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Distal Radius Fractures: Beyond the Basics

James A Johanning*, Mehnaz Parvez and Carrie Marzolf
Department of Physician Assistant Studies, St. Catherine University, USA

Introduction

Distal radius fractures are a fundamental orthopedic problem confronting trauma care providers. This fracture is one of the most common fractures seen in the trauma care setting. It is estimated this type of fracture accounts for 20% of all fractures seen in Emergency Departments [1]. In addition, "the incidence of radial fractures is increasing as life expectancy grows, leading to a larger population of patients who are at risk for these injuries." [2]. With respect to age, peak incidence occurs in both young adults and individuals of advanced age [2]. Distal radius fractures are sometimes treated with immobilization but also frequently require surgery [1]. It is notable that distal radius fractures are associated with several potentially avoidable complications and comorbidities which include osteoporosis, complex regional pain syndrome and acute carpal tunnel syndrome [3-5]. With this, it is imperative that trauma care providers be versed in not only diagnosis and appropriate treatment of these fractures but also in taking measures to recognize and treat potential debilitating complications.

While there are different types of distal radius fractures, this article will focus on the most common: The Colles Fracture. The Colles fracture was first described by Irish surgeon and anatomist Dr. Abraham Colles [6]. It is best defined as a distal radius fracture with dorsal comminution, dorsal angulation, dorsal displacement, radial shortening, and an associated ulnar styloid fracture [7]. The term Colles fracture is often used synonymously for distal radial fractures with dorsal angulation alone [8]. In the author's experience, the term "Colles" is used more loosely in the trauma care setting to include non-displaced fractures or those with any one or more of the above features.

The ideal audience for this article is the primary care, urgent care or emergency trauma care provider. The goal is to demonstrate appropriate diagnosis and treatment, the need for orthopedic surgery consultation *vs.* fracture care in a primary care setting and how to avoid potential complications. This article reviews safe and effective splinting options for treating such fractures. Going beyond the basics, the focus will be on three potentially preventable conditions that are associated with distal radius fractures. These include: acute carpal tunnel syndrome, undiagnosed osteopenia and osteoporosis, and complex regional pain syndrome.

Diagnosis: Diagnosing distal radius fractures typically involves an accurate history, physical examination and radiologic imaging [2]. There are many mechanisms that can lead to fracture of the distal radius, however, the most common is a fall on an outstretched hand ("FOOSH") [9].

On physical examination, patients often present with mild to moderate acute distress, guarding of the affected extremity, pain at the level of the wrist and possibly a visible deformity [2]. "Ippers – v" or IPRRSSS-V is an easy pneumonic one can apply to virtually any orthopedic issue. Created by this author, it stands for I: Inspection, P: Palpation, R: Range of Motion, R: Reflexes, S: Strength, S: Sensation, S: Stability, S: Special tests and V: Vascular. For the distal radius fracture, inspection of all surfaces of the wrist is imperative as any bleeding or severe skin tenting indicates an open fracture or pending open fracture [2]. Both open and pending open fractures require emergent orthopedic surgical consultation [10]. Palpation will typically reveal focal tenderness at the distal end of the radius and sometimes the ulnar styloid. Often, there is tenderness at the anatomic snuffbox (ASB), proximal carpal row, distal radioulnar joint (DRUJ), ulnar styloid, ulnocarpal joint or elsewhere. This may represent alternative or additional pathology such as scaphoid fracture, disruption of the DRUJ, scapholunate dissociation, fractured hook of hamate, true wrist dislocation or other [11]. These associated injuries should be evaluated and treated appropriately however, this article will focus on isolated distal radius fractures. Range of motion should be examined in all planes to include flexion, extension, radial and ulnar deviation as well as supination and pronation. Limitations due to pain in all planes of motion are expected in the acute setting and re-examination after a period of immobilization is sometimes necessary [11]. It is notable that if supination and pronation are significantly limited and painful, one should suspect a DRUJ disruption [12]. If this is the case, the patient likely needs reduction and / or surgical intervention [12]. Reflexes are expected normal or may be blunted due to pain. Strength will be expectedly limited due to pain, however, true weakness due to nerve injury is rare [13]. Nonetheless, a focal motor examination including radial, median and ulnar nerve motor inputs should be performed [2]. Any true weakness deserves further careful evaluation [13]. This will be discussed further in the Acute Carpal Tunnel Syndrome section below. All distal radial fracture patients' sensation should be examined with light touch and two-point discrimination over the radial, median and ulnar nerve distributions [2]. This also is further discussed in the Acute Carpal Tunnel Syndrome discussion below. In the acute setting, it is ill advised to perform other stability or special tests for the wrist as it could displace a non-displaced (ie. non-surgical) fracture. Assessment of vascular integrity follows. Vascular examination can include distal radial and or ulnar pulses or capillary refill being less than two seconds alone. It is important to document abnormal or normal neurovascular findings as this confirms it to be intact or impaired and serves as a baseline to compare to by orthopedists and other specialists involved in upcoming care [2].

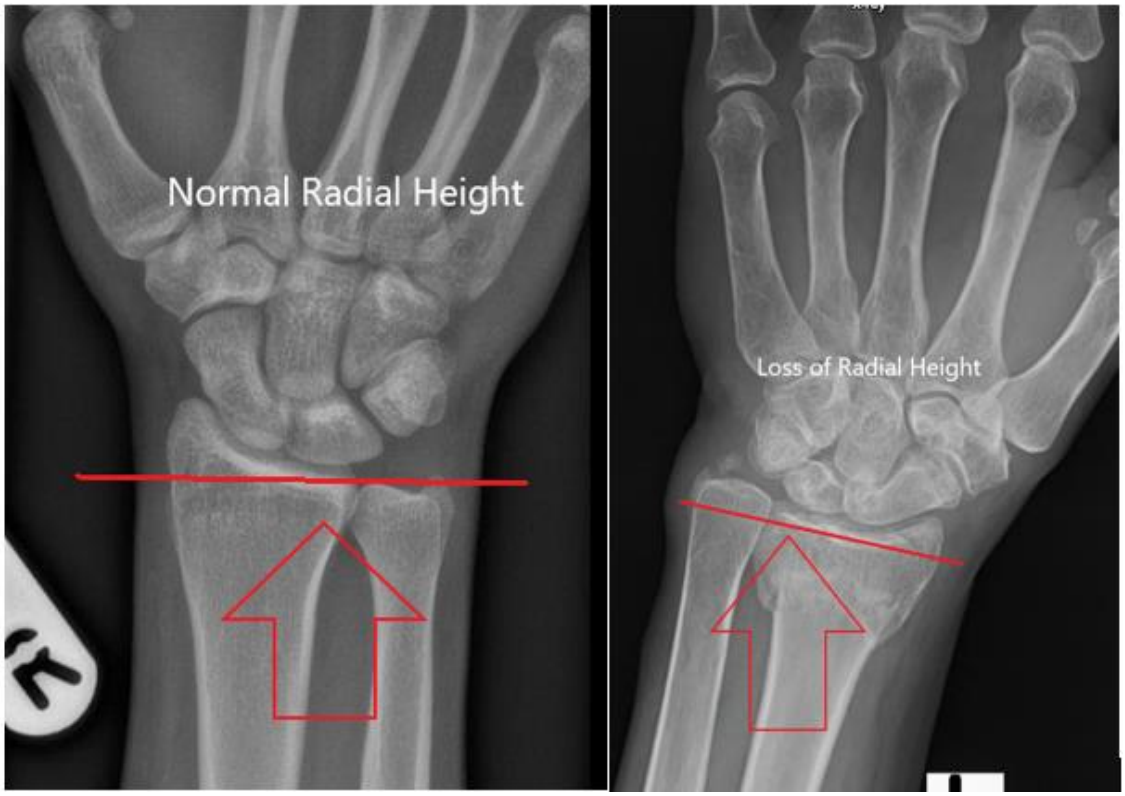
Radiographic Imaging: Imaging of distal radius fractures starts with x-rays [2]. In some cases, further imaging

such as CT scans are required however this article will focus on x-ray interpretation. In the acute setting, preferred views in wrist trauma include: PA and lateral and oblique images [14]. Upon analysis, the trauma care clinician should first diagnose the fracture and type. For example, a radial styloid fracture, scaphoid fracture or scapholunate dissociation may mimic a distal radius fracture clinically. The distal radius fracture is a metaphyseal fracture that occurs approximately 1.5 inches proximal to the articulation with the proximal carpal row [2].

Once a distal radius fracture is confirmed on imaging, there are three key findings on X-ray that help determine treatment: radial height, radial inclination and volar tilt [2]. These findings are important in determining appropriate treatment including splint, follow up and referral destination. There are different approaches to reducing fractures, holding fractures and fixation of fractures. The discussion in this article is limited to the trauma and care clinician making the initial determination of splinting, index treatments and surgical *vs.* non-surgical referral.

The three key radiographic features mentioned above are now described in detail. Importantly, if any of these three features are compromised, then surgical consultation is indicated to determine definitive treatment with immobilization *vs.* closed reduction and or surgical intervention.

Radial Height is an assessment of the length of the radius. The radius should be as long as or slightly longer than the ulna on the PA x-ray view [15]. It is important to measure radial height at the DRUJ on the PA view (Figure 1a). A distal radius fracture with loss of radial height is shown in (Figure 1b). This leaves a person with "positive ulnar variance" ie. the ulna is longer than the radius by 2.5 mm or more. Loss of radial height due to distal radius fracture leading to positive ulnar variance can lead to poor wrist function and ulnar sided wrist pain secondary to ulnar impaction syndrome [16,17].



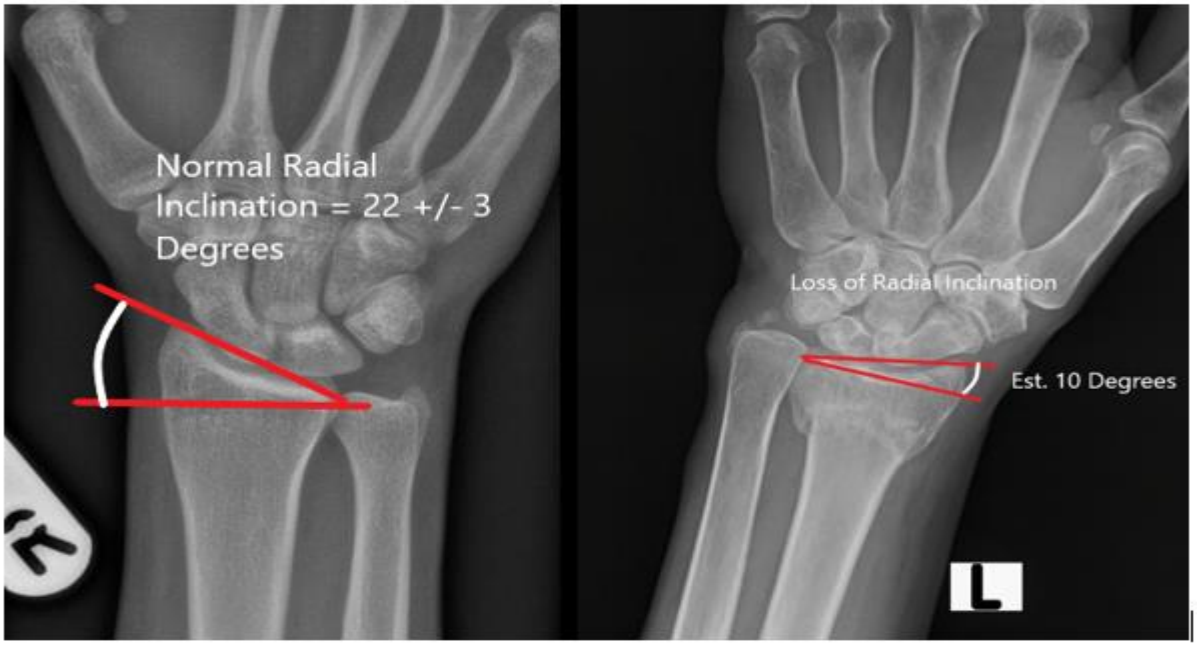
Figures 1a: Normal Radial Height; **1b**: Loss of Radial Height.

Radial Inclination (RI): is an assessment of the integrity of the radial styloid on the PA view of the wrist. It is measured from the DRUJ as the angle from horizontal across the radius to the tip of the radial styloid. Normal Radial inclination is approximately 19-25 degrees [14]. Figure 2a which shows normal RI. Loss of RI after distal radius fracture can be seen in Figure 2b.

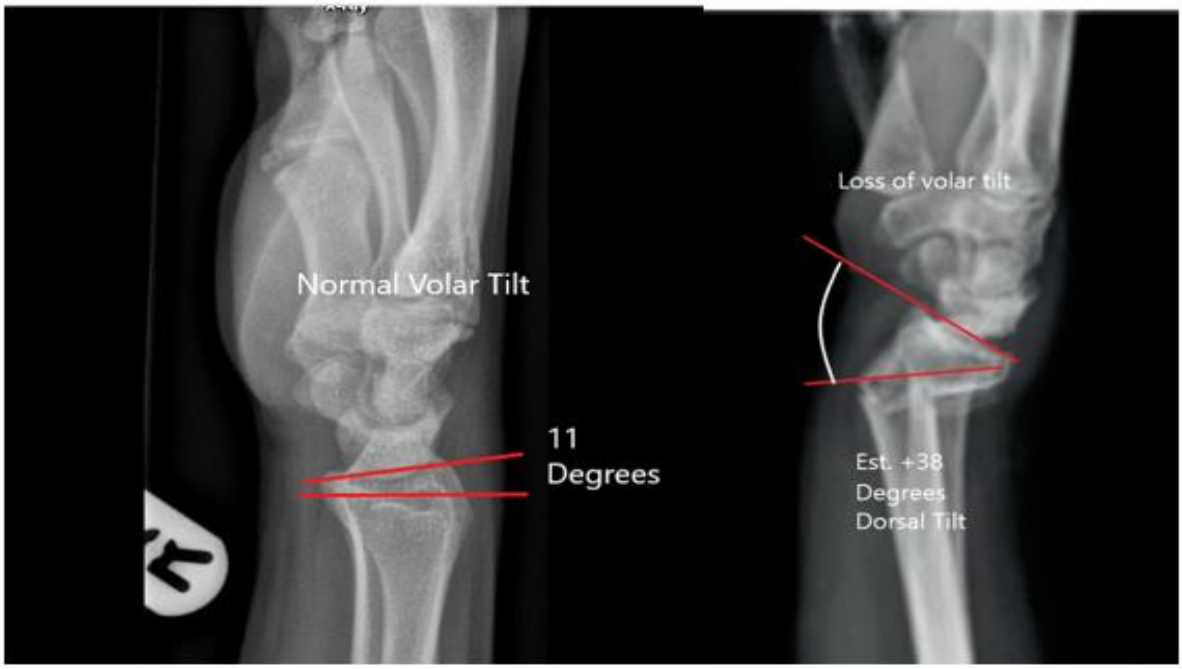
Volar tilt (VT): Is a measurement of the wrist joint itself. The accepted normal wrist VT is approximately 11 degrees in the volar or palmar direction (Figure 3a). This provides for a functional plane of motion in flexion and extension. Notably, a wrist joint with neutral volar tilt has already lost 11 degrees of volar tilt and is displaced. Loss of volar tilt leading to malunion leads to limited flexion and extension of the wrist and a limited functional outcome [17]. Loss of volar tilt is shown in (Figure 3b).

It is noteworthy that with each of these three features, there are acceptable and unacceptable degrees of angulation and millimeters of length that is best determined by an orthopedic specialist. There is even some debate in the orthopedic community on this, however, general consensus is agreed upon [18]. In the author's opinion, it is the trauma care providers' responsibility to determine non-surgical versus the need for reduction and possible surgery. Based upon this best

splint choice and appropriate referral should follow. It is worthy to emphasize and repeat that if any one of these three features are compromised, surgical consultation is indicated to determine definitive treatment.



Figures 2a: (R)Normal Radial Inclination; **2b**: (L)Loss of Radial Inclination.



Figures 3a: Normal Volar Tilt, **3b:** Loss of volar tilt.

Treatment: Distal radius fractures are commonly treated with either appropriate immobilization and careful follow up or closed reduction with immobilization or surgical intervention [1,2]. This discussion will focus on appropriate initial immobilization with splinting. The above details should be used as a guide to determine the splint of choice. Sugar tong splints are recommended for multiple reasons including the advantage of controlling pronation and supination in the case of a DRUJ disruption, and immobilization of the elbow which minimizes fracture migration in the first few days after injury [18]. In the author's experience, fractures that obviously need surgery require less aggressive immobilization initially. This is due to the fact that the patient will undergo formal reduction. It is those fractures that undergo reduction in the

clinic or those that are non-displaced that necessitate more aggressive splinting in the form of the sugar tong splint. Fracture migration is most common within the first 2 weeks from injury and often due to overuse and the pull of the brachioradialis (BR) muscle on the distal fragment with elbow usage. It is for this reason; the BR insertion is sometimes released in surgical settings. [19]. The sugar tong splint controls forearm supination and pronation as well as elbow flexion and extension. It is more protective and minimizes risk of fracture migration in the early stages of fracture healing.

A volar splint is indicated if it is determined that a fracture is displaced and requires orthopedic consultation for reduction and management *vs.* surgical intervention. This splint allows for elbow range of motion to the patient's tolerance. A common error in applying this splint is having it too long on the volar (palmar) side (Figures 4a,4b). Note the limited MCP flexion in Figure 4b. Splints that are too long into the volar portion of the hand impede MCP flexion and lead to significant and debilitating finger stiffness. Hand stiffness is a common complication of distal radius fracture [20]. Avoidable finger stiffness can delay functional outcome after distal radius fracture by months and may require additional treatment such as physical or occupational therapy that otherwise would be unnecessary. Figure 4c and 4d show a well-placed volar splint for the patient who likely needs reduction of the fracture or surgery. Notice the demarcated distal palmar crease and demonstration of full 0-90 Degrees of MCP flexion which avoids an avoidable and debilitating complication. This is a crucial feature to adopt and employ in the practice of trauma and care when it comes to distal radius fracture.

Figures 4a,4b: A common error in applying volar splint; **4c,4d:** A well-placed volar splint.

A sugar tong splint is indicated for a distal radius fracture that is determined to be most likely non-surgical for the reasons outlined above [18]. In the author's opinion, a sugar tong splint should be used if there is any question as to which splint is indicated. The same recommendations apply regarding the volar length of a sugar tong splint as the volar wrist splint. The volar aspect of a sugar tong splint applied in the setting of distal radius fracture should not extend beyond the distal palmar crease. Figures 5a and 5b demonstrating inappropriate sugar tong splinting which limits MCP flexion. Figures 5c and 5d which show appropriate splints allowing full MCP flexion. Of importance for the urgent care and emergency provider, special precaution should be taken with prefabricated splints which are often too long volarly and limit MCP flexion. These splints should be molded and modified appropriately or avoided all together in favor of custom splints utilizing plaster, ortho-glass or other modifiable medium.

Figures 5a,5b: Inappropriate sugar tong splinting which limits MCP flexion; **5c,5d:** Appropriate splints allowing full MCP flexion.

Beyond the basics of Distal Radius Fractures

Acute Carpal Tunnel Syndrome

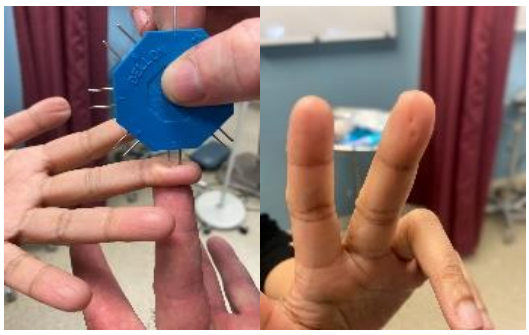
Carpal Tunnel Syndrome (CTS) following distal radius fracture is an overall rare yet potentially ominous complication. Carpal tunnel syndrome post distal radius

fracture has been estimated to occur in 9.1% of all DR Fx's [21,22]. These are divided into acute, subacute, transient or delayed CTS [22]. This article focuses on acute carpal tunnel syndrome (ACTS) which is a surgical emergency [23]. Among all types of carpal tunnel syndrome, ACTS comprises the majority. ACTS occurs in an estimated 5.4 to 8 % of all distal radius fractures [22]. It is sometimes unrecognized and can lead to permanent median nerve sensory - motor dysfunction [22]. The cause of acute carpal tunnel syndrome in the setting of distal radius fracture includes direct nerve injury from bony contact as well as hemorrhage into the carpal tunnel [22]. The carpal tunnel is a fixed space and any spacial compromise can damage the median nerve leading to temporary or permanent numbness over the median nerve distribution. It also impairs the motor function to all median nerve innervations distal to the carpal tunnel, specifically abductor pollicis brevis (APB) which is responsible for thumb abduction. [24]. Notably, motor input to flexor pollicis longus (FPL), flexor digitorum superficialis (FDS) and profundus (FDP) to index through small digit is maintained as the motor branch of the median nerve exits proximal to the carpal tunnel [25]. In addition, the opponens pollicis (which functions to adduct the thumb and is involved in pinching) is innervated by the deep terminal branch of the ulnar nerve [25]. Therefore, thumb adduction is often also preserved in CTS and is involved in the action of pinching. Pinch is a complex maneuver involving motor inputs from not only the median nerve to FPL and FDP to index and thenar musculature but also from ulnar nerve inputs to the opponens pollicis. This is significant as pinch strength (which is often measured clinically) can be maintained in the setting of carpal tunnel and mislead a provider when there is actual median nerve motor compromise. The best test of strength in the setting of CTS is resisted thumb abduction [24]. The abductor pollicis brevis muscle (APB) is isolated here and is the only muscle of the thenar eminence which is purely median innervated *(via median nerve inputs that pass through the carpal tunnel)* [25]. Performing this test is quite specific and involves having the patient place their hand palm upward and aligning the thumb to the index finger with subsequent resisted cephalad extension of the thumb. See Figure 6a which shows the less sensitive test of pinch strength and 6b which shows the preferable test: resisted thumb abduction.

Figure 6a: Resisted pinch strength testing; **6b**: Preferable resisted thumb abduction test.

Functional compromise of chronic median neuropathy can be permanent and lead to significant limitations. If acute carpal tunnel syndrome is missed or neglected, irreversible damage to the median nerve may result [26]. In the setting of distal radius fracture, acute carpal tunnel syndrome should be evaluated in all patients to prevent these potential complications. Careful evaluation of sensory-motor input is recommended in all distal radius fractures. This article will focus on the median nerve. Sensory testing per the trauma care clinician should include sensation to light touch over the radial, median and ulnar nerve distributions. If there is any suggestion of compromise as compared to the opposite side, 2-point discrimination is indicated. Loss of 2-point discrimination is seen in acute carpal tunnel syndrome [26]. Two-point discrimination is a sensitive and replicable test to assess median or other nerve sensation. Normal 2-point discrimination over the median nerve distribution at the thumb, index, long and radial half of the tip of the ring finger is approximately 5 mm. Notably, patient's notice the long finger over all others when asked which digit is most affected by CTS [27]. Therefore, this testing is recommended over all median nerve distributions with particular focus on the volar aspect of the long finger for this reason. Accurate measurement of 2-point discrimination is provider dependent and needs to be performed accurately. Preferably this is performed with weighted 2-point discriminator devices without excessive pressure applied per the provider. See Figure 7a and 7b showing inappropriate 2-point discrimination with excessive pressure applied and Figure 7c showing appropriate 2-point discrimination technique with no excessive pressure applied to the patients digit. This naturally avoids enhanced patient perception of 2-point *vs.* 1-point discrimination during examination.

For the trauma care provider: if a patient has limited APB strength with or without sensory deficits over the median nerve distribution in the setting of distal radius fracture, emergent orthopedic consultation is indicated.



Figures 7a,7b: Inappropriate 2-point discrimination.

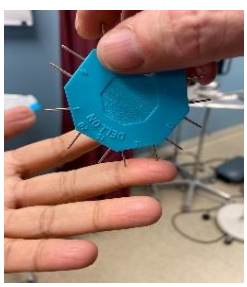


Figure 7c: Appropriate 2-point discrimination.

Undiagnosed osteoporosis and osteopenia

Osteoporosis, often asymptomatic, is a systemic skeletal disease characterized by low bone mass and microarchitectural deterioration of bone [28]. The World Health Organization has defined osteoporosis as a bone mineral density of 2.5 standard deviations below the mean in adults aged 20 – 29 years. It is measured using dual-energy x-ray absorptiometry (DEXA). Osteopenia is defined as a bone mineral density between 1 and 2.5 standard deviations below the mean [29]. Osteoporosis frequently manifests as a fracture from a low-energy trauma [29,30]. A distal radius (DR) fracture from low-energy trauma, such as falling from a standing height, is a common presentation of undiagnosed osteoporosis [30]. DR fractures are the second most common fracture in the elderly, accounting for 18% of all fractures in women above 65 years [31]. Additionally, studies show that one year after experiencing a DR fracture, elderly patients are at a greater risk of vertebral and hip fractures [32] "All fractures may lead to disability or impairment of health-related quality of life (HRQOL), particularly those of the hip and vertebrae" [33]. Outcomes after hip fractures show 30% of patients die within one year of hip fracture [34]. Increasing awareness for follow-up for bone health assessment following a DR fracture is imperative. This author group recommends all females over the age of 50 years who are diagnosed with a distal radius fracture should undergo DEXA scan screening for osteoporosis.

Complex Regional Pain syndrome

Complex regional pain syndrome (CRPS) is a condition that causes chronic pain and usually occurs following a traumatic event or surgery [35]. CRPS can lead to significant morbidity due to chronic and disproportionate pain from what is expected following the injury. In addition, the pain can last years. It is a clinical diagnosis based on standardized diagnostic criteria [35]. There are two types of CRPS. CRPS type 1 is when a specific nerve is identified and CRPS type 2 is when there is not an identifiable nerve lesion. [36] CRPS type 1 accounts for 90% of cases [35].

CRPS is a potential complication of conservatively or surgically treated wrist fractures [37]. The pain usually presents 4-6 weeks after the inciting event [35]. The incidence of developing CRPS following a wrist fracture varies in the literature from 0.64% after surgery for distal radius fracture [38] and 3.8% overall after a wrist fracture [39]. Currently, it is controversial whether giving Vitamin C following a distal radius fracture reduces the incidence of CRPS type 1. Some studies have shown that the use of vitamin C 500 mg daily for 50 days reduces the incidence of CRPS type 1 [37,40] However, another study showed the incidence of CRPS was not reduced with use of vitamin C following distal radius fracture [41]. Due to the significant morbidity associated with CRPS along with the low cost and minimal adverse side effects of vitamin C, the author's recommend prophylactic vitamin C 500 mg daily for 50 days following a distal radius fracture.

Conclusion

Distal radius fractures are a common pathology faced by trauma and care providers. Understanding a detailed approach including relevant history, physical exam and radiology interpretation is essential in appropriate evaluation and treatment. The radiographic concepts of radial height, radial inclination and volar tilt are useful in determining effective splint application as well as appropriate referral. Splints that allow maximum range of motion particularly of the MCP joints of the fingers are important in avoiding complications of stiffness and prolonged recovery as well as the rare but ominous condition of complex regional pain syndrome (CRPS). Going beyond the basics of distal radius fractures, all patients presenting with this should be evaluated meticulously for acute carpal tunnel syndrome. When present this should be referred emergently for evaluation and potential emergent carpal tunnel release. Distal radius fractures have a high association with undiagnosed osteopenia and osteoporosis. Patients with osteopenia and osteoporosis are at risk for fragility fractures in the future. The authors herein recommend all patients with distal radius fractures who are female and over the age of 50 undergo screening for osteoporosis via DEXA scan. Distal radius fractures are associated with development of complex regional pain syndrome. In addition, vitamin C has been shown in some studies to be beneficial in reducing the incidence of CRPS. While there is some equivocal evidence it's still the author's opinion that vitamin C 500 mg daily for 6 weeks should be recommended for all patients with distal radius fractures.

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***Corresponding author:** James A. Johanning, MPAS, PA-C, Assistant Professor, Department of Physician Assistant Studies, St. Catherine University, USA, Email: jjohanning994@stkate.edu

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