OPEN REDUCTION AND INTERNAL FIXATION OF DISTAL RADIAL FRACTURE

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ABSTRACT

Distal Radial Fractures are categorized among the commonest fractures of the hands. These fractures are adjudicated by the anatomical dislocations or deformations depending on the extent and type of injury causing them. For such fractures, reduction by anatomical means and stable fixation promise a better outcome and cure for a patient. These include a wide range of therapeutic options: internal fixation using intra focal and extra focal pins, or using palmar plates, locking screws, external fixation methods including the bridge of the wrist etc., might be implemented for a betterment of the fracture. Most of the external fixation methods restrict the anatomical movement of the fractured joint, making it uncomfortable for the patient as well as an increase time of cure. Not only these, but also techniques like arthroscopy are considered in case of articular fractures. Though internal fixation is more sought in cases of distal radial fractures, the literature search reveals that internal fixation is better in younger population compared to lesser cure in elderly patients. This is because there is a very low-level evidence of type of fracture relating to the different type of fixture. This article focuses mainly on different techniques and treatment options used in open reduction with internal fixation and discusses the pros and cons of external fixation versus internal fixation; with a brief review of types of fractures of distal radius and an epidemiological perspective.

Keywords: Distal radial fracture, Colles fracture, Combined external and internal fixation

INTRODUCTION

Distal Radius fractures account for about 15% of the fractures in adults [1] making it one of the commonest orthopedic problems encountered. Fractures of the forearm and the wrist frequent highly compared to other fractures. Management of these common fractures is sometimes being critical and has remained challenging. The most common pattern of Distal Fractures was classified by Abraham Colles in 1814 [2]. Followed by classifications like Barton's fractures, Chauffer's fractures and so on. Management of distal fractures with better results and lesser complications has been more vigorously pursued by modern orthopedic surgeons and hand surgeons. [3,4,5] The literature through the years of research implies that there is a correlation between the anatomy of the distal radius and the outcome of management [5,6,7]. The management methods of the distal radial fracture are a bit wider, and a few references suggest management where wrist stiffness is seen [8,9]. The management methods comprise of the established methods like external fixation and open reduction with internal plate fixation, with both of them might having percutaneous wire pinning [10]. This review focusses on the open reduction with internal fixation.

Epidemiology:

Distal radial fractures are commonest of the upper extremity fractures, and these might occur adjuvant to other fractures and injuries. Including infants, adults and old age people, these fractures account for about 25% in total with 15% coming from adult patients. Distal radial fractures are more common in the 18 to 65-years age group [11]. A study by Jerrhag Et. al., has shown an increase of 2% of Distal radial fractures in men and 3.4% in women [11]. The attribution of Distal radial fractures to any single cause is difficult but a few problems like obesity and osteoporosis have greater incidence rates to other causes. Distal radial fractures have two most common age groups: less than 18 years or greater than 50 years. Distal radial fractures in children aged in 12-14-years boys and 10-12-years-old girls relate to decreased bone mineralization during puberty [11,12]. The patients above the age of 50 years, it is observed that women with age greater than 65 years with a risk of osteoporosis (postmenopausal), the incidence rate is as high as 40%. Diabetes is also found to be an agonistic factor for distal radial fractures [13].

### Anatomy and biomechanics of Distal Radius:

The loads and the force experienced by distal radius is varied across the class of people. The distal radius generates a force of 100 N, while the finger-flexion generates force around 250 N [14]. In a study, it was found that a grip force around 10 N would be translated to 26.3 N axial force in metaphysics of distal radius depending on hand position and length [15]. Radiocarpal joint assessment is dealt with specific radiographic parameters.
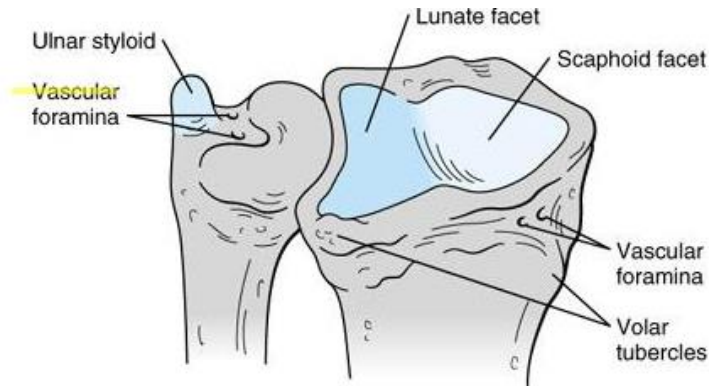
Anatomy of Distal Radius-Ulna.

The anatomy involved in the radiocarpal joint and the distal radial fractures include:

a. **Palmar tilt:** Palmar tilt is the angle between the line perpendicular to the long axis of the radius and to a second line drawn from the dorsal to the volar cortex of the distal radius. The angle averages between 10°-12° angle.

b. **Radial Inclination:** This is the angle between the longitudinal axis of the radius and the radial cortex of the apex of the radial styloid and center of the sigmoid notch on the distal radius. This averages between 22°-23° angle.

c. **Length of the radius:** It is the distance between radial styloid apex and ulnar head at the distal radioulnar joint. The length varies between 11 mm to 12 mm.

d. **Ulnar variance:** This is the difference in length between the ulnar corner of the sigmoid notch and the distal extent of the ulnar head on posteroanterior view.
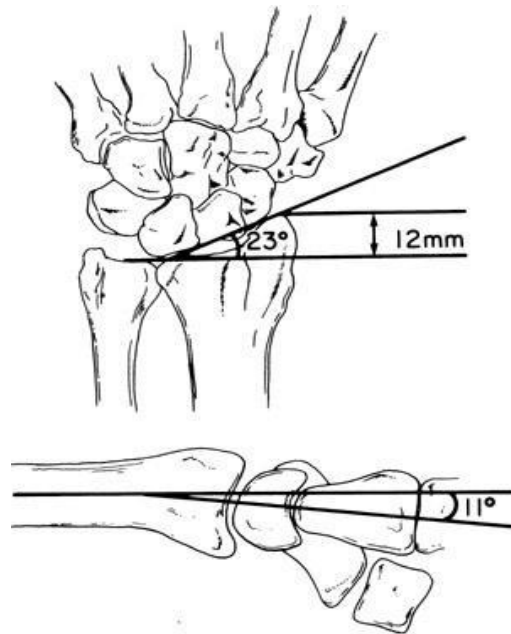
Classifications of Distal Radial Fractures and related Pathophysiology:

Distal radial fractures as a name could be misleading as there are many other forms of it. The Distal radial fractures of different kinds could be managed and clinically presented in different ways. These are classified into many types as below:

a. **Colles' Fracture** [16]: As discussed above, Colles' fracture gets its name from Irish Surgeon Dr. Abraham Colles, who is one among the first people to classify the Distal radial fractures and injury patterns in 1814. These could be classically presented as "Falls on Outstretched Hand" (FOOSH) [17]. This kind of metaphysical fracture occurs near to 1.4-1.6 inches in proximity to carpal articulation. It could be characterized by displacement of the distal fragment of the radius with dorsal angulation. The presentation of Colles' fracture is by Dinner's fork on the X-Ray.

b. **Smith's Fracture** [18]: It is essentially called a reverse Colles' fracture. Opposing to Colles' fracture, this fracture has a volar angulation of the distal fragment. Smith's fractures might occur individually or in association with other injuries. These fractures are more common in the pediatric population.

c. **Chauffeur's Fracture** [19]: This is an intraarticular fracture of the radial styloid with a variable fracture size and is also considered to be a result of FOOSH injury including compression of scaphoid against the radial styloid.

d. **Die-Punch Fracture** [20]: This fracture involves lunate facet of the radius and is an intra-articular fracture. The fracture usually occurs between the ulnar articulation and the scaphoid facet. This fracture occurs because of the axial loading of the lunate causing an impaction. This occurs an an isolated fracture but may be associated with other injuries too.

e. **Barton's fracture** [21]: This is an intra-articular rim fracture of the distal radius. It can be either dorsal or volar. These fractures are usually the result of dorsiflexion.

f. **Salter-Harris type fracture** [12]: This is a pediatric fracture that involves the epiphysial plate. These fractures are graded from Grade I - IX, each of them having a different kind of management and presentation [22].

Evaluation of Distal Radial Fractures:

X-Ray imaging is the most convenient method proved to diagnose Distal radial fractures. The X-ray imaging would look for anatomical considerations like height, the inclination of radius, volar tilt and Distal radial ulnar junction widening [23]. It is suggestive to have computed tomographic imaging if the X-ray imaging is not sufficient for the determination. Computed tomographic imaging would be helpful for further surgical considerations and decisions while fixations when the fractures are intra-articular. Computed topographies are also useful to eliminate the cases of ligamentous disruptions to that of fractures, hence keeps as an adjuvant to X-ray imaging. Magnetic resonance imaging might be used in a few cases of distal radial fractures [24].

To evaluate Distal radial fractures, over the years, there exists a wide range of grading once the fractures are imaged. Relating the evaluation to the type of fractures, as mentioned in the above section would help in knowing the mechanism, presentation and management of the injury. Of many grading systems,

Frykman classification is a classical method of grading a distal radial fracture. Besides Frykman classification, there are other classifications like elder's classification, Malone classification, Mayo Classification, Fernandez classification, Universal classification.

Frykman Classification:

Frykman classification done in 1967 is the first classification after the identification of ulnar styloid fractures, which identifies the involvement of radiocarpal and radioulnar bones [25]. Frykman classification has four main types of injuries, and each type f injury has an addition of ulnar styloid fracture.

Radial Fracture	Classification	
	Without ulnar fracture	With ulnar fracture
Extra-articular fracture	Type I	Type II
Intra-articular fracture with radiocarpal joint	Type III	Type IV
Intra-articular fracture with distal radioulnar joint	Type V	Type VI
Intra-articular fracture involving both radiocarpal & distal radioulnar joints	Type VII	Type VIII

Table 1: Enlists the types of Frykman classification.

Elder's classification:

2 years before Frykman's classification, in 1965, Older et. al--later re-classified by Solgaard [26,27] has published a four-part classification for the extra-articular Colles' type fracture [26]. This classifies the fractures based on the angulation and extent of displacement. It doesn't include intra-articular fractures like Frykman's classification.

Melone's classification:

This is a five-part classification done on the basis of four components to radiocarpal articular injuries [28]. This includes radial styloid and shaft, dorsal and palmar medial fragments of the lunate facet of the radius. Melone's classification is used in the surgical fixation of the fractures.

Mayo classification:

Mayo Clinic [29] has proposed a new classification of radial fractures in 1992. Mayo classification is similar to Frykman classification, but it also holds a difference between radio scaphoid and radiocarpal joint surface involvement [30]. There is no particular stress on the ulnar fractures in this classification.

Fernandez Classification:

A year afterwards Mayo Classification, Fernandez in 1993 has proposed a new classification for the distal radioulnar joint injuries [29]. This classification uses a mechanism-based approach and thus gives a perspective on the soft-tissue damage. It has a separate group of classification for distal radioulnar injuries.

Type	Fracture
I	Stable (following reduction of the radius the DRUJ is congruous and stable)
II	Unstable (subluxation or dislocation of the ulnar head present)
III	Potentially unstable (subluxation possible)

Table 2: Distal radioulnar injury classification

Treatment and Management of Distal Radial Fracture:

The treatment and management involve management of pain, immobilization of the injury and also an evaluation of the neurovascular compromise. It is expected that patients with a reduced sensation and motor activity need to seek medical attention. The literature around the Distal radial fractures suggests closed reduction and cast immobilization in elderly [31]. Similarly, any stable fractures can be treated by cast immobilization and closed reduction [32]. In unstable distal radial fracture, an additional fixation is suggested if the fracture is unmanageable [33].

External Fixation:

External fixation is an option for highly unstable and comminuted fractures or injuries. The method is based on the ligamentotaxis, to pull the fracture through longitudinal traction. The External fixation does not directly correspond to the reduction and maintenance of the dorsal tilt and intra-articular fragments. In a trail, external fixation is compared to closed reduction and found that patient treated with external fixation has relatively good radiological results but similar functional results than that of closed reduction [34].

The reconstruction of the articular surface needs neutralization of stress after the external fixation is performed [35]. Also, the anatomic reduction is difficult or more impossible by the external fixation, as the ligamentotaxis is based on the dorsal radiocarpal ligaments in transverse direction [35,36].

Internal Fixation:

Open reduction internal fixation has been developed to treat distal radial fractures which cannot be managed by external fixation. Open reduction offers a rigid internal fixation [30], and offers a stable construct of the fracture. Internal fixation offers an early mobilization of the wrist than the external fixation. Management of these fractures depend on several factors like age, the articular incongruity and/or presence of any ligament injuries. The goal is to restore the anatomical structure and allowing motion to the fractured joint.

a. **Technique:**

First consideration is that the soft-tissue swelling is an indicator for the postponement of any surgery to the wound. In complex intra articular fractures, where the internal fixation with open reduction are apparent, closed reduction is done using the finger traps. In cases where both internal and external fixation needs to be performed, an external fixator is applied that reduces the fracture by distraction.

❖ **Surgical Exposure:** The configuration of the fracture is first determined, and, in most cases, it is directed by the displacement of the major fragment on the trauma films. The priority is to obtain a satisfactory articular alignment and fixation by Kirschner wires.

❖ **Palmar approach:** In the management of the shearing palmar fractures, or when a provision of plate fixation is needed, this approach is needed. For this incision is made longitudinally between flexor carpi radialis tendon and the radial artery. The radial sensory nerves are retracted radially with the radial artery, keeping in mind that all sensory nerves are not retracted extensively. There needs to be an attention towards the care of not injuring the lateral antebrachial cutaneous nerve. An L-Shaped incision in a radial to ulnar fashion is made for the insertion of pronator quadratus on the distal radius. During this point of the procedure, there is a visualization of the fracture. The fracture reduction is performed by manipulating the fragments using a dental probe or periosteal elevator. The fixation of the fracture is held with smooth 0.045-inch Kirschner wires. The most common palmar plate for the fixation is the 3.5 mm straight or angled T-plate that provide a direct fixation of proximal and distal fractions.

Plate Designs and fixation types:

Axelrod and McMurty evaluated 17 distal radial fractures managed with dorsal plate. There was a complication rate more than 50% with more than 15% of the patients with an early complication and the remaining with a late complication. For the same reason, traditional 3.5 mm T-Plates and lower profile implants are used in reduction and in provision of rigid internal fixation.

Fixation types:

a. **Fragment-specific fixation:** Based on the mechanical elements of the fracture, the radial, ulnar and intermediate structures play an important role in the fixation types. For example, the double plating technique led to a statistically significant increase in stiffness compared to traditional 3.5 mm T-plate. The mechanical stability is increased by the lower-profile implants when placed in orthogonal relation to the deforming forces of the wrist. Employing this concept, Jakob et al. 34 reported statistically significant improvement in range of motion and grip strength between 6 months and 1 year in 68 intraarticular and extraarticular distal radius fractures managed with the double-plating technique and early mobilization. A hybrid system based on this concept that combines K-wires with miniature plates and screws has been introduced (TriMed, Valencia, CA, U.S.A.) to allow ultralow– profile fixation of individual fracture fragments.

b. **Radial Styloid Fixation:** A stable reduction in the styloid fragment is needed in the restoration of the distal radial bone. This is performed through palmar incision using a longitudinal traction secured with a 0.045-inch K-wire. Afterward, a 3 to 7-hole radial pin is clamped to the k-wire beneath the tendons.

c. **Bone graft:** Presence of the deficient metaphyseal bone is a

d. major problem in the intraarticular and distal radial fractures. As there are high-energy forces associated with these fractures, the articular surface is impacted most of the times. Autogenous bone-graft are

important to fill in the void that is created after the elevation and reduction of the depressed articular surface. The bone-grafts provide osteoprogenitor cells and mechanical properties which help in faster healing of fractures.

e. **Combined external and internal fixations:** This is based on the need to maintain the reduction while internal fixation is insufficient and doesn't provide better healing [37]. The external fixation halts the muscular forces that tend to reduce the healing.

Figure: Cross pinning using K-wire of the disrupted radio-ulnar joint.

CONCLUSION

Restoration of the function and the mobility is the primary objective in treating patients with intraarticular distal radius fractures. Though this depends mostly on various factors like age, sex and the nature of the fracture. The open reduction and internal fixation is indicated in treating patients with unstable radial fractures and with articular incongruity. Besides, the bone stock presence is an important factor for a stable reconstruct of the motion at the fracture site. The early diagnosis and management is needed for an early recovery of the fracture. A low-profile implant and mechanical construct support each column of the injured wrist, providing a good range of motion and functional results.

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