

Pre and post operative radiological assessment of distal radius fracture

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Abstract: *Background:* Distal radius fractures are the most common fractures of upper limb. It accounts nearly 15- 20% of all fractures. Many surgical modalities are available for treatment of the same. It ranges from closed reduction & K-wiring to open reduction & fixation using plates. *Objectives:* To compare the radiological outcomes of distal radius fractures treated with various operative interventions by parameters like radial inclination, radial height and radial tilt. To find out appropriate modality of management for all varieties of distal end radius fracture. Correlation of the functional and radiological outcomes of various operative modalities and its comparison between different types of fractures. *Methods:* 110 patients were called for functional and radiological assessment. All the cases were classified according to fracture patterns for comparison of x-rays of operated and opposite wrist joint to analyse the radiological and functional outcomes. *Result:* Overall 110 patients were operated with slightly male preponderance, 62 male patients (56%) and 48 female patients (44%). Plating had superior outcomes followed by K-wiring. *Conclusion:* Distal radius fractures are increasingly common. Goal of treating distal radius fracture should be to achieve a painless, congruous wrist joint with anatomic reduction of the fracture along with faster and optimum recovery of functions which can be effectively assessed by radiological parameters.

Keywords: DASH, Distal radius fracture, Pre-operative, Post-operative.

Introduction

Distal radius fracture remains the most common fracture encountered in health care. These represent the most common fracture in upper extremity and poses a serious public health concern [1]. With increasing life expectancy, aging population, and subsequent increase in osteoporosis it has ultimately contributed to rise in the incidence of distal radius fractures, with reports of substantial increment over the past 3 to 4 decades [2-3]. Although closed reduction and plaster application was widely practiced earlier [4], surgical fixation of distal radius fractures enables patients to resume daily activity earlier and independently [1, 5].

Thus, there has been a notable trend towards more aggressive fracture fixation in patients with distal radius fracture [1, 6]. Management of DRFs has been an area of intense research and

innovation. Whereas closed reduction and percutaneous pinning and external fixation remained the mainstays of treatment in the past, open reduction and volar fixed-angle plating has become popular and has dramatically shifted the landscape in several ways. Since the end of the 20th century, when internal fixation with a volar locking plate was introduced, the incidence of DRF surgery in general and plating in particular have increased markedly.

DRFs have a bimodal distribution, with a peak in younger persons (18-45 years) and a second peak in older persons (>65 years). High-energy injuries being more common in the younger group and low-energy injuries being more common in the older group with weaker bones as the mechanism, this difference has implications for treatment. Isolated DRF typically include Smith's fracture, Colle's

fracture, Die-punch, Bartons fracture and Chauffeurs fractures and extra articular DRF [7]. An increasing awareness of osteoporosis has led to workup for osteoporosis as a must. They are often comminuted.

Younger patients have stronger bones, requiring more energy to create a fracture in these individuals. In young adults, isolated distal radius fractures are more frequently the result of high energy falls sustained on the playground or during sporting events [8], motorcycle accidents, fall from height, and such fractures must be considered to be a separate entity from the fractures in the older population. The injury to bone and soft tissue in high-energy distal radius fractures is greater than in typical distal radius fractures. Well-established concept is that functional recovery closely parallels the accuracy of skeletal restoration. Hence the treatment modality of fixing distal radius fractures should be such that it hold the fractured fragments in anatomic reduction till union occurs, preventing loss of reduction as well as good early functional recovery.

With increase in incidence of distal radius fractures in last 30 years the management options have expanded remarkably. It was observed with due course of time that the invention of volar locking plate was a breakthrough step in management of distal radius fractures. Plating was found to be an outstanding technique in maintaining anatomic reductions throughout the fracture healing process with seldom loss of reductions and hence better radiological outcomes. Despite this, evidence-based guidelines for management of distal radius fractures of different types are still lacking [9]. The mainstay of this study is radiological assessment of common surgical interventions for various types of distal radius fractures.

Essential Radiographic Imaging Studies and Classification: The imaging modality remains the mainstay of diagnosis of any fracture pathology [10].

- *X-rays* are the standard imaging modality in the diagnosis of DRF.
 - i. *Postero-anterior view:* PA view should be taken with the wrist and elbow at shoulder height. This makes wrist, elbow and shoulder all in the transverse plane,

perpendicular to the x-ray beam. It is used to assess for radial height, radial inclination, ulnar variance, ulna styloid fracture, and distal radio-ulnar joint widening.

- ii. *Lateral view:* Lateral view is taken with the elbow adducted to the side. Shoulder, elbow and wrist are in sagittal plane. Radial tilt is always measured on a lateral view.
- iii. *Tilted lateral view:* Tilted lateral view taken with a pad under the hand to incline the radius about 20 degrees towards the beam. It is useful to assess residual depression of palmar lunate facet and possible hardware penetration into the articular surface.

- *CT scan* should be performed if conventional radiographs provide insufficient detail about radiocarpal articular step-off and gap. The 3D reconstruction images are highly informative these days showing the extent of articular involvement and hence aids in choosing correct treatment modality.
- *Magnetic resonance imaging (MRI)* is of benefit when concomitant injuries of ligaments and triangular fibrocartilage complex (TFCC) are suspected or if a fracture is suspected but not demonstrated on routine radiographs [11].

The Radiographic predictors of functional outcomes: The treatment goal of DRF is a wrist that provides pain-free motion and stability to permit all sorts of activities without the propensity of future arthritic changes. Clinical outcomes of a healed DRF depends on certain key radiological parameters which must be duly addressed while treating them.

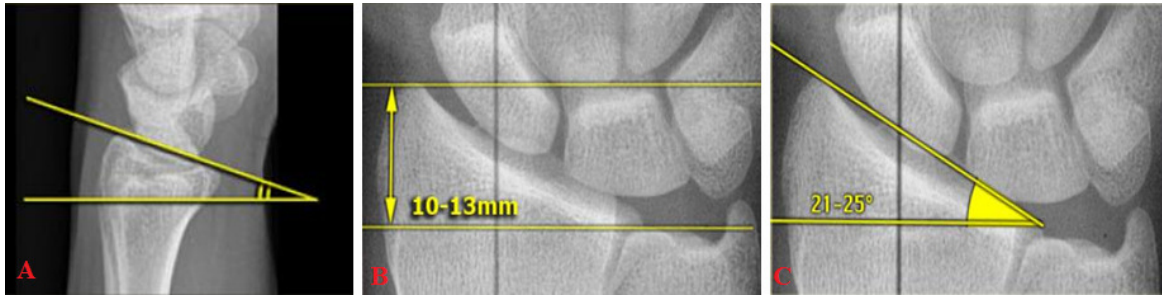
- i. *Intra-articular incongruity:* If incongruity is >2mm, operative intervention must be done to make the joint congruous. Articular step off should be <2mm, post operatively to reduce degenerative changes in future.
- ii. *Palmar tilt* (Fig 1 (A)): Normally the distal end of radius is tilted volarly around 10-22 degrees. Clinical studies have implicated that any degree of

volar tilt from <22 degrees upto neutral is acceptable. A dorsally tilted distal end of radius has poorer functional outcomes with difficulty in gripping objects.

iii. *Radial length* (Fig 1 (B)): Normally the radial length is observed to be around 11-13mm. More than 3mm of radial shortening results in symptomatic loss of strength and also ulnar side wrist pain.

iv. *Radial inclination* (Fig 1(C)): The average radial inclination is 21-25 degrees. It is important to maintain this inclination in order to deviate the wrist ulnarly and hence generate more power while working [12].

Fig-1: (A) Palmer tilt, (B) Radial height, (C) Radial inclination [11]



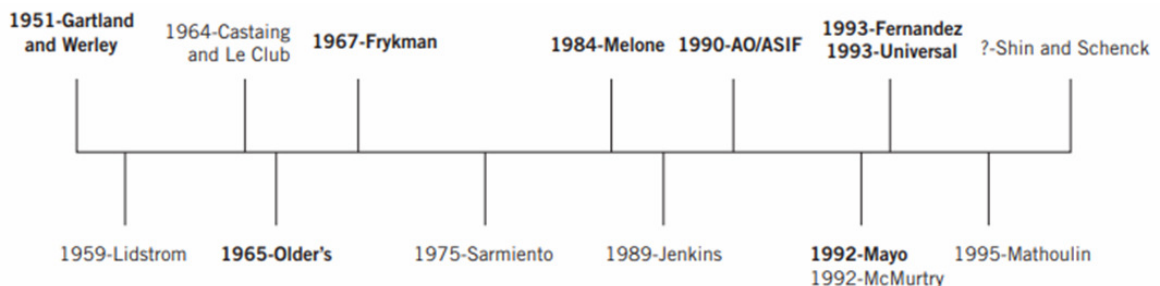
Guidelines for acceptable reduction following DRFs are:

1. Intra-articular stepoff - Less than 2 mm of intra-articular stepoff at radiocarpal joint.
2. Radial tilt – Any degree of volar tilt from <22 degrees upto neutral is acceptable.
3. Radial height – Shortening of <4mm is acceptable.
4. Radial inclination – Should be >15 degrees in PA radiographs [10].

Classification: Various types of classification exists. A classification is useful only if it considers the severity of the bone lesions and serves as a basis for the treatment and evaluating results. In 1814, *Colles* described an extra-articular, dorsally displaced, metaphyseal fracture with radial shortening [13]. *Barton*, in 1838, described intra-articular fractures with either volar or dorsal displacement of the distal radius

[14]. *Smith*, in 1847, classified volarly displaced fractures into three types, based on anatomical description [15]. Other eponymal fractures of distal end of radius includes the *Die-punch* fracture and the *Chauffeur’s* fracture. In 1930, *Nissen-lie*, in 1951 *Gartland* and *werey* and in 1959 *Lindstrom* developed systems of classification that were based on the presence of displacement at the site of fracture and involvement of radio-carpal joints along with presence or absence of fracture of ulnar styloid process. The *AO* system of classification is most inclusive. It relies on increasing severity of osseous and articular lesions making it useful for broad anatomical categories. *Fernandez* in 1993 published a specific classification that separates the fracture according to mechanism of injury [16].

Fig-2: Timeline showing fifteen acknowledged distal radius fracture classification [17].



Operative treatment of radius fractures: Intra articular congruity is the main focus in the outcome of distal radius fracture treatment. Main goal is the restoration of articular congruity. Various treatment plans are available [18].

- (1) Percutaneous pinning: Percutaneous pinning with closed reduction is perfect choice in radius fracture without intraarticular instability or without metaphyseal comminution. In this method Percutaneous 1,6mm K wire can be placed from the tip of radial styloid or through fracture line. This method's complication includes pin tract infection or injury to superficial branch of radial nerve.
- (2) External fixation: It used to be the preferred choice in the operative treatment of distal radius fracture except the volar Barton fracture. Possible complication includes pin track infection, injury to superficial branch of radial nerve, fixator loosening, joint stiffness.
- (3) Dorsal plates: This is the easiest method of treatment of distal radius fracture. However the convex shape of distal radius dorsally and convex grooves for the extensor tendons makes the limitation of placing the dorsal plate beyond the proximal end of Lister's tubercle, otherwise it will damage the extensor tendons. Tendon rupture and tenosynovitis are the commonest complication.
- (4) Volar fixed angle plates: Orbay and Fernandez first introduced this method in 2002. By this method it is possible to avoid the contact between the plate and underlying tendons as the distance between the flexor tendons and volar cortex is long enough and the plate can be covered by pronator quadratus muscle repair. This method is suitable for Smith's fracture, Colle's fracture and Barton's fracture. It is also advised in aged patient having weaker bone mineralization. It is not the method of choice in fractures in paediatric patients. In injury where the fracture is associated with severe soft tissue loss the volar plating is not advisable. Loss of fixation, injury to palmar cutaneous branch of median nerve, carpal tunnel syndrome, rupture or tenosynovitis of flexor pollicis longus, are the commonest complication.

- (5) Bone grafting: When a dorsally displaced fracture of distal radius treated by dorsal approach a metaphyseal bone defect is produced. This can not be reduced without bone graft. The probability of bone grafting diminishes if the fracture is treated through volar plating. Bone grafting is also indicated in comminuted intra articular fracture.

Material and Methods

Total 110 patients were taken into the study with following inclusion and exclusion criteria.

Inclusion criteria:

- All operated cases of lower end radius fracture.
- Age of patients >18 years

Exclusion criteria:

- Open fractures of lower end radius
- Fractures associated with other ipsilateral limb fractures
- Fractures associated with carpal bone involvement
- Isolated fracture of radial styloid
- Pathological fractures of lower end radius.
- Lower end radius fractures associated with nerve and tendon injury.
- Bilateral fractures of lower end radius.

Methodology: 110 patients gave consent to participate in the study. We recorded the demographic data, type of injury, date of surgery, injury-surgery interval, type of operative intervention, mode of injury, associated complications. We classified the patients radiologically according to Frykman's classification. We examined the patients for pain, their day to day activities and assessed their function and disability using DASH score. We measured the range of motion using a goniometer and pinch/grip strengths using Jamar Dynamometer. We took x-rays for radial height, radial inclination, radial tilt, loss of reduction and correlated them with functional outcomes, pain, strengths gained and wrist range of motion after surgery. The functional and radiological

outcomes of operated limb were compared with normal limb.

The disability of the arm, shoulder and hand (DASH) score questionnaire is an upper-extremity specific outcome measure introduced by American Academy of Orthopaedic Surgeons in collaboration with a number of other organizations. DASH scoring system is based on clinical parameters and a functional score based on how the patient perceives upper extremity functions with specific activities. Minimum score is 0 suggesting no disability and maximum score is 100 suggesting severe functional disability.

Statistical Analysis: Descriptive analysis was done to present the collected data. With the advantage of large sample size and normal distribution of data, parametric statistical methods were employed for statistical analysis. Pearson’s correlation coefficient method was used to find correlation between injury surgery interval and various assessment criteria. One way ANOVA test was applied to compare the DASH score,

VAS pain score, percentage of range of motion, percentage of strength, radial height, radial inclination and radial tilt amongst various types of operative interventions in all the different types of fractures. A p-value of <0.05 was considered significant. Once significance was established, post-hoc tuckey test was used for pair wise comparison between plating vs k wiring & plating vs distractor for all fracture types. All the analysis of data was done using STATA 14.2 software.

Results

This study includes 110 patients of DRF, operated with various types of operative interventions.

In our study, 43 year old female patient with history of fall on outstretched hand sustained extra-articular fracture of lower end of radius managed with k-wiring on left side (Figure 3).

Fig-3: 43 year Old female patient- (A) Pre-operative x-rays, (B) Post-operative x-rays and (C) Follow up x-rays



In our study, 45 year old male patient with history of RTA, sustained extra-articular fracture of lower end of radius managed with volar plating on left side (Figure 4) and 34 year old male

patient with history of RTA, sustained juxta-articular, unstable fracture of lower end of radius managed with external fixator on left side (Figure 5).

Fig-4: 45 year Old male patient- (A) Pre-operative x-rays, (B) Post-operative x-rays and (C) Follow up x-rays

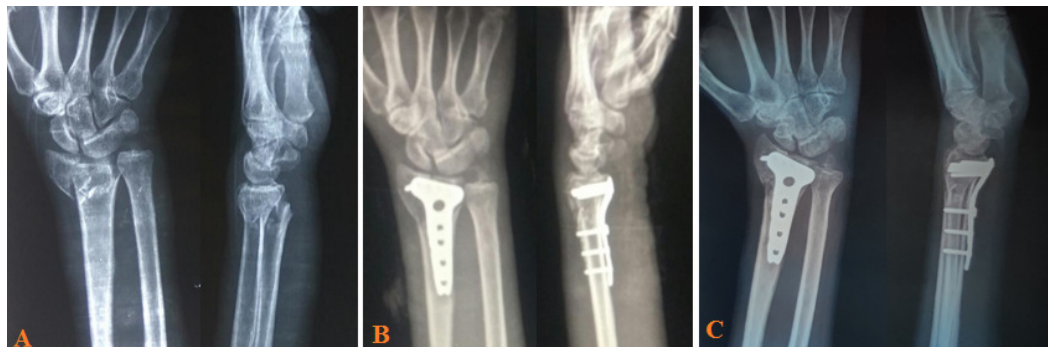
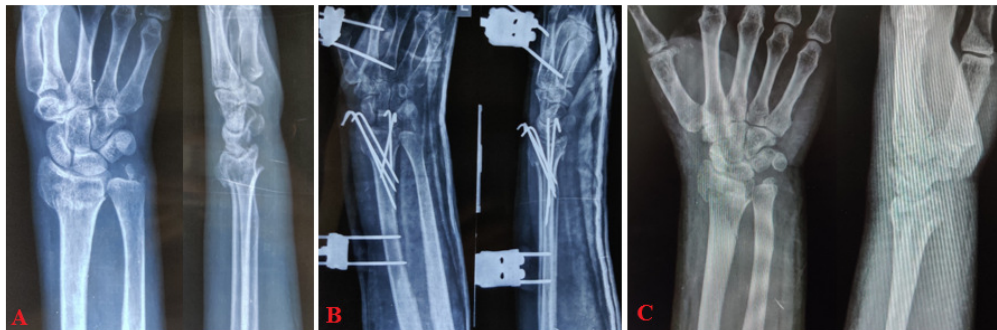


Fig-5: 34 year Old male patient- (A) Pre-operative x-rays, (B) Post-operative x-rays and (C) Follow up x-rays



In our study majority of patients were in age group of 41-50yrs of age (Table 1) with 56% male and 44% female predominance.

Age group	Frequency	Percentage
11-20	1	0.91
21-30	14	12.73
31-40	25	22.73
41-50	31	28.18
51-60	17	15.45
61-70	16	14.55
71-80	6	5.45

There was no significant side predisposition - 53.75% on left side and 46.25% right side. Most common mode of injury causing distal end radius fractures was low energy trauma by fall on outstretched hand (46%) where majority of patients were osteoporotic. Second most common cause being high energy trauma by road traffic accidents (37%). Fall from height (11%) was found to be the third most common cause of DRFs, followed by assault and other cases(3%) each (Table 2).

Mode of injury	Frequency	Percentage
Domestic FOOSH	51	46.36
RTA	41	37.27
FOOSH from height	12	10.91
Assault	3	2.73
Others	3	2.73

Plating (53%) was found to be the most commonly performed surgery in DRFs in our study followed by k-wiring (40%). Out of 58 cases managed with plating, volar plating was done in 55 (50%) cases and dorsal plating was done in only 3 (3%) cases. Distractor (7%) was done in 8 cases owing to its limited indications, non-compliance and delayed rehabilitation (Table 3).

Type of intervention	Frequency	Percentage
Plating (Volar + Dorsal)	58 (55+3)	52.73
K-wiring	44	40
Distractor	8	7.27

By understanding the correlation between the mode of injury and type of operative intervention it was observed that majority of the patients sustaining a domestic fall had trivial injuries because of low energy trauma and hence could be easily managed with K wiring (29 out of 51). Whereas on the other hand those sustaining RTA had significant injuries because of high energy trauma and hence needed fixation with plating (32 out of 41).

In our study, almost 33 (30%) patients had no post-operative complications out of which 27 were treated with plating suggesting satisfactory results. 17 (15%) had mild occasional pain with no functional disability. 11 subjects developed stiffness. Seven subjects reported pain while performing specific activities. 14 patients had implant

related issues. Plating has better results than K-wiring and distractor, when compared on the grounds of functionality, range of motion, post-operative pain, strength and radiological parameter.

Discussion

The ultimate treatment goal is a pain-free hand that functions well. To obtain such a result, treatment of DRFs has changed during the last 30 years from conservative management to an operative approach initially with K wiring advancing upto variable angle locking plates.

It was a general conclusion that plating provided significantly better outcomes for all the types of fracture patterns. Patients in plating group also had significantly less complications compared to other modalities. The mean age of study population in our study was 46.4 years, which was consistent with the age incidence in studies done by Rozental et al. (51 years) [19] and Rizzo et al (46 years) [20].

Study shows predominance of DRFs more in females in elderly age group and more in males in younger age groups. The sex distribution in our study population was found to be of 62 males and 48 females with male to female ration being 1.3:1, hence both sex groups were equally affected. This kind of bimodal distribution is seen because DRFs in young adults occurs mostly due to high velocity injury like RTA whereas elderly population is more prone to falls, hence ends up having fractures with low enrgy trauma. This etiological variation was also found consistent in our study similar to studies by Saving J et al (2019) [21], Flinkkila et al. (1998) [22].

In our study there were 54% patients with left sided involvement and 46% with right side involvement. Hence there is no side predominance in the incidence of DRF. Similar findings were reported by study conducted by Marcheix et al (2010) [23].

All the 110 patients were classified according to Frykman’s classification. Out of all the 8 types, type 2 and type 3 fractures were found to be most common type of fracture. Incidence of type of fracture is nearly consistent with studies in literature (Table 4).

Table 4 : Comparison of incidence of distal radius fractures according to Frykaman's classification with other international studies

Fracture type	J Cuenca et al. [24]	Flinkkila et al. [23]	Our study
Type 1	12.80%	19%	18.18%
Type 2	17.90%	29.70%	19.09%
Type 3	23.50%	3.30%	19.09%
Type 4	14.50%	5.30%	7.27%
Type 5	7.80%	5.80%	13.64%
Type 6	4.50%	10.40%	6.36%
Type 7	9.50%	3.30%	9.09%
Type 8	9.50%	14.90%	7.27%

Out of all the patients, 58 (55 volar + 3 dorsal) were operated with plating, 44 with K-wiring and external fixator was applied to only 8 patients. No patient suffered from post op neurological deficit. When the functional and radiological parameters were assessed for various modalities, it was found that plating has significantly superior results compared to k-wiring and external fixators. This conclusion from our study was also supported by numerous studies conducted in different parts of world by comparing DASH scores of every patients (Table 5).

Table-5: Comparison of DASH score among different surgical modalities with other international studies

Study	Plating group	K-wiring group
Karantanaet al.[25]	9	12
Marchiex et al. [23]	10	22
Rizzo et al. [21]	9	23
Our study	2.76	11
Study	Plating group	Distractor group
Egol et al. [26]	13	17
Wei et al.[27]	4	18
Wilckeet al.[28]	7	11
Our study	2.76	17.23

When the grip strengths were measured on Jamer Dynamometer, it was observed that plating lead to gain upto 90% of strength against only 73% in k-wiring and only 61% in distractor.

Radiological assessment: Goehre et al. [29], Karantana et al [25] and Rizzo et al. [20] concluded in their respective studies that post-operative radiological parameters significantly affect the functional outcomes in DRF's. Moreover, all of these also inferred that plating was way better than any other modality in maintaining the radial inclination, radial height and radial tilt till union. On the other hand 11% patients operated with k-wiring showed loss of reduction in Goehre et al.'s study [29], similarly in our study 3 patients treated with closed reduction and external fixation modalities had to suffer loss of reduction and ended up in malunited fracture resulting in higher DASH scores and painful arthritis.

Conclusion

It is mandatory to obtain near total function of hand irrespective of type of fracture radius. To achieve this goal we should classify the fractures pre operatively, if required CT scan should be done for proper planning and reduction of the fracture and fixation using latest implant. It is obvious with the study, anatomical reduction and its maintenance using rigid implants like anatomical plates gives better functional outcome. K-wire fixation can be used for relatively younger age group with better bone quality. External fixator should be reserved for severely comminuted fractures with poor bone quality, functionally low demand patients and poor skin condition pre-operatively.

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