of physeal fractures.⁷

Diagnosis and management strategies for treating distal radius fractures have evolved over the last decade. Optimizing pediatric fracture management, using ultrasound in the management of fractures, and a focus on nonoperative management of geriatric fractures are some of these changes.

Evaluation of distal radius fractures should include radiographs, a physical examination assessing and documenting motor and sensory function, and adequate pain control. Treatment and reduction goals depend on the degree of displacement, intraarticular involvement, and age.^{8,9} Splinting choices depend on the injury pattern; options range from removable Velcro wrist braces to molded plaster/fiberglass splints.^{10,11}

There are differences in the treatment algorithms for distal radius fractures between pediatric, young adult, and geriatric patients. Pediatric injuries are treated with a specific focus on their relation to the growth plate. Because of the ability of pediatric bones to heal through significant displacement, the guidelines for appropriate pediatric reductions sometimes allow for more angulation and displacement than for older patients.¹² For adult patients with a distal radius fracture, there are established guidelines for both appropriate reduction goals and for when operative treatment is indicated. Recent studies have shown that geriatric patients (> 65 years of age) have equivalent patient-centered outcomes with operative and nonoperative management.^{4,13–16} Because of this, both the American Academy of Orthopedic Surgeons and the American Society for Surgery of the Hand have emphasized the importance of optimizing initial reduction and having clear conversations with patients about the lack of benefit associated with surgical treatment.⁹

This narrative review summarizes the current treatment guidelines for distal radius fractures for pediatric, young adult, and geriatric patients in the ED. The review can be used to guide the treatment of these fractures across a broad spectrum of injuries. It covers fracture patterns, radiographic identification of distal radius fractures, fracture reduction guidelines, imaging, analgesia, splint molding, complications, and follow-up considerations.

Clinical Presentation

The most common mechanism leading to a distal radius fracture is a fall onto an outstretched hand.¹⁷ The physical exam starts with assessment for gross deformity, which suggests displacement of the fracture. Pain with dorsiflexion or pronation, ecchymosis, wrist edema, and deformity are strong predictors of a fracture.¹⁸ Lacerations or puncture wounds can indicate open fractures. Physical examination should also include an evaluation of the motor and sensory function of the hand and forearm nerves.¹⁹

When there is a clinical concern for a distal radius fracture, history should focus on the mechanism of injury, timing, and severity of symptoms. To understand the impact the injury may have on work/school, ascertain the patient's dominant hand, profession, and comorbidities. Past medical history should include a review of risk factors for osteopenia/osteoporosis (female sex, advanced age, body mass index < 18.5, tobacco use, and previous fractures).²⁰ Patients with

osteopenia/osteoporosis are at higher risk for nonunion, and fracture instability.²¹ Distal radius fractures may also be the sentinel event in the “fragility fracture cascade” because they typically occur earlier than hip or vertebral fractures. Identification at this stage can aid in earlier diagnosis of osteoporosis and more aggressive medical interventions.²²

Compartment syndrome is a known but rare (< 1% of cases) complication of distal radius fractures.²³ The two main findings associated with compartment syndrome of the forearm are pain out of proportion to exam and pain with passive stretch of the muscles in the compartment. Because both can be difficult to assess prior to fracture stabilization, this evaluation should continue after the splint is applied. The other classic signs of compartment syndrome are paresthesias, paralysis, pallor, and pulselessness, all of which are late signs that may indicate permanent damage has occurred; therefore, the clinician should prioritize diagnosing compartment syndrome before symptom onset.²⁴ Structures deep in the volar compartment of the forearm are most at risk of injury from compartment syndrome because they lie between bony structures, the interosseous membrane of the forearm, and deep muscle fascial layers. These at-risk structures include the median nerve and anterior interosseous nerve. Structures in the superficial volar, dorsal, and mobile wad compartments are less tightly bound and are less likely to experience acute compartment syndrome.²⁴

The physical examination should also include an evaluation of the motor and sensory function of the radial, ulnar, median, anterior interosseous and posterior interosseous nerves of the hand and forearm. Details on this examination are provided in [Table 1](#).^{11,25–29}

Nothing in the literature supports the broad use of two-point discrimination to evaluate fracture-associated nerve injury in the acute setting. In the subacute setting, two-point discrimination has correlated with electromyography studies examining median nerve dysfunction in patients who developed acute carpal tunnel syndrome related to a distal radius fracture, but these electromyography studies were done months after the injury occurred.³⁰ It is not the authors' practice to include two-point discrimination in the evaluation of acute distal radius fractures, unless there is another injury that is concerning for nerve transection.³¹

Anatomy

There are two primary bones in the forearm. The ulna is the stable/fixed unit of the forearm. The proximal end is the olecranon, which tapers through the forearm until it ends at the ulnar styloid. The radius rotates around the ulna as the forearm pronates and supinates. Proximally, the radial head articulates with capitellum of the humerus. Distally, the radius becomes the larger of the two bones. The distal radius and ulna articulate with each other at the distal radioulnar joint and with the scaphoid, lunate and triquetrum carpal bones.² The

Table 1. Physical examination of nerve function for patients with a distal radius fracture in a narrative review summarizing optimal evaluation and treatment strategies.

Nerve	Motor (Prompt and function)	Sensory Areas	Notes
Posterior interosseous	“Give me a thumbs up.” Extension of the thumb	Motor only	Branch of the radial nerve
Anterior interosseous	“Make an A-Okay sign.” Flexion of the thumb at the interphalangeal joint (flexor pollicis muscle)	Motor only	Branch of the median nerve
Median	“Make a claw.” Flexion of the PIP and DIP of the 2 nd and 3 rd digits.	Thenar eminence. Volar thumb, 2 nd , 3 rd digits and radial half of the 4 th digit.	
Ulnar	(The ulnar nerve provides this flexion function of the 4 th and 5 th digits) “Spread your fingers wide and cross your fingers” Controlled by the ulnar nerve innervated dorsal interosseous muscles.	Hypothenar eminence. Volar 5 th digit and ulnar half of 4 th digit	
Radial	“Rev a motorcycle.” Bring wrist into dorsiflexion.	Dorsal hand, thumb, 2 nd , 3 rd digits	

PIP, proximal interphalangeal; DIP, distal interphalangeal.

most significant ligamentous stabilizers of the distal radioulnar joint are the volar and dorsal radioulnar ligaments of the triangular fibrocartilage complex.³³ (Figure 1)

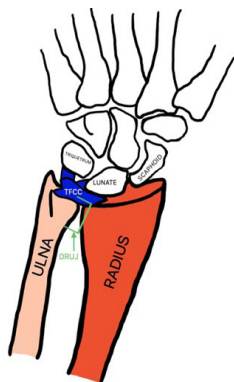


Figure 1. Anatomy of the distal radius and ulna. The radius and ulna articulate with each other at the distal radioulnar joint. The triangular fibrocartilage complex is the most significant stabilizing structure of this joint. The radius and ulna articulate with the triquetrum, lunate, and scaphoid carpal bones.

Imaging
Radiograph

Three-view wrist radiographs with posteroanterior (PA), lateral, and oblique views are the standard radiographs for evaluating injuries concerning for distal radius fractures.³⁴ The addition of the oblique view to the PA and lateral views has been shown to detect 4-5% more fractures.³⁵⁻³⁷ The measurements guide the need for fracture reduction from the PA and lateral views.³⁵ Dedicated forearm radiographs are not typically indicated for these injuries unless there is concern for

more proximal injuries based on physical exam.¹⁷ Radiography has a sensitivity of approximately 95% for detecting distal radius fractures and is 57% sensitive for detecting all wrist fractures including carpal bones.^{38,39}

The relationship of the radius to the ulna can be simplified by the “Rule of 11s”: The radius should be 11 mm longer than the ulna, the radius should have 11° volar tilt, and the radius should have 22° inclination.⁴⁰ Understanding these anatomic measurements is also important for defining when a fracture reduction is adequate and when surgery is indicated. These reduction goals are discussed in detail in Table 2 of the adult fracture pattern section.

Radial length is measured on PA radiographs with normal radial length of 10-13 mm. This is calculated as the distance between lines drawn perpendicular to the main axis of the radius at the distal tip of the radial styloid and the articular surface of radius where it abuts the ulna.^{39,41,42} (Figure 2)

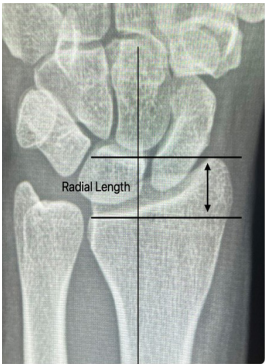


Figure 2. Measuring radial length.

Radial inclination is measured on PA radiographs with normal radial inclination ranging between 21° – 25° . Radial inclination is defined as the angle between a line drawn perpendicular to the shaft of the distal radius that starts at the sigmoid notch of the radius and a line connecting the sigmoid notch of the distal radius and the distal tip of the radial styloid.² (Figure 3)

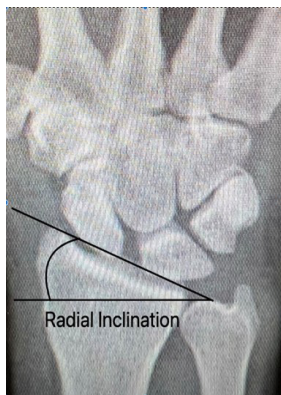


Figure 3. Measuring radial inclination.

Volar tilt is measured on lateral radiographs. The normal volar tilt is between 2° – 20° . Volar tilt is the angle between a line perpendicular to the long axis of the radius that starts at the palmar rim of the radius and a line connecting the dorsal and palmar rims of the articular surface of the distal radius.² (Figure 4)

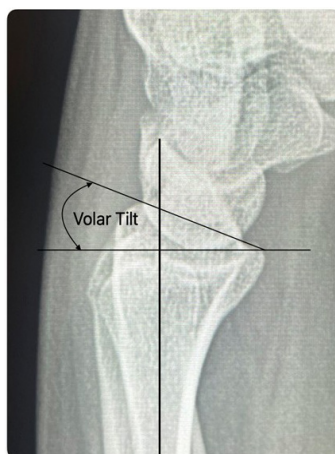


Figure 4. Measuring volar tilt.

Ulnar variance is measured on PA radiographs by calculating the difference between a line drawn through the sclerotic margin of the distal radius (running perpendicular to the longitudinal axis of the radius) and the distal rim of the ulnar dome.² Positive ulnar variance occurs when the ulna extends beyond the lunate fossa of the radius, and negative ulnar variance indicates the ulna does not reach the lunate fossa.² (Figure 5)



Figure 5. Measuring ulnar variance.

Computed Tomography

Computed tomography (CT) of distal radius fractures has limited utility for the initial evaluation of wrist fractures in the ED. Computed tomography of a distal radius fracture can identify occult fractures not seen on radiograph and provide details of the intraarticular extent of complex fractures. The American College of Radiology (ACR) Appropriateness Criteria defines CT for initial evaluation of blunt or penetrating wrist trauma as “usually not appropriate.” In the acute setting the ACR recommends CT only if initial radiographs are negative and one of three conditions exist: disruption of the distal radioulnar joint; carpal malalignment; and penetrating trauma with suspected foreign body.⁴³ Computed tomography for operative planning may be beneficial. Multiple studies have demonstrated that CT identifies injury patterns that change management for patients between 20–48% of the time.^{44–47} Overall, CTs do not impact care in the ED but may change surgical management.³³

Other Imaging Modalities

Ultrasound has been shown to have a sensitivity of up to 98% and a specificity of 93% compared to radiograph for identifying adult and pediatric forearm fractures.⁴⁸ Ultrasound can identify irregularities in the bone cortex at the fracture site, and this can be used to visualize the target for hematoma blocks (discussed in the analgesia section). Furthermore, ultrasound has utility for real-time visualization of cortical alignment during fracture reduction attempts.^{49,50} Although ultrasound has not been found to have a significant impact on surgical intervention rates or functional outcomes, using ultrasound instead of fluoroscopy can decrease radiation exposure for patients.⁵¹

Magnetic resonance imaging (MRI) is most useful for evaluating soft tissue injury, such as injuries to the triangular fibrocartilage complex, scapholunate ligament, and lunotriquetral

ligament, but it has little utility in evaluating acute fractures. Thus, MRI is not indicated in the acute ED setting.⁴³

Adult Fracture Patterns

The seven most common distal radius fracture patterns are discussed below. Emergent surgery for distal radius fractures is recommended in the setting of neurovascular compromise, compartment syndrome, open fracture, or irreducible dislocations.¹⁷ When patients have nonemergent surgery, outcomes are optimized when surgery is completed within 6-15 days of the initial injury.⁵²



Figure 6. This image of a Colles fracture demonstrates dorsal displacement with no intraarticular involvement. The fracture has an associated ulnar styloid fracture.

Colles fractures account for one-sixth (17.5%) of wrist fractures. In this injury pattern, the distal radius fracture fragment is comminuted with *dorsal* angulation and displacement but does not have intraarticular involvement (Figure 6).⁵³



Figure 7. This image of a Smith fracture demonstrates volar displacement with no intraarticular involvement. While the anteroposterior image raises concern for an intraarticular component, the lateral images demonstrate that the distal radius articular surface is intact. This fracture has an associated ulnar styloid fracture.

A Smith fracture, also referred to as a reverse Colles fracture, is a *volarly* displaced fracture that is comminuted and does not involve the articular surface (Figure 7).⁵⁴



Figure 8. Barton fracture with disruption of the intraarticular radial rim.

A Barton fracture is a distal radius fracture with involvement of the *dorsal* intraarticular rim leading to dorsal displacement of the distal radius and can involve subluxation/dislocation of the radiocarpal joint (Figure 8). Young males and motorcycle riders account for approximately 70% of Barton fractures.⁸ A reverse Barton fracture is a fracture along the *volar* intraarticular surface of the distal radius. In an emergency setting, closed reduction and splinting should be attempted for both Barton and reverse Barton fractures; however, due to the instability of these fractures and involvement of the articular surface, surgery is necessary to stabilize the joint and approximate the articular surface.^{55,56}

The reduction goals for Colles, Smith, Barton, and reverse Barton fractures are the same: restore radial length and inclination (PA radiographs); limit intraarticular stop-offs (PA, oblique, and lateral radiographs), and restore appropriate volar/dorsal angulation (lateral radiographs). While uninjured wrists have approximately 11° of *volar* angulation, the reduction goals are to restore the anatomy so there is not greater than 5-10° of *dorsal* angulation.⁹ Surgery is generally indicated if these goals are not achieved.⁹ (Table 2)

A Galeazzi fracture is a fracture of the distal one-third of the radius with dislocation of the distal radioulnar joint, which leads to an unstable fracture. It accounts for 7% of adult and 3% of pediatric forearm fractures. For adults, the treatment of a Galeazzi fracture is open reduction and internal fixation (ORIF), because 80% of closed reduction attempts in adults fail.⁵⁷⁻⁵⁹ In pediatric patients, closed reduction and casting is attempted first. A study by Eberl et al found successful closed

Table 2. Fracture reduction goals in adults (18-65 years of age) for Colles, Smith, Barton, and reverse Barton fractures.⁹

Radial Shortening	< 3 mm	PA radiographs
Acceptable Dorsal Angulation	< 10°	Lateral radiographs
Intraarticular Step Off	< 2 mm	PA, oblique and lateral radiographs
Change in Radial Inclination	<5°	PA radiographs

PA, posteroanterior.



Figure 9. Galeazzi fracture. The radius fracture is easy to locate. The ulna is distally displaced (+ ulnar variance) indicating disruption of the ligamentous structures of the distal radioulnar joint.

reduction is possible in 85% of pediatric cases, with only 15% requiring ORIF.⁶⁰ (Figure 9)

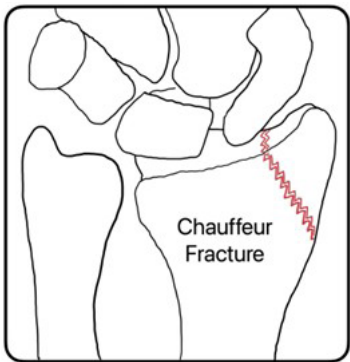


Figure 10. The chauffeur fracture is a distal radius fracture through the radial styloid.

A chauffeur fracture is an oblique or transverse intraarticular fracture of the distal radius through the radial styloid. The radial styloid fragment remains attached to the carpal bones through multiple ligaments, and there is typically significant displacement of the radial styloid from the remainder of the radius.⁶¹ Chauffeur fractures are treated operatively if there is more than 2 mm of displacement between the radius and radial styloid.⁶² (Figure 10)

Ulnar styloid fractures are present in 40% of distal radius fractures and are typically treated nonoperatively, but generally lead to increased pain and disability within the first

year after the injury.⁶³ Surgical fixation can be considered when the fracture occurs at the base of the ulnar styloid with displacement of greater than 2 mm, which can compromise the stability of the distal radioulnar joint.⁶⁴

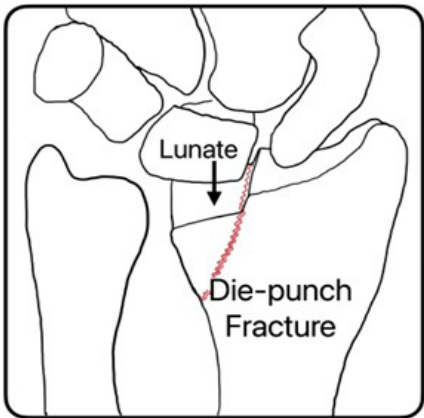


Figure 11. The die-punch fracture is an impaction fracture of the radius caused by force from the lunate.

Die-punch fractures (lunate fossa fracture) are intraarticular compression fractures at the lunate fossa of the distal radius that occur due to axial loading from a fall on an outstretched hand.. There are five subtypes of die-punch fractures, and all of them generally require open reduction and internal fixation.^{65,66} (Figure 11)

Geriatric Fractures

In 2022, the American Academy of Orthopaedic Surgeons and the American Society for Surgery of the Hand issued a strong recommendation to treat distal radius fractures nonoperatively in patients > 66 years of age.⁹ Studies that look at functional outcomes using scales including the Disabilities of the Arm, Shoulder, and Hand (DASH) Score and the Michigan Hand Outcomes Questionnaire, have demonstrated that long-term outcomes are similar between closed reduction and casting/splinting compared to operative treatment of distal radius fractures in this population.^{4,9,13–15} A 2022 meta-analysis demonstrated significantly lower DASH scores (representing higher functional capacity) in the casting group by –2.55 points on the 100 point scale across 11 studies. While this change in DASH scores does not reach the threshold of ten points for being a clinically significant improvement, it does demonstrate that casting is not inferior to surgical treatment in this age group.^{4,16} As a result of this data, each of these professional societies emphasize the importance of effective initial reduction, assessment of patient’s functional status, and focused conversations with patients to explain that surgery is unlikely to improve their long-term function.

Pediatric Fractures

Pediatric bones are comprised of four distinct areas. The epiphysis sits at each end of the bone and contains the articular surfaces. The physis is the active site of longitudinal bone growth (commonly known as the “growth plate”) and is the region with the most healing potential. The metaphysis is adjacent to the physis away from the articular surface. The diaphysis is the mid-section of the bone and is comprised of matured dense cortical bone.

The physis contains the growth center of pediatric bones. It is made up of four zones that each have a specific role in bone development. Nearest to the epiphysis is the zone of resting cells. This is followed by the zone of proliferating cells, which is where chondrocytes rapidly divide.⁶⁷ The third zone is the zone of maturing cells (hypertrophic zone), where bone lacks collagen and is not calcified. This is the most likely zone to fracture. Finally, the zone of provisional calcification is where bone develops greater strength (Figure 12).

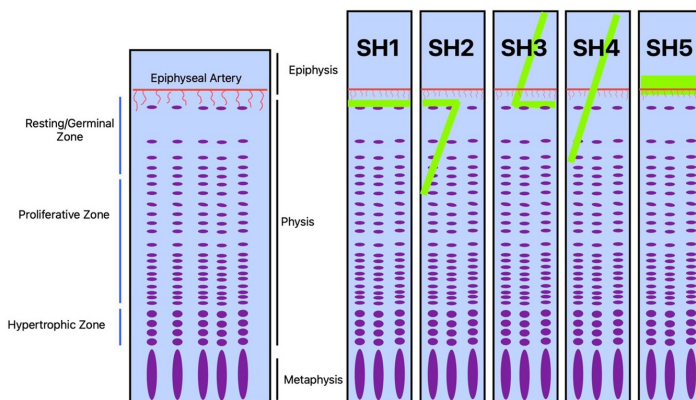


Figure 12. Zones of the growth plate and location of Salter-Harris fractures in relation to the epiphyseal artery and zones.

Most of the blood supply for the physis is supplied through the epiphyseal artery, which lies between the epiphysis and the zone of resting cells. Disruption of the epiphyseal artery places the bone at risk for growth arrest. This can occur with Salter Harris III, IV and V fractures.^{68,69} The rate of growth arrest related to distal radius Salter Harris fractures has been approximated to be 5%, while the risk for Salter Harris fractures of the ulna are much higher at near 50%.^{70,71} The risk of growth arrest in Salter Harris III and IV injuries is 10 times the risk associated with Salter Harris I and II fractures (0-4.6%). Data on Salter Harris V fractures is limited because they are rare injuries, occurring in <0.1% of fractures.⁷²

Physeal Fractures

Physeal fractures make up 15-20% of all pediatric distal radius fractures, and most can be managed nonoperatively. The Salter Harris classification system describes pediatric

physeal fractures to predict risk of growth arrest and recommend interventions.

- Salter Harris I: Injury directly at the physis.
- Salter Harris II: Fracture starts at the physis and extends away from the articular surface.
- Salter Harris III: Fracture extends from the physis towards the articular surface.
- Salter Harris IV: Fracture involves the physis and extends both towards the articular surface and away towards the metaphysis.
- Salter Harris V “Erasure”: Crush or compression injury to the growth plate, involving erasure of the growth plate.
 - Occurs because of repetitive micro-trauma across the growth plate (classically in gymnasts’ wrists) or from an acute force.⁶⁹
 - This fracture pattern has the potential to initially be missed radiographically. the radiograph can appear normal because there is no visible fracture line and the injury occurs to germinal cells within the epiphysis.⁷³ Eventually, it can be seen as a bony bar that arrests growth at the physis.⁶⁹

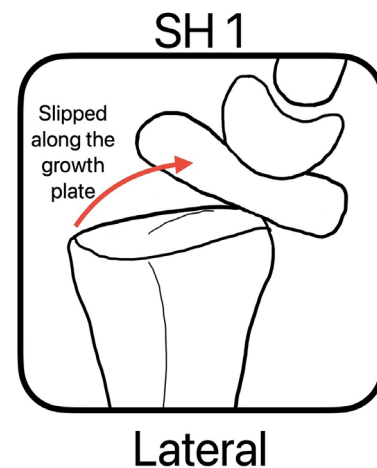


Figure 13. Displaced Salter Harris I fracture through the growth plate on a lateral view. The injury can also be occult where there are no radiographic findings, but an injury occurs at the growth plate.

Salter Harris I fractures can either be obvious with the distal radius completely slipped off the radial shaft, or they can be occult where the fracture occurs within the growth plate (see Figure 13). Radiographic evidence of Salter Harris I fractures can be absent on initial radiographs, and the accepted practice is to immobilize the extremity if there is pain with palpation over the growth plate, even if no fracture is identified. These patients should be referred to their pediatrician for repeat radiographs in 10-14 days; this is a somewhat arbitrary timeframe as radiographic signs of occult fracture healing can take up to 35 days to appear on

radiograph.⁷⁴ In addition, recent studies have shown that the rate of MRI-proven fractures in pediatric patients splinted with concern for occult Salter Harris I fracture is as low as 3%.⁷⁵ For displaced Salter Harris I fractures, a closed reduction is recommended to restore normal bony anatomy.

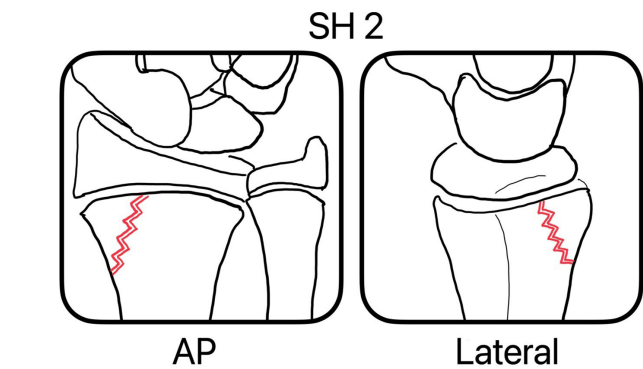


Figure 14. Salter Harris II fractures extend away from the articular surface.

Salter Harris II fractures do not disrupt the blood supply from the epiphyseal artery, which allows for more remodeling potential. The risk of growth arrest is reported to be 0-4.3%.⁷⁶ These injuries occur more frequently in adolescents, with one series reporting 70% of Salter Harris II fractures occurring in patients > 12 years old.⁷⁷ The closer the patient is to skeletal maturity the less opportunity there is for remodeling of displaced fractures.⁷⁶ Injuries < 1 cm of shortening and 15° of angulation are acceptable without reduction.^{78,79} (Figure 14)

Salter Harris III/IV fractures disrupt the epiphyseal artery and enter the articular surface; therefore, they must be reduced and splinted into anatomic alignment to limit the risk of partial growth arrest and cartilage damage. Most displaced Salter Harris III or IV fractures will be treated with percutaneous pinning or ORIF.⁸⁰ These are rare injuries that make up ≤ 5% of all Salter Harris fractures.¹ (Figure 15 and 16)

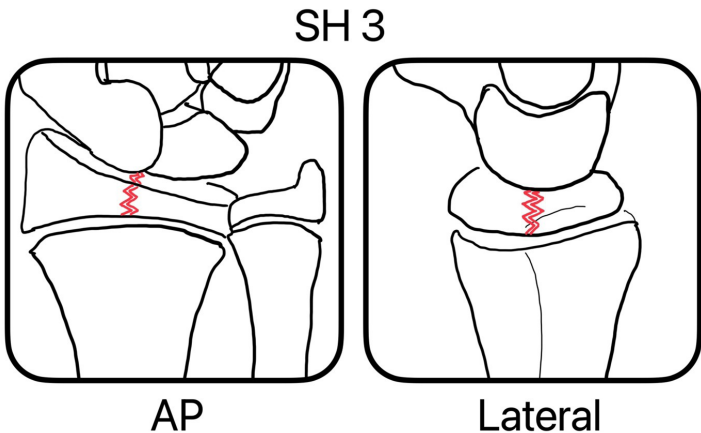


Figure 15. Salter Harris III fractures extend from the physis to the articular surface.

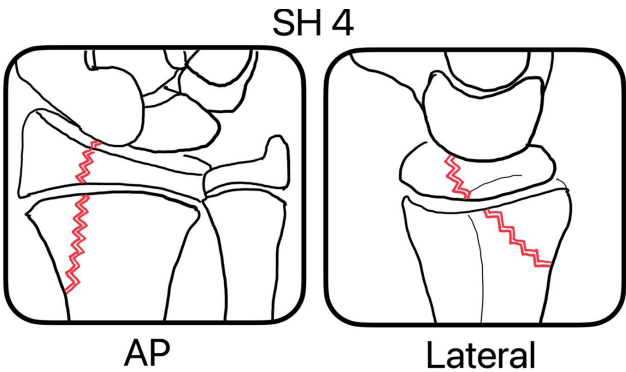


Figure 16. Salter Harris IV fractures involve the physis and extend both toward the articular surface and away from the articular surface.

All Salter Harris fractures that are managed nonoperatively require serial radiographs every one to two weeks to ensure fracture reduction is maintained. The patient must be followed until growth is visualized on radiographs to ensure there is no growth arrest. If loss of reduction occurs after seven= days, the general practice is to not. attempt re-reduction, because late manipulation can lead to iatrogenic physeal arrest.⁸⁰ One study found loss of reduction in roughly one-third of patients with pediatric Salter Harris II fractures, most of which were identified within the first two weeks post-reduction.⁸¹ (Table 3)

Table 3. Physeal fracture reduction goals for Salter Harris fractures.	
Salter Harris I	If displaced, restore anatomic alignment
Salter Harris II	< 1 cm of shortening and < 15° of angulation are acceptable without reduction
Salter Harris III	Restore anatomic alignment: usually surgical treatment
Salter Harris IV	Restore anatomic alignment: usually surgical treatment
Salter Harris V	Nondisplaced fracture pattern

Risk of Growth Arrest

Treatment of pediatric fractures that involve the physis focus on minimizing the risk of growth arrest. Factors associated with higher risk of growth arrest include younger age (< 10 years), greater initial displacement and angulation of the fracture, recurrent injury to the same joint, and higher grade Salter Harris fractures (III, IV, V).⁸²

Metaphyseal Fractures

The metaphysis is the portion of the bone that widens between the physis and the diaphysis of the forearm. This zone contains bone that is partially calcified and is vulnerable to fractures. Metaphyseal fractures can be further categorized into buckle fractures, greenstick fractures, and complete fractures. (Figure 17)



Figure 17. Complete metaphyseal fracture, with associated ulnar styloid fracture.

Metaphyseal fractures that involve disruption of both cortices of the bone (complete) can remodel through a significant range of displacement depending on the age of the patient. Fractures within the tolerances presented in [Table 4](#) can be splinted in place without further reduction. Metaphyseal fractures outside of these ranges require closed reduction prior to splinting.^{83–86}

A study by Orland et al found that 27% of pediatric patients < 10 years of age who received sedation for closed reduction of a distal radius fractures in a Level I pediatric trauma center did not require reduction if acceptable displacement guidelines were followed.⁸⁹ Beyond the patient safety concerns associated with unnecessary sedation, studies have shown that the cost difference between casting with sedation in the ED and casting in an orthopedic clinic is \$3,800–\$7,000.^{89,90}

In all cases, complete metaphyseal fractures require a molded splint to reduce the risk of further fracture displacement. Multiple studies have demonstrated that these fractures have a rate of re-displacement between 11–39%.^{91–95} They should also have follow-up radiographs at one week after the injury to evaluate for re-displacement of the fracture.⁹¹ Patients will be transitioned to a cast at that visit, and they can expect to be in a cast for 4–6 weeks.

Buckle fractures demonstrate no cortical lucency and include a stable, nondisplaced compression injury of one

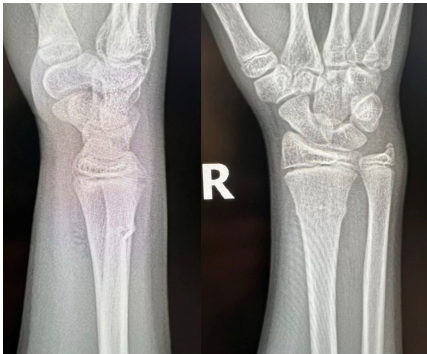


Figure 18. Distal radius buckle/torus fracture.

cortex. They are managed nonoperatively with a removable Velcro wrist splint or short-arm cast.^{96,97} A recent study found that orthopedic management of distal radius buckle fractures is trending toward use of removeable wrist splinting for approximately three weeks, minimal follow up, and no reimaging.⁹⁶ The 2023 FORCE trial found similar pain relief (3.21 versus 3.14) for wrist splints versus rigid immobilization, and no differences in pain or function at six-week follow-up.⁹⁸ ([Figure 18](#))



Figure 19. Greenstick fractures of the radius and the ulna.

Greenstick fractures are defined as partial thickness fractures where the cortex and periosteum are interrupted on one side of the bone while they remain uninterrupted on the opposing side. Greenstick fractures typically occur in patients 5–14 years of age.^{83,84} ([Figure 19](#))

Table 4. Acceptable displacement of pediatric metaphyseal fractures by age.

Age range	Acceptable sagittal angulation	Acceptable coronal angulation	Shortening from Bayonet apposition (the bone is offset side-to-side without angulation)
5-9 years ^{83,84}	25°	20°	< 1 centimeter
≥10 years ^{86–88}	15°	15°	Not tolerated if < 2 years of growth remaining: Growth typically completes at 14 years of age in girls and 16 years of age in boys.

Nondisplaced greenstick fractures require initial immobilization with a sugar-tong splint and transition to a short-arm cast at clinic follow-up.⁹⁹ Table 5 lists the acceptable limits of angulation and shortening for greenstick fractures based on age. For fractures outside these limits, closed reduction is recommended for optimal recovery.^{100,101}

Table 5. Acceptable greenstick fracture angulation.

Infant	< 30°
Children	< 15°

The mechanisms that lead to a greenstick fracture involve rotational forces; therefore, reduction requires the opposite rotation. If the fracture apex points to the volar arm, reduction requires traction and pronation. If the apex of the fracture points to the dorsal arm, reduction involves supination. The rule of thumb is to rotate the hand toward the apex of the fracture to reduce it. Splints should be applied with the forearm in the position required to achieve reduction (pronation or supination).⁸⁶

Acute Analgesia

There are multiple pain management options for patients with distal radial fractures. Nonsteroidal anti-inflammatories (NSAIDs) are a cornerstone of pain management and have been shown to not have a detrimental impact on extremity fracture healing in adult or pediatric patients, which makes ketorolac a reasonable choice for analgesia in the acute setting.^{102–106} Intravenous (IV) opiates, such as fentanyl, hydromorphone, and morphine may be necessary to treat acute fracture pain. Fentanyl has a half-life of approximately 45 minutes and may require multiple doses compared to the longer acting opiates hydromorphone (2-hour half-life) and morphine (4-hour half-life). Low-dose IV ketamine (0.1-0.3 mg/kg) has been shown to have similar analgesic effects to morphine and is a reasonable alternative, or adjunct, to IV opiate medications. Ketamine has been shown to have significant analgesic effect up to one hour.^{107–109}

Hematoma blocks have been shown to be safe and effective for the reduction of distal radius fractures. Multiple studies have found that compared to procedural sedation, hematoma blocks are noninferior in treating pain during fracture reduction, may improve post-reduction pain and decrease ED length of stay.^{110–112} Specifically, a study by Bear et al found that pediatric patients who received a hematoma block spent 2.2 hours less time in the ED compared to procedural sedation.¹¹³ To perform a hematoma block the following steps are taken:

- Localize the fracture site by palpation, ultrasound, or fluoroscopy.
- Clean the forearm skin using chlorhexidine,

- povidone-iodine, or another disinfecting solution.
- The incidence of infection from hematoma block is exceedingly low, with multiple studies reporting zero complications of infection.^{114–116}
- There was no reported difference in infection rates between chlorhexidine and povidone-iodine.¹¹⁷
- Introduce a 21-gauge sterile needle 1-3 cm proximal to the fracture at approximately a 30–45° angle and advance it until blood is aspirated from the fracture hematoma.
- Inject 5-10 mL of 1% lidocaine into the fracture hematoma.
- Perform reduction 5-10 minutes after the hematoma block is placed.¹¹⁸

Analgesia for distal radius fractures can also be achieved by ultrasound-guided nerve blocks of the forearm.^{119,120} Of note, our institution requires that any nerve block impacting the median nerve (both blocks of the median nerve itself or more proximal blocks) only be performed with ultra-short acting anesthetic (chloroprocaine) because of the risk of masking acute carpal-tunnel syndrome if the median nerve is entrapped because of injury or during reduction. This is a rare complication, found in roughly 4% of distal radius fractures and is associated with high-energy injuries and polytrauma. While this can present acutely, symptoms generally appear one week after injury.¹²¹

Bier blocks are used for analgesia in some institutions. The procedure involves placing a tourniquet on the proximal arm, exsanguinating the arm through elevation and pressure wrapping, and injection of IV anesthetic into the extremity to achieve anesthesia. While Bier blocks have been shown to provide similar analgesia and quality of reduction compared to hematoma blocks, risks including local anesthetic systemic toxicity, tourniquet pain, and resource intensity buffer the potential benefits of performing Bier blocks in the ED.¹²²

Outpatient Pain Management

Patients discharged from the ED will require a thoughtful analgesia plan. The American Academy of Orthopedic Surgeons recommends that fractures be treated with “non-opioid pain medication (eg, ibuprofen, acetaminophen), splint, ice, elevation, and reassurance.”¹²³ When opiates are deemed necessary, they should be low dose and of short duration (2-3 days).^{124–127} Opiates premixed with acetaminophen can cause confusion for patients trying to calculate acetaminophen dosage; when possible, noncombination medications may be more appropriate. A randomized trial evaluating five oral analgesic plans, including ibuprofen/acetaminophen and opioid/acetaminophen combinations, found no difference in analgesia between nonopioid and opioid combinations.¹²⁸ Significantly more nausea and vomiting were reported among patients receiving opioids. Thus, priority should be placed on

ensuring proper dosing of ibuprofen and acetaminophen.¹²⁹ If it is decided that a patient warrants opiate pain medication, the clinician should follow the U.S. Centers for Disease Control and Prevention 2022 Clinical Practice Guidelines for Prescribing Opioids for Pain, which recommend three days or less of an opioid prescription in the setting of acute fracture-related pain.¹³⁰

For pediatric patients, multiple studies have demonstrated no benefit of adding opiates to NSAIDs and acetaminophen for outpatient pain management once an extremity fracture has been immobilized.^{131–134} Pain management strategies should focus on rest, ice, elevation, and reassurance. Immobilizing with a sling or elevating the affected limb while sleeping are nonpharmacologic adjuncts for pain management, although specific data is limited on pain improvement from these interventions.¹³⁵

Reduction Techniques

Closed reduction of distal radial fractures in the ED entails use of both manual manipulation and finger trap techniques. Finger trapping involves suspending the hand vertically with the use of finger traps attached to an IV pole while applying weights (typically 10 pounds) to the upper arm to provide longitudinal traction across the fracture site. This is maintained for approximately 15 minutes. While this is a common practice, there is minimal literature reviewing the efficacy of this technique.¹³⁶

Fracture reduction technique depends on the direction of displacement of the distal radius. Fractures with *dorsal* displacement, such as Colles, Barton, and some die-punch fractures, first require traction in line with the deformity and then re-creation of the injury with exaggerated *dorsal* tilt of the distal part of the fracture. This maneuver disengages the fracture fragments from the periosteum to liberate the distal bone so that it can be pushed/reduced volarly and in line with the radial shaft. *Volarly* displaced radius fractures, such as Smith, reverse Barton, and certain die-punch fractures, are reduced with a mirrored reduction technique. With longitudinal traction in place, *volar* displacement is first accentuated, and then dorsal pressure reduces the fracture to be in line with the shaft of the radius.

Pediatric Galeazzi fractures require sedation for reduction and may require general anesthesia for appropriate closed reduction. After reduction, they are splinted in supination to support the reduction.^{58,60,137}

Displaced distal radius fractures should be immobilized with a sugar-tong splint, which limits both wrist flexion/extension and forearm pronation/supination.¹³⁸ While patients may be transitioned to a cast that does not include the elbow at clinic follow-up, in the acute setting splints for distal radial fractures should immobilize the elbow.¹³⁹ It is not standard of care to provide thumb immobilization with the splint; a recent metaanalysis found that thumb

immobilization does not improve scaphoid fracture healing, pointing to limited utility of thumb immobilization even if there are associated carpal fractures.¹⁴⁰

Indications for surgery after closed reduction include post-reduction radial shortening > 3 mm, dorsal tilt > 5–10°, intraarticular displacement (chauffeur and Barton fractures), or fracture step-off > 2 mm.^{9,141} Any open fracture or fracture associated with neurovascular injury requires emergent orthopedic surgery evaluation (see the section on open fractures below for more details).

Splint Molding

A detailed discussion about splinting is beyond the scope of this paper, but it is important to understand splint molding. Many fractures re-displace during splint application. Fractures that are most likely to re-displace include those with concomitant ulnar fractures, completely displaced fractures, and those with significant oblique angulation from the original axis.¹³⁸ Effective three-point molding techniques can minimize the risk of re-displacement after reduction. One study found that the rate of re-displacement of fractures between ED reduction and orthopedic clinic follow-up following targeted teaching on three-point molding technique decreased from 65% to 44%.¹⁴² Attempts at re-reduction of displaced distal radial fractures in the ED generally do not significantly improve radiographic alignment or decrease need for surgery.¹⁴³

To place a three-point mold use the following steps:

- Point 1: Apply pressure just distal to the fracture in a direction that supports the displaced fragment from moving back to its original location.
- Point 2: Apply pressure just proximal to the fracture and in the opposite direction of point 1.
- Point 3: Apply pressure to the proximal forearm in the same direction as point 1.
 - The third point both molds the splint and limits rotation of the forearm.

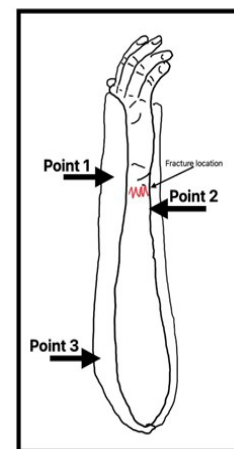


Figure 20. Three-point mold for a dorsally displaced distal radius fracture in a sugar-tong splint.

The cast/splint index is a measure of adequate compression of a splint and is defined as a ratio of anteroposterior to lateral internal diameters of the splint at the level of the fracture.¹⁴⁴ Studies have demonstrated that a cast/splint index > 0.8 correlates with increased risk of re-displacement of the fracture.^{145,146} For example, if the volar width of the splint is 5 cm (which should match the width of the forearm), then the diameter on lateral radiograph should be < 4 cm to have an appropriate cast/splint index (< 0.8). (Figure 20)

Open Fractures

An open fracture requires urgent operative intervention and stabilization. The American Academy of Orthopaedic Surgeons Practice Guidelines on Preventing Surgical Site Infection recommends debridement and irrigation in the operating room of open fractures as soon as reasonable, and within 24 hours post-injury, to decrease risk of fracture-related infection and surgical site infections.¹⁴⁷ Administering antibiotics within an hour of an open fracture limits the spread of infection.¹⁴⁸ Studies have found 2.4 times increased risk of infection if antibiotics are given > 120 minutes after injury, and an infection rate of 20% if antibiotics are given > 150 minutes following injury, compared to 4% if given within one hour.^{149,150}

The Gustilo-Anderson system was created to help define the severity of open fractures and it guides antibiotic choice for open fractures.¹⁵¹

- Type I: < 1 cm wound length. Simple fracture pattern. Minimal soft tissue damage and contamination.
- Type II: > 1 cm wound length. Simple or comminuted fracture pattern. Moderate soft tissue damage/contamination.¹⁵²
- Type III: > 1 cm wound length. Extensive soft tissue damage and trauma.

For grade I and II open fractures, 2 g cefazolin IV is the recommended antibiotic, or 3 g for patients > 120 kg. For grade III open fractures, additional Gram-negative coverage is recommended and often achieved with the addition of 6 mg/kg gentamicin IV.¹⁴⁰

LIMITATIONS

There are several limitations to this narrative review. The first is that because a significant proportion of the data related to the treatment of distal radial fractures comes from the orthopedic literature, it must be translated to the ED clinical setting. Additionally, evidence for the use of ultrasound and ultrasound-guided nerve blocks in the ED for the treatment of distal radial fractures is still provisional. While some data has been intriguing, the tools have not been widely adopted into community practice.¹⁵³ Guidelines on appropriate criteria for pediatric fracture reduction goals vary between sources; thus, we have presented recommendations that compile data from multiple studies conservatively. Finally, we did not discuss

appropriate splinting methods in this review; there is variable practice between locations on appropriate materials and methods for splinting/casting.

CONCLUSION

Distal radial fractures are common in patients of all ages. Initial evaluation should involve radiographs, a physical exam assessing for motor and sensory deficits, and adequate pain control. Treatment and reduction of the fracture depend on the specific fracture pattern, degree of displacement and patient age. Adequate reduction of fractures in adult patients (18-65 years of age) is defined using the following measurements: < 5 mm of radial shortening; < 5-10° of dorsal angulation (or within 20° of the other wrist); < 2 mm intraarticular step off; and < 5° of radial inclination change. In patients ≥ 65 years of age, nonoperative management of displaced distal radius fractures has recently been shown to have noninferior outcomes to patients who are treated surgically. Therefore, most geriatric patients are treated with closed reduction alone; this means that the reduction in the ED will determine long-term bony alignment. Pediatric patients have the ability to heal significantly displaced fractures. There are age and fracture-morphology guidelines that guide whether pediatric distal radial fractures require reduction prior to splinting in the ED.

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