Fracture of the Distal Radius: Epidemiology and Premanagement Radiographic Characterization

OBSERVERVE. Fractures of the distal radius are common and frequently encountered by the radiologist. We review the epidemiology, classification, as well as the concept of instability. Salient qualitative and quantitative features of the distal radius fracture identifiable on the routine radiography series are highlighted. We conclude with a synopsis of descriptors that are of greatest utility to the clinician for treatment planning and that should be addressed in the radiology report.

CONCLUSION. A detailed understanding of the intricacies of the distal radius fracture is necessary for the radiologist to provide a clinically relevant description.

Fracture of the distal radius is common. Although frequently encountered by the radiologist, those attributes that should be highlighted to guide treatment options may not be emphasized in the radiologist’s report. Unfortunately, there is no universally accepted reliable classification system available for the radiologist.

In this article, we review epidemiology of the distal radius fracture, classification, and the concept of instability. Specific qualitative and quantitative features of the distal radius fracture apparent on the radiograph are discussed. We conclude with a series of questions the radiologist should address in the initial description of fracture involving the distal radius.

Epidemiology of the Distal Radius Fracture

The incidence of fractures of the distal radius has increased recently in all age groups. The exact cause for this rise is unclear. Some theories include lifestyle influences (urban versus rural living), childhood obesity, and osteoporosis [1–3].

Pediatrics

In the pediatric population, distal radius fractures occur most commonly around the time of puberty, a period in which bone mineralization is relatively low. These fractures are more common in boys than in girls. It has been estimated that the cost of treatment of distal radius fractures in the pediatric population in the United States is approximately $2 billion per year. The most common mechanisms in this demographic include sporting activities, motor vehicle accidents, and playing. Fortunately, in the pediatric population, anatomic reduction is not required because there is significant bone turnover, resulting in excellent outcomes with low complication rates [1].

Young Adults

The young adult population is least likely to incur fracture of the distal radius [1, 3]. From the ages of 19 to 49 years, fractures are more common in men than women. Over the age of 50 years, likely due to the effects of osteoporosis, distal radius fractures are more common in women. Common mechanisms in this age group include sporting activities and motor vehicle accidents. When fractures are extraarticular, there is typically a good outcome. When intraarticular, the rate of posttraumatic arthritis is high; however, studies indicate this does not significantly impact livelihood [1].

Elderly

Over 85,000 Medicare beneficiaries sustain distal radius fractures each year [4]. In the elderly population, fractures are more common in women than men, again, likely attributable to the impact of osteoporosis [1, 3]. The most common mechanism is the fall from a standing height [1, 3]. Unfortunately, the distal radius fracture has a significant impact in the elderly, altering the ability to prepare meals, perform housekeeping duties, climb stairs, shop, and get out of an automobile. These limitations re-
result in increased mortality relative to control subjects. Management outcomes of the distal radius fracture in the elderly differ from those in young adults. Recent studies have shown no change in functional outcome in those treated surgically versus those treated without surgical intervention, regardless of the radiographic discrepancies [1, 3]. Nevertheless, the use of internal fixation in this population continues to rise. If this trend continues and the use of internal fixation reaches that of the national average (50%) in this population, it has been estimated that the future Medicare burden of distal radius fracture treatment in the elderly could reach $240 million annually [4]. Newer plate technology costs Medicare nearly three times more than the traditional treatment options [3]. Fall prevention strategies and osteoporosis management have proven successful in decreasing the risk of the distal radius fracture [1].

Management Trends
Interestingly, over the past decade, there has been a noticeable rise in surgical intervention for management of the distal radius fracture, which does not appear to be related to the relative increase in incidence of the injury. This trend may be related to an increase in the management of such fractures by hand surgeons instead of orthopedic surgeons. Additionally, open reduction and internal fixation have increased versus other surgical options despite similar functional outcomes [1]. In a recent article, Jupiter [3] highlighted the need for surgeons to provide valid and appropriate data regarding cost and outcomes for the treatment of distal radius fractures in light of an increase in health care spending.

Characterization Methods
Eponyms
There are several popular eponyms used to define fractures of the distal radius. Although eponymous references in radiology provide interesting historical perspective, they often lack reliability. Some of the more common eponyms for fractures of the distal radius include the Colles, Smith, Barton, and Hutchinson fractures. A diagrammatic depiction of these eponymous fractures has been provided in Figure 1.

The Colles fracture was described by Abraham Colles in 1847, which has been accepted as a reverse or volar form of the Colles fracture [8, 9] (Fig. 2). John Rhea Barton described the Barton fracture in 1838, with the definition refined later by Hamilton in 1860. This fracture entails either dorsal or volar fracture-dislocation of the wrist. A triangular fragment of the dorsal or volar margin of the distal radius is sheared off and displaced in a dorsal or volar direction with the carpus. This fracture is often distinguished from the Colles and Smith fractures by the presence of intraarticular radiocarpal joint involvement [8, 9] (Fig. 3).

To complicate matters, the Smith fracture was divided into three types in 1957 by Thomas [8] and revisited in a description by Ellis [9] in 1965. The type 2 Smith fracture described by Thomas is essentially what has become accepted as the Barton fracture.

The Hutchinson fracture refers to an oblique fracture of the radial styloid process with extension into the wrist joint (Fig. 4), described by Jonathan Hutchinson in 1866. This fracture is also called a chauffeur, lorry driver, or backfire fracture because the fracture was historically associated with hand cranking to start motor vehicles [10].

Classification Systems
As management of the distal radius fracture evolved and expanded, numerous classification systems were created in effort to assist with treatment decisions. Although each classification system is unique, certain basic and important variables can be extrapolated from a review of the more common schemes. When assessing five popular and well-recognized classification systems (AO classification, universal classification, Fernandez classification, Frykman classification, and Melone classification) the following fracture features are stressed [11, 12]: presence or absence of displacement, extension into the distal radioulnar or radiocarpal joint or both, presence and severity of comminution, and presence of associated lesions such as fracture of the ulna or soft-tissue injury.

To be clinically relevant, a classification system should be reproducible. A review by Belloti et al. [12] in 2008 examined intra- and interobserver reproducibility of the universal classification of distal radius fractures by Cooney, Fernandez classification, Frykman classification, and AO classification. The authors concluded that none of these more commonly used and referenced classification schemes is fully reproducible. This may explain why none of the current classification systems is considered the standard for description.

Radiographic Assessment of the Distal Radius Fracture
Although CT and MRI have the ability to provide information that cannot be ascertained by conventional radiography, routine acquisition with these modalities is neither cost-effective nor time efficient. CT provides improved anatomic detail pertaining to the fracture. MRI is considered an adjunct in the assessment of the intrinsic scapholunate and lunotriquetral ligament as well as injuries of the triangular fibrocartilage with or without concomitant distal radioulnar joint instability. MRI is also used to identify potential radiographically occult fractures [13, 14].

At a minimum, posteroanterior and lateral views are necessary in the initial radiographic inspection. At our institution, oblique radiography is also a component of the standard examination. The posteroanterior view should be acquired with the patient’s elbow and shoulder at 90° and the forearm in neutral rotation. When the lateral view is acquired correctly, i.e., in the absence of relative pronation or supination, the pisiform bone should be superimposed on the distal pole of the scaphoid [13–15].

Posteroanterior View Inspection
Radial length—Radial length, used when assessing shortening of the radius after fracture, can be obtained using the posteroanterior view. Two lines are drawn perpendicular to the long axis of the radius, one at the tip of the radial styloid and the second at the ulnar border of the distal radial articular surface (Fig. 5). This length is normally approximately 12 mm. Excessive radial shortening after fracture of the distal radius may be associated with tears of the triangular fibrocartilage complex [16, 17].

Radial inclination—The articular surface of the distal radius exhibits approximately 23° (range, 13–30°) of normal radial inclination. Radial inclination is the angle between a line perpendicular to the central axis of the radius and a line connecting the radial and ulnar limits of the articular surface of the distal radius (Fig. 6). This can be altered with fracture of the distal radius [13–15, 17].

By applying a 10–20° angle in the lateral projection, paralleling the articular surface of the distal radius, visualization of the articular surface is improved as a result of normal radial inclination. At our institution, the orthopedic surgery service routinely acquires this angled lateral view after surgical fixation under fluoroscopy while the patient is still in the operating room to confirm satisfactory reduction and proper hardware placement [11, 13, 14] (Fig. 7).

Ulnar variance—Ulnar variance, defined as neutral, positive, or negative, is evaluated on the frontal view. Ulnar variance, according to the method of perpendiculars, is the vertical distance between two tangential lines both
perpendicular to the long axis of the radius. One line is drawn at the level of the radial sigmoid notch and the second at the level of the lateral cortical margin of the distal ulna. With excessive radial shortening, ulnar positive variance will be present [17] (Fig. 8).

**Radial translation ratio**—Tears of the triangular fibrocartilage complex (TFCC) are the most frequent associated injury, seen in 39–84% of unstable distal radius fractures. Tears of the distal radioulnar ligament at the level of the ulnar attachment occur in 21–33% of distal radius fractures. Peripheral tears of the TFCC can lead to distal radioulnar joint instability and poor functional outcome [11, 13, 17].

There is controversy in the literature pertaining to the association of fracture of the ulnar styloid and distal radioulnar joint instability. A more reliable marker may be the radial translation ratio. The distal radioulnar joint gap is the distance between two longitudinal lines along the cortical rim of the sigmoid notch of the radius and the adjacent ulnar head. The ratio of the distal radioulnar joint gap relative to the radion-ulnar width of the proximal fracture fragment reflects the radial translation ratio (Fig. 9). This ratio was proven to be a significant independent risk factor of distal radioulnar joint instability following unstable distal radius fracture, with a cutoff value of 15% [17].

**Lateral View Inspection**

**Volar tilt**—The normal distal radius shows relative volar tilt. Volar tilt is the angle between a line perpendicular to the central axis of the radius and a line connecting the dorsal and volar margins of the articular surface of the distal radius on the lateral view. Loss of the normal volar tilt can accompany fractures of the distal radius (Fig. 10). Extreme dorsal angulation may be associated with injury to the TFCC [17].

**Teardrop angle**—The volar rim of the lunate facet of the distal radius forms a teardrop shape along the distal, volar surface of the radius on the lateral view. A teardrop angle can be acquired by drawing a line down the long axis of the radius that intersects a line drawn through the center of the lunate facet—teardrop. A normal teardrop angle is approximately 70° (Fig. 11). This angle is used to determine whether there is persistent articular incongruity after reduction of a fractured volar rim fragment [14].

**Concept of Instability and Management Implications**

A fracture of the distal radius is considered unstable by definition if it is unable to resist displacement following anatomic reduction [15, 16]. There are a variety of factors that have been proposed as predictors for instability in the literature [18]. Some of the more redundant factors of instability in the literature include fracture prereduction with the following radiographic features [13, 15, 16, 18–20]: dorsal tilt greater than 20°, radii inclination less than 15°, radial shortening greater than 5 mm (or alternatively, resultant ulnar positive variance), severe comminution, severe displacement, extension into the radiocarpal joint, concomitant fracture of the ulna, and patient more than 60 years old or presence of osteoporosis. If the clinician predicts that there is a high likelihood that closed reduction will be lost, the clinician can decide to forgo cast immobilization and pursue surgical intervention.

**What the Radiologist Should Report**

Eponymous references for fracture of the distal radius provide an interesting historical perspective; however, their precise definition may vary from one person to the next. No current classification system is considered superior prior [11–13]. Common features highlighted by the more popular classification systems, reviewed in conjunction with the many purported markers of both distal radius fracture and distal radioulnar joint instability, provide insight to those variables that carry important clinical implications. When factoring in the practicality and efficiency of using these variables in the everyday practice of the radiologist, we suggest that the following questions should be addressed by the radiologist: Is there osteopenia? Is there soft-tissue injury? Is the fracture simple or comminuted? Is there intraarticular (radiocarpal or distal radioulnar joint involvement)? Is there displacement? Is there abnormal dorsal or, less likely, volar tilt of the articular surface? Is there subluxation or dislocation of the distal radioulnar joint? Is there fracture of the ulnar styloid? (Figures start on next page)

**References**

Fig. 1—Eponymous distal radius fractures. A–E, Drawings show normal distal radius in lateral projection with dorsal surface to right (A), Colles fracture (B), Smith fracture (C), dorsal Barton fracture (D), and volar Barton fracture (E). Hutchinson fracture, fracture of radial styloid, is not shown and is best seen on frontal or oblique view.

Fig. 2—Colles and Smith fractures. A and B, Frontal (A) and lateral (B) radiographs of 56-year-old man with Colles fracture of distal radius after ground-level fall while painting. This fracture does not extend into radiocarpal joint, and exhibits dorsal displacement of principal distal fracture fragment. (Fig. 2 continues on next page)
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Fig. 2 (continued)—Colles and Smith fractures. 
C and D, Frontal (C) and lateral (D) radiographs of 47-year-old man with Smith fracture of distal radius after motorcycle crash. Fracture does not extend into radiocarpal joint, and there is volar displacement of principal distal fracture fragment.

Fig. 3—Volar and dorsal Barton fractures. 
A–D, Frontal (A) and lateral (B) radiographs in 44-year-old man with volar Barton fracture after motorcycle crash and frontal (C) and lateral (D) radiographs in 81-year-old woman with dorsal Barton fracture after slip on ice. There are fractures of distal radius exhibiting intraarticular extension into radiocarpal joint, with volar (A and B) and dorsal (C and D) displacement of triangular fracture fragment and carpus.
Fig. 4—Hutchinson fracture. A and B, Frontal (A) and oblique (B) radiographs in 57-year-old man with fracture of radial styloid after motorcycle crash. There are additional fractures of triquetrum and pisiform.

Fig. 5—Normal and abnormal radial length. A and B, Frontal radiographs of wrist show normal radial length (A) as well as marked shortening of radial length in 43-year-old man following impacted distal radius fracture (B). To obtain radial length, two dashed lines are drawn perpendicular to single solid line that projects along long axis of the radius. One dashed line is drawn at tip of radial styloid, and second at ulnar border of distal radial articular surface. Normal radial length is approximately 12 mm.
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Fig. 6—Frontal radiograph in 39-year-old woman shows normal radial inclination angle, formed by solid line perpendicular to long axis of radius and dashed line connecting radial and ulnar limits of articular surface of distal radius, with normal range of 13–30°.

Fig. 7—Oblique lateral view. Lateral radiographs of distal radius obtained after volar plate and screw fixation in 31-year-old man with distal radius fracture. A and B, Conventional lateral radiograph (A) was obtained after procedure. Angled lateral projection (B) acquired intraoperatively provides enhanced detail of articular surface of distal radius because beam is parallel to normally inclined distal radial articular surface.
Fig. 8—Normal and abnormal ulnar positive variance. Ulnar variance, according to method of perpendiculars, is vertical distance between two tangential lines both perpendicular to long axis of radius. One line is drawn at level of radial sigmoid notch and second at level of lateral cortical margin of distal ulna.

A, Frontal radiograph shows minimal ulnar negative variance on otherwise unremarkable radiograph.

B, Abnormal ulnar positive variance is present as result of radial shortening related to impacted fracture of distal radius in 43-year-old man.

Fig. 9—Radial translation ratio in 43-year-old man with distal radius fracture.

A and B, Radiograph of fracture of distal radioulnar joint gap relative to radioulnar width of proximal fracture fragment (A) reflects radial translation ratio. This ratio is independent risk factor of distal radioulnar joint instability after unstable distal radius fracture, with cutoff value of 15%. Distal radioulnar joint gap is distance between two longitudinal lines along cortical rim of sigmoid notch of radius and adjacent ulnar head (B).

Fig. 10—Normal and abnormal volar tilt.

A, Radiograph of normal distal radius shows relative volar tilt. Volar tilt is angle between line perpendicular to central axis of radius and line connecting dorsal and volar margins of articular surface of distal radius on lateral view. Normal volar tilt is approximately 11°.

B, Loss of normal volar tilt, replaced by extreme dorsal tilt, is seen after fracture of distal radius in 27-year-old man.
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Fig. 11—Normal and abnormal volar teardrop angle. Volar rim of lunate facet of distal radius forms teardrop along distal volar surface of radius on lateral view. Teardrop angle can be acquired by drawing line down long axis of radius that intersects line drawn through center of lunate facet or teardrop.

A, Normal teardrop angle is approximately 70°.

B, Abnormally increased teardrop angle related to distal radius fracture is seen in 46-year-old woman.