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PANORAMIC REVIEW OF DISTAL RADIUS FRACTURES

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ABSTRACT

Introduction: *fractures affecting the distal radius are common, their incidence increases as life expectancy increases, leading to a larger population of individuals at risk of suffering these injuries. They are usually comminuted and intra-articular fractures that are outside the traditional eponymous classification.*
Objective: *to detail current information related to distal radius fractures epidemiology, anatomy, mechanism of injury, clinical evaluation, classification, imaging evaluation, treatment and complications.*
Methodology: *a total of 27 articles were analyzed in this review, including review and original articles, as well as clinical cases and books, of which 19 bibliographies were used because the other articles were not relevant to this study. The sources of information were PubMed, Google Scholar and Cochrane; the terms used to search for information in Spanish, Portuguese and English were: distal radius fractures, radius anatomy, Colles fracture, Smith fracture, Barton fracture, treatment of distal radius fractures.*
Results: *distal radius fractures account for about one sixth of all fractures treated in the emergency department, the incidence of distal radius fractures in the elderly correlates with the degree of osteopenia and increases with increasing age. The volar ligaments are stronger and provide greater stability to the radiocarpal joint compared to the dorsal ligaments. The most common mechanism is a fall on the hand in extension with the wrist in dorsiflexion. Currently, there is no consensus on the most optimal classification system for distal radius fractures.*
Conclusions: *knowing correctly the whole picture of distal radius fractures allows to have a better performance when treating them. It is essential not to overlook in the physical examination the exploration of the ipsilateral elbow and shoulder to rule out the presence of associated injuries and to perform a complete evaluation to detect other possible injuries or life-threatening problems. Distal radius fractures can be treated conservatively or surgically depending on several factors, so classification is essential. There are multiple alternatives in surgical treatment, so the most appropriate one should be chosen for each case. The most common complications in this type of fracture are median nerve dysfunction, post-traumatic osteoarthritis, malunion or pseudoarthrosis and stiffness of the fingers, wrist and elbow.*
KEY WORDS: *fracture, distal radius, Colles, Smith, Barton, treatment.*

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INTRODUCTION

Fractures affecting the distal radius are common, their incidence increasing as life expectancy increases, leading to a larger population of individuals at risk for these injuries. Fractures of the distal radius are more prevalent in children, adolescents and the elderly. However, fracture patterns, management and complications are different according to age group. Distal radius fractures can be caused by any trauma to the forearm, as well as the result of some types of falls. Isolated distal radius fractures present some eponyms, each one with its characteristic peculiarities, among these are Smith, Colles, Torus/Buckle, Greenstick and Die-punch fractures. These fractures mostly occur as a result of fall injuries to the outstretched hand. In the elderly they usually occur due to low energy falls. They are usually comminuted and intra-articular fractures that are outside the traditional eponymous classification. In children and adolescents, it is usually due to high energy falls sustained on the playground or during sporting events. In addition, fractures of the distal radius may show up in more complicated injury patterns, such as Galeazzi fracture-luxation, both bone fractures, radial styloid fractures, and Barton and Chauffeur fractures. The mechanism of these fractures is usually more complex or atypical, in the article we present epidemiology, anatomy, mechanism of injury, clinical evaluation, classification, imaging evaluation, eponyms, treatment and complications of distal radius fractures(1-4).

METHODOLOGY

A total of 27 articles were analyzed in this review, including review and original articles, as well as cases, clinical trials and books, of which 19 bibliographies were used because the information collected was not important enough to be included in this study. The sources of information were Cochrane, PubMed and Google Scholar; the terms used to search for information in Spanish, Portuguese and English were: distal radius fractures, radius anatomy, Colles fracture, Smith fracture, Barton fracture, treatment of distal radius fractures.
The choice of bibliography exposes elements related to distal radius fractures epidemiology, anatomy, mechanism of injury, clinical evaluation, classification, imaging evaluation, treatment and complications.

DEVELOPMENT

Epidemiology

Fractures of the distal end of the radius are among the most common fractures of the upper limb, accounting for about one-sixth of all fractures treated in the ED. The incidence in the elderly correlates with the degree of osteopenia and increases with increasing age, as do hip fractures(5,6).

There is an incidence of about 67 fractures of the upper extremities per 10,000 persons per year, with distal radius and ulna fractures accounting for about 25% of these fractures, a relatively high number compared to fractures of the radial head, which have an incidence of 2.5 per 10,000 per year, representing 1.7 to 5.4% of all fractures(7,8).

In men over 35 years of age, the incidence is about 90 cases per 100,000 persons per year, and remains relatively constant until the age of 70 years, when an increase is evident. Risk factors for fractures of the distal end of the radius in the elderly are reduced bone mineral density, white race, family history, female sex and early menopause(6,9).

Anatomy

The distal metaphysis of the radius consists primarily of cancellous bone. The articular surface has a biconcave facet to articulate with the proximal row of the carpus and a notch to articulate with the distal end of the ulna. About 80 percent of the axial load is borne by the distal radius and the remaining 20 percent by the ulna and triangular fibrocartilage. Reversal of the physiologic palmar tilt generates a transfer of loads directed to the ulna and triangular fibrocartilage. The remaining load is eccentrically borne by the distal radius and is concentrated on the dorsal aspect of the scaphoid fossa. The distal radius is the site of multiple ligamentous insertions; in the distal radius fracture, these commonly remain intact and support reduction through ligamentotaxis. The volar ligaments are stronger and provide greater stability to the radiocarpal joint compared to the dorsal ligaments.

Studies show that the average thickness at the level of the dorsal tubercle was 22.1 mm, the average slope of the lateral column was 155° while that of the intermediate column was 145°(6,10).

Mechanism of Injury

The most common mechanisms in young people are falls from a height, followed by traffic accidents and injuries generated in sports activities. In older people, distal radius fractures are usually the result of low-energy mechanisms, such as a simple fall from height. The most common mechanism is a fall on the hand in extension with the wrist in dorsiflexion. Fractures of the distal radius are seen when the wrist is in dorsal flexion between 40° and 90°, and the force required is less the smaller the angle of dorsiflexion. Initially there is a stress fracture of the volar aspect of the radius, subsequently, the fracture line is directed in a dorsal direction while the bending moment causes a compressive force resulting in dorsal comminution. Impaction of the metaphyseal cancellous bone further alters dorsal stability. Also, shear force affects the pattern of injury and generally causes alterations in the articular surface. High energy injuries usually result in fractures of the distal end of the radius with significant displacement or comminution(6,8,9,11).

Clinical Evaluation

The history should focus on the mechanism of injury, duration and quality of symptoms, and questioning of the affected individual should include details such as their dominant hand, profession and comorbid conditions, as these factors may influence treatment and possible surgical intervention.

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Individuals usually show variable deformity of the wrist, with a displacement of the hand relative to the wrist dorsal in Colles fractures or dorsal Barton fractures and volar in Smith fractures. In addition, the wrist is swollen, with ecchymosis, pain on palpation and pain on mobility(8,9,12,13).

It is important to explore the ipsilateral elbow and shoulder to rule out the presence of associated injuries and to perform a complete evaluation for other possible injuries or life-threatening problems. A complete neurovascular examination should be done, assessing the functionality of the median nerve. Symptoms of carpal tunnel compression are common, in about 13% to 23%) due to traction exerted at the time of wrist hyperextension, direct trauma from bone fragments, hematoma formation or increased compartment pressure(6,11,14).

Figure 1. X-rays showing right distal radius fracture, lateral and AP projections.

Source: The Authors.

Imaging Evaluation

Posteroanterior and lateral radiographs of the wrist should be performed, and oblique views may be used if the fracture needs to be better defined. Symptoms at the shoulder or elbow should also be assessed by radiography. Radiographs of the contralateral uninjured wrist allow assessment of the patient's ulnar variance, as well as scapholunate angle. Computed tomography (CT) allows assessment of the extent of intra-articular involvement. In addition, CT is often necessary when radiographs appear normal, but the history and physical examination strongly suggest a fracture, and may also be useful in surgical planning. MRI provides little utility to radiography and CT in the diagnosis of distal radius fracture, however, it can be useful when there is ligamentary lesion involvement(6,8,11).

The normal radiological relationships are :

- Radial inclination: 23° on average with a range of 13° to 30°.
- Radial length: 11 mm on average with a range of 8 mm to 18 mm.

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- Palmar (volar) inclination: 11° to 12° on average with a range of 0° to 28°.

Classification

Currently, there is no consensus on the most optimal classification system for distal radius fractures(3).

Descriptive classification:

- Open or closed.
- Displacement.
- Angulation.
- Comminution.
- Shortening of the radius.

Frykman's classification of fractures of the distal end of the radius is based on the pattern of intra-articular involvement. Odd fractures do not involve the distal ulna and even fractures involve the distal ulna.

- Types I/II of Frykman: extra-articular.
- Frykman's types III/IV: intra-articular involving the radiocarpal joint.
- Frykman's types V/VI: intra-articular affecting the distal radioulnar joint.
- Frykman Types VII/VIII: intra-articular affecting the radiocarpal and distal radioulnar joints(6,15-17).

Fernandez classification is a classification system based on the mechanism of production.

- Type I: metaphyseal fracture by flexion with loss of palmar tilt and relative shortening of the radius with respect to the ulna with injury to the distal radioulnar joint.
- Type II: shear fracture requiring reduction and often bracing of the articular segment.
- Type III: compression fracture of the articular surface without the characteristic fragmentation; may be associated with severe ligamentous injuries.
- Type IV: avulsion fracture or radiocarpal fracture-dislocation.
- Type V: combined injury with significant soft tissue involvement due to a high-energy injury.

There are other classifications such as the universal classification and the AO.

Eponyms

Colles' Fracture: traditionally referred to extra-articular fractures, it currently addresses both extra-articular and intra-articular fractures of the radius with various levels of dorsal angulation, dorsal displacement, radial translation and radial shortening. Physical examination reveals the characteristic fork back deformity, which is common in more than 90% of distal radius fractures. The mechanism of injury is a fall on the hand in hyperextension and radial deviation, with the forearm in pronation. Intra-articular fractures are more frequent in young individuals and as a consequence of high-energy trauma, presenting associated injuries, in addition to injury to the radiocarpal joint and the distal radioulnar joint.

Smith's Fracture or Inverted Colles' Fracture: presents a fracture with volar angulation of the distal radius with a gardener's spade deformity, with volar displacement of the hand and the distal fragment of the radius. The mechanism of injury is almost always a fall on the hand with the wrist in flexion and the forearm fixed in supination. It shows an unstable fracture pattern, usually requiring open reduction and internal fixation because of the difficulty in maintaining an adequate closed reduction.

Barton's Fracture: usually by a shear mechanism that gives a fracture-dislocation or subluxation of the wrist where the dorsal or volar margin of the distal radius accompanies the carpus and hand in its displacement. The volar injury is more common. The mechanism of injury is a fall on the wrist in dorsiflexion with the forearm fixed in pronation. The vast majority of these types of fractures are unstable and require open reduction with internal fixation with a neutralization plate to maintain a stable anatomical reduction.

Fracture of the Styloid Process of the radius: also called chauffeur's fracture or Hutchinson's fracture, it owes its name to the mechanism of abrupt recoil of the starting handle of old cars. It is a fracture-avulsion where the extrinsic ligaments remain attached to the styloid fragment. It can be caused by direct trauma, usually the mechanism of injury is a compression of the scaphoid on the styloid process with the wrist in dorsiflexion and ulnar deviation. Sometimes it involves the entire styloid, although it can also affect only its dorsal or volar portions. It is generally related to lesions of the intercarpal ligaments, usually requiring open reduction with internal fixation(6,8,9,17).

Treatment

The impact factors in the treatment are:

- Fracture pattern.
- Local factors: comminution, fragment displacement, bone quality, soft tissue injuries and energy of injury.
- Factors dependent on the affected individual: dominant hand, concomitant diseases, physiological age, lifestyle, occupation, associated injuries and level of collaboration.

The parameters in radiographs to define that a reduction is acceptable in a healthy and active individual are:

- Intra-articular step: 2 mm.
- Radial inclination: loss 5°.
- Radial shortening: less than 2 mm to 3 mm with respect to the contralateral wrist.
- Palmar tilt: neutral tilt 0°, however, up to 10° of dorsal angulation is acceptable.

Following a distal radius fracture, carpal alignment may have the greatest impact on the results:

Alignment of the carpus is determined by the intersection of two straight lines on lateral radiographs: one parallel to and through the midshaft of the radius diaphysis, the other through and parallel to the great. When the two lines intersect inside the carpus, the

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carpus is said to be aligned. When the two lines cross outside the carpus, the carpus is said to be misaligned.
There are multiple factors related to loss of reduction secondary to closed manipulation of a distal radius fracture, the most notable of which are:

- The extent of metaphyseal comminution.
- The initial displacement of the fracture: the greater the level of displacement, the more energy transmitted to the fracture site and thus the greater the likelihood of unsuccessful closed treatment.
- The age of the patient: osteopenic elderly patients tend to show loss of reduction.
- Secondary displacement after closed reduction dictates and predicts instability, as well as repeated manipulation rarely presents radiological results considered satisfactory(6,8,17).

Conservative Treatment
All displaced fractures should be reduced in a closed manner, even when surgical treatment is considered necessary. The reduction of the fracture helps to reduce the subsequent inflammation, as well as reduces pain and relaxes the compression of the median nerve.
Cast immobilization is indicated in:

- Elderly individuals with low functional demands where the expected functional limitation is a lower priority compared to immediate health problems and/or surgical risk.
- Non-displaced or minimally displaced fractures.
- Displaced fractures with a stable fracture pattern, which can be expected to heal with acceptable radiological parameters.

Analgesia for closed reduction can be by intrafocal anesthetic block with supplemental intravenous sedation, intravenous regional anesthesia or conscious sedation.

Closed reduction technique (fracture with dorsal deviation):
The distal fragment is in hyperextension, traction is exerted to reduce the distal fragment over the proximal fragment generating pressure on the distal end of the radius, then a well molded brachiopalmar splint is placed, with the wrist in neutral position or in slight flexion. It is advisable to avoid extreme positions of the wrist and hand, and the metacarpophalangeal joints should be left free. When the swelling has subsided, a well-molded cast is applied. The ideal position of the forearm, the duration of immobilization and the need or not for a long cast (brachiopalmar) is still a matter of debate. Extreme flexion of the wrist increases the pressure inside the carpal tunnel, and stiffness of the fingers, which is why it is advised to be avoided. Fractures that require maximum wrist flexion to ensure reduction may require surgical management. The cast should be used for about 6 weeks or until healing is evident on X-rays. Serial radiological checks are recommended to detect probable loss of reduction.

Figure 2. Fluoroscopic control of distal radius fracture in AP.

Source: The Authors.

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Surgical Treatment

Surgical treatment presents better functional results, being remarkable in pain and pressure at 3 months and in mobility at 6 months, showing integration to the work environment in less time.

Indications:

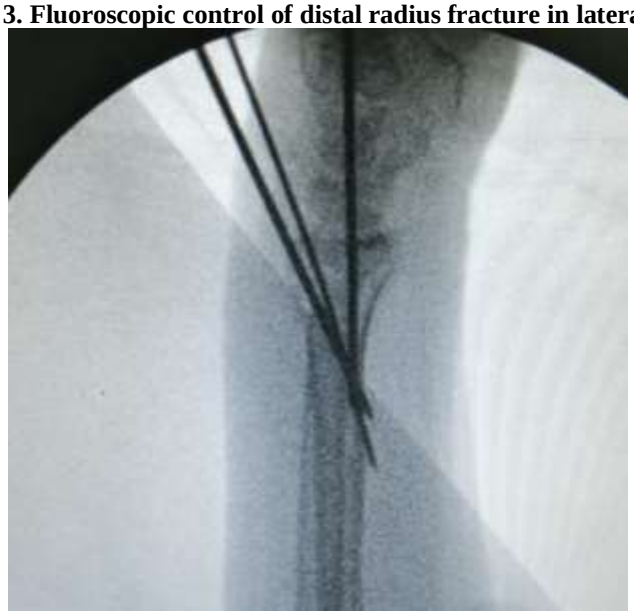
- Open fractures.
- Comminution, step or joint opening.
- Metaphyseal comminution or bone loss.
- High energy injuries.
- Secondary loss of reduction.
- Loss of volar support with displacement.
- Incongruence of the distal radioulnar joint.

Surgical Techniques

Percutaneous Nailing: generally used in extra-articular fractures or intra-articular fractures in two fragments. It is usually performed using two or three K-wires placed through the fracture site, usually from the styloid process of the radius in the proximal direction and from the dorsal ulnar side of the distal fragment of the radius in the proximal direction. There are other methods used such as trans ulnar nailing with several needles. Percutaneous nailing is often used to supplement an antebrachiopalmar or external fixator. The needles are removed 6 to 8 weeks after surgery and the cast can be maintained for an additional 2 to 3 weeks.

Kapandji "Intrafocal" Nailing: it is based on propping up the distal fragment to prevent its secondary displacement, placing needles radially and dorsally directly in the fracture site, then a lever is placed on the distal fragment and the needles are directed towards the opposite cortex, intact, of the proximal fragment, this action neutralizes the dorsal or proximal displacement of the fragments. It is a relatively simple, cheap and very effective method(6,18).

Figure 3. Fluoroscopic control of distal radius fracture in lateral view.



Source: The Authors.

External Fixation: it has a low rate of complications; however, since the appearance of locked volar plates, its use has been reduced.

Transarticular external fixation:

- Restores the length and inclination of the radius by ligamentotaxis, infrequently recovers palmar inclination.
- May require supplementary K-wires.
- Excessive distraction should be avoided so as not to cause finger stiffness, which can be seen in an increase in intercarpal distance.
- Fixator pins are maintained for 6 to 8 weeks.

Non-transarticular external fixation:

- Stabilizes the fracture of the distal radius with nails located only on the radius, proximal and distal to the fracture site.
- Requires the distal segment to be non-fragmented and large enough.
- Better than transarticular fixator for maintaining volar tilt, prevents carpal alignment defects and improves fist strength and hand function outcomes.

Open Reduction and Internal Fixation

Dorsal Plates:

- Most surgeons are accustomed to this approach, avoiding the neurovascular structures of the palmar aspect.

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- The fixator is placed on the compression side of the fracture and neutralizes the forces that tend to collapse.
- Good results and theoretically earlier recovery and more anatomical restoration than those achieved with external fixation.
- The placement of dorsal plates is related to complications in the extensor tendons.

Non-Blocked Volar Plates

- Neutralization plate is usually indicated for Barton's volar shear fracture.
- It is usually not able to ensure fracture reduction when dorsal comminution is present.

Locked Volar Plates

- Stabilize distal radius fractures with dorsal comminution.
- They surpass the external fixator as the most widely used form of treatment in fixation of distal radius fractures.

Fixation with moldable plates with adjustable holes:

- Indicated in more complex fracture patterns involving multiple sites of the radial and ulnar columns.

Supplemental methods of Fixation:

- May be supplemented with an autograft, allograft, or synthetic graft. If necessary to stabilize smaller fragments, K-wires can be used.

Arthroscopy-Assisted Reduction of Intra-Articular Fractures:

Arthroscopy is very useful for the diagnosis of soft tissue injuries related to distal radius fractures, however there is discussion as to whether this technique provides better functional results than conventional techniques. Some of the fractures that would possibly benefit most from arthroscopically assisted surgery are:

1) articular fractures without metaphyseal comminution, particularly those with central impacted fragments.

2) Fractures showing notable injury to the interosseous ligament or triangular fibrocartilage, without a large fracture of the base of the ulnar styloid process.

Fractures of the ulnar styloid process: the indications for fixation of an ulnar styloid fracture are under discussion. Several investigators recommend fixation of displaced fractures of the base of the ulnar styloid process(6,8,9).

Figure 4. Postoperative control X-ray for Barton type distal radius fracture.

Source: The Authors.

Complications

Median nerve dysfunction: in a complete median nerve injury that does not improve after fracture reduction requires surgical exploration. Dysfunction of the median nerve after reduction requires removal of the splint and placing the wrist in neutral position; if there is no improvement, exploration and consequent release of the carpal tunnel will be considered.

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Post-traumatic arthrosis: it is the result of the injury of the radiocarpal and/or radioulnar joints, and shows that it is required to restore the anatomy of the articular surface.
Malpositioned consolidation or pseudoarthrosis: usually due to inadequate fracture reduction or stabilization. Usually requires internal fixation with or without osteotomy with bone graft.

Complications of external fixation include pin path infection, reflex sympathetic dystrophy, wrist and finger stiffness, and radial nerve sensory neuropathy. It is therefore advisable to place the pins under direct vision to identify the branches of the superficial radial nerve.

Stiffness of the fingers, wrist and elbow: it is generated primarily with prolonged immobilization with a cast or an external fixator. Therefore, the importance of correct occupational therapy to mobilize the fingers and elbow while maintaining wrist immobilization is evident, as well as adequate physiotherapy after the immobilization is removed.

In addition, tendon ruptures often occur, usually in the extensor pollicis longus tendon of the thumb. Degeneration of the tendon due to disruption of the tendon sheath vessels, as well as mechanical entrapment in the fracture callus, can result in rupture of the tendon fibers. Wearing dorsal plates has been associated with extensor tendon complications. Mediocarpal instability may result from injury to the radiocarpal ligaments or from a rupture of the dorsal or volar rim of the distal radius(6,8,19).

CONCLUSIONS

Knowing correctly the whole picture of distal radius fractures, allows one to have a better performance at the time of treating them. It is essential not to overlook in the physical examination the exploration of the ipsilateral elbow and shoulder to rule out the presence of associated injuries and to perform a complete evaluation to detect other possible injuries or life-threatening problems. Distal radius fractures can be treated conservatively or surgically depending on several factors, so classification is essential. There are multiple alternatives in surgical treatment, so the most appropriate one should be chosen for each case. The most common complications in this type of fracture are median nerve dysfunction, post-traumatic arthrosis, malposition consolidation or pseudoarthrosis and stiffness of the fingers, wrist and elbow.

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