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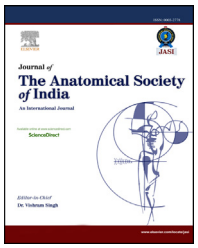

Original Article

Correlation between functional outcome and radiological parameters of healed fracture of distal radius after closed reduction with plaster or percutaneous fixation

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ABSTRACT

Introduction: The aims of this study are to 1) Investigation of morphometric difference in radiological parameters of malunited and normal distal radius of same patients in two age groups. 2) Correlation of functional outcome and radiological parameters of healed fracture distal radius.

Methods: A prospective radiological and clinical study of 90 patients with extra-articular distal radius fracture managed by conservative or partial surgical treatment was carried out for a period of 12 months. The radial length, radial angle/inclination, radial tilt and ulnar variance of the fractured wrist were compared to the contralateral normal side on X-rays at 12 weeks. The final healed radiographs were also analyzed for their functional outcome using MHQ and DASH questionnaires.

Results: Shows decrease in mean value for radial length and radial angle and increase in mean value for ulnar variance and palmer tilt of malunited distal radius in both age groups. Statistically there is a significant correlation between radiological parameters and functional outcomes in the younger group patients. In older age group satisfactory functional results were achieved late (at 20th–24th week) as compared to younger age group (at 16th –20th week) despite unsatisfactory radiological results.

Discussion: The ultimate aim of treatment radiologically and functionally is restoration of the normal anatomical alignment and a pain free, mobile wrist joint without functional limitation. Morphological finding of this study will hopefully facilitate anatomist and clinician in describing the difference between normal and malunited distal radius.

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1. Introduction

The anatomic reduction in fracture treatment is the foremost important and considered in light of functional outcome. Fractures of the distal radius are the most common of the upper extremity and also most common of all orthopedic injuries, about 20% of all fractures presenting to emergency. Osteoporosis is a risk factor in women above 50 year of age for distal radius fracture. The complication rate following the distal radius fracture varies from 10 to 80%, these may occur from the fracture itself or its treatment. The most frequent complications are impairment of joint mobility, malunion, residual pain and RSD (reflex sympathetic dystrophy). Malunion results when fracture is unable to resist displacement once it has been reduced anatomically. Malalignment of the distal radius was associated with a higher risk of poor outcome, but the impact diminished with advancing age, significant dorsal tilt may lead to diminished strength and movement. The radiological end-result of distal radius fractures does not always correlate to the functional outcome. It has been reported that patients may experience no problems despite malunion.[1] Individual outcomes are not entirely predictable because of the different functional demands, expectations, and pain tolerance for each patient. In young adults the need for an anatomic reduction has been stressed. It has been suggested that a maximum of 10° of dorsal tilt, 15° of radial inclination, 2 mm of radial shortening and 2 mm of intra-articular incongruity may be accepted.[2] Elderly populations may tolerate greater degrees of residual deformity because of a more sedentary lifestyle. Lafontaine et al identified several risk factors associated with secondary fracture displacement despite a satisfactory initial reduction. These included the presence of dorsal tilt >20°, comminution, intra-articular involvement, an associated fracture of the ulna, and age greater than 60 years. If three or more of these factors were present there was a high likelihood of fracture collapse.[3] Several studies have determined that the severity of the initial radial shortening alone seems to be a reliable indicator of instability.[4–6] In patients older than 60 years of age, Leone et al found that the degree of radial shortening and volar tilt and the amount of dorsal comminution were predictive of early or late failure. An unexpected finding was that in patients older than 65 years of age, one third of the initially undisplaced fractures subsequently collapsed.[7] Nesbitt et al determined that age was the only statistically significant predictor of secondary displacement. After obtaining an acceptable initial closed reduction, those patients who were more than 60 years of age had four times the risk for failure within the initial 4 weeks as compared with younger patients. The risk for displacement increased with each subsequent decade.[8] It is apparent that late fracture displacement is common in elderly patients, which may be related to their lower bone density. In healthy, active elderly patient if there is a loss of fracture position in the first month then adjuvant the treatment with percutaneous or external fixation. Greater force is necessary to fracture the radius in younger patients because of their higher bone density, which can result in more comminution and a higher risk for subsequent fracture collapse.[9] Supplemental internal or external fixation is indicated in younger patients for fractures with >2 mm of radial shortening and>15° of dorsal tilt following a closed reduction, especially if there is comminution of two or more cortices.[10,11] In a prospective study of 61 consecutive patients presenting with distal radial fractures treated by plaster immobilization, showed that shortening of >4 mm was associated with wrist pain at a mean follow up of 23 months.[12] Trumble et al[10] also have reported that shortening was strongly associated with poor outcome. McQueen and Caspers[13] performed comprehensive functional assessment on 30 patients with extra-articular fractures after a mean of five years. They showed that malunion (dorsal tilt>20° and >2 mm of radial shift) was clearly associated with significant functional limitation. In contrast, the limit of palmar tilt has not been well defined in the literature. The overall goal of the orthopedic surgeon should be the optimal restoration of anatomy and function of the wrist.

2. Materials and methods

A prospective radiological and clinical study of 90 patients with extra-articular fractures of the distal radius treated by conservative or partial surgical treatment was carried out for a period of 12 months. There were all female patients in this study group with age ranging from 30 to 84 year. They were divided in two age groups (below 50 years and above 50 years of age). In majority of cases the mode of injury of distal radius fracture was fall on outstretched hand, while the majority of injuries in the younger patients were secondary to motor vehicle accidents (Fig. 1). Sixty of these patients undergone manipulation and the application of a Colles' cast and remaining 30 were treated by closed reduction and subcutaneous pinning. They were reviewed at 4 week, 8 week, and 12 week with check radiographs. Thereafter a well molded plaster was applied and patient was called for regular follow up. The length of immobilization was 6–8 weeks. The final radiographic assessment of fracture union was performed at 12 weeks. From this Radial length, radial angle/inclination, radial tilt and ulnar variance were measured. We compared the radial length, radial angle/inclination and radial tilt and ulnar variance of the fractured wrist to the non-injured contralateral side on radiographs obtained after fracture healing at 12 week in both age groups of patients (Figs. 2–5).

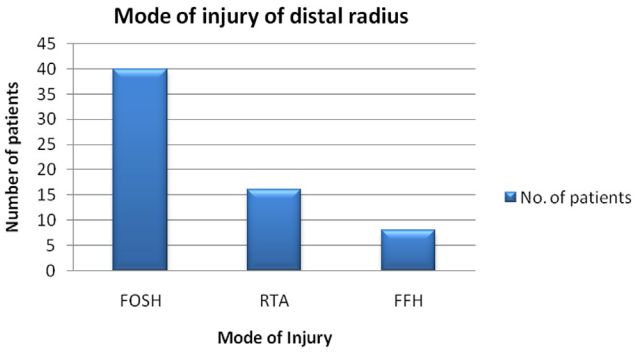

Fig. 1 – FOSH – Fall on outstretched hand, RTA – Road traffic accident, FFH – Fall from height.

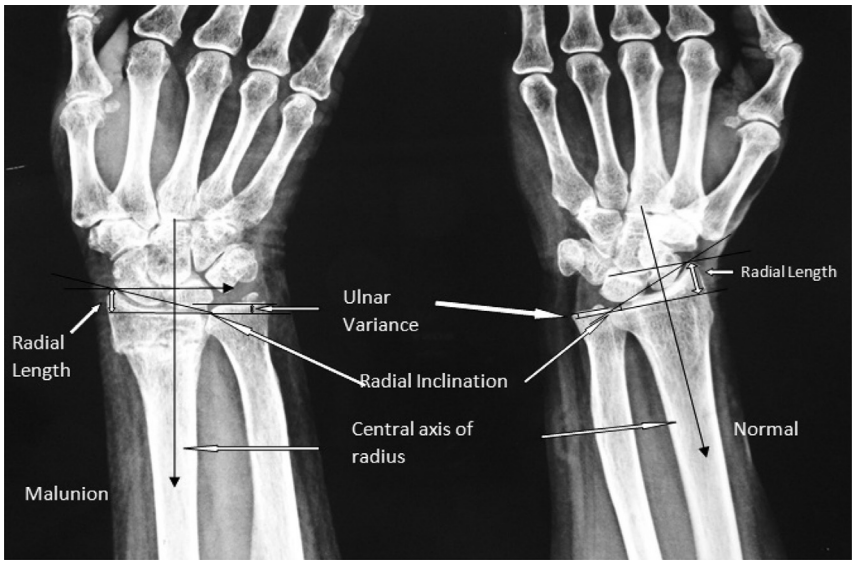

Fig. 2 – Radiograph of patient hands with wrist <50 years of age (PA view).

The clinical parameters considered were the range of movement of the wrist (palmer flexion and dorsal flexion) and forearm (pronation and supination). The flexion-extension, pronation-supination and ulnar-radial deviation ranges were expressed as a percentage of the uninjured contralateral wrist. Grip strength using the grip dynamometer with the elbow in 90° of flexion and the forearm in neutral rotation, these results were also expressed as a percentage of the uninjured side. We used the pain score of Trumble et al and their combined outcome rating system, which is the sum of the total range of motion, pain relief and grip strength divided by 3.[10]

3. Results

In our study of 90 patients, 48 patients had satisfactory radiological result, 08 patients lost the radiological records and 34 patient's shows malunion of distal end radius of clinical significance (Table 1).

We have compared the data of radiological parameters of normal and malunited distal radius to show the correlation between functional outcome and radiological parameter of healed fracture distal radius in different age group. In middle age group (below 50 years) Mean ± SD of normal distal parameters (radial length, radial inclination, ulnar variance and palmar tilt) were 10.21 ± 1.39, 21.00 ± 0.70, 0.36 ± 0.00 and 9.47 ± 0.51 respectively similarly the Mean ± SD of malunited distal radius parameters (radial length, radial inclination, ulnar variance and palmar tilt) were 7.62 ± 0.93, 11.65 ± 0.49, 1.58 ± 0.29 and 13.29 ± 2.22 (Table 2). In old age group (above 50 years) Mean ± SD of normal distal radius parameters (radial length, radial inclination, ulnar variance and palmar tilt) were 9.97 ± 1.31, 21.17 ± 0.69, 0.32 ± 0.00 and 10.06 ± 0.66. Similarly the Mean ± SD of malunited distal radius parameters (radial

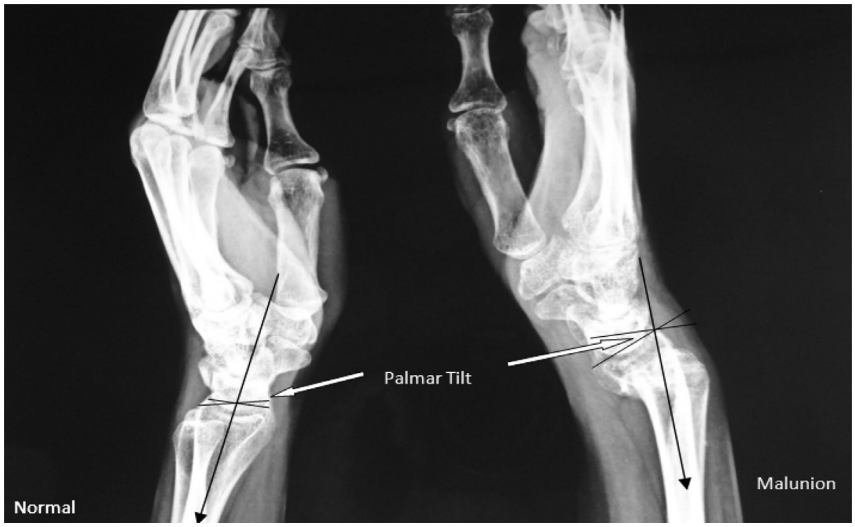

Fig. 3 – Radiograph of patient hands with wrist <50 years of age (Lat. view).

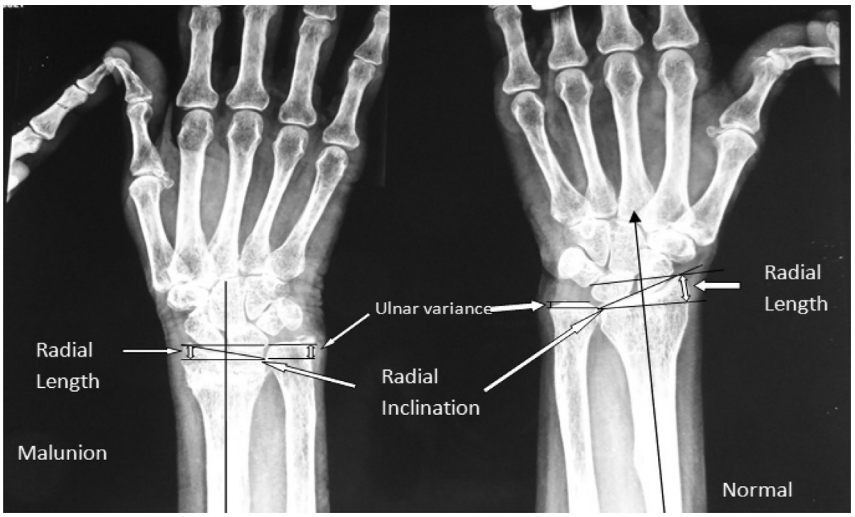

Fig. 4 – Radiograph of patient hands with wrist >50 years of age (PA view).

Fig. 5 – Radiograph of patient hands with wrist >50 years of age (Lat. view).

length, radial inclination, ulnar variance and palmar tilt) were 7.50 ± 0.93, 12.35 ± 1.05, 2.20 ± 0.27 and 15.65 ± 2.47 respectively (Table 3). Data of each parameter was compared between normal and malunited distal radius in both middle age group and old age group. In middle age group radial length shows the mean difference of 2.59 mm, radial inclination shows the mean difference of 9.35°, ulnar variance shows the mean difference of 1.20 mm and palmar tilt shows the mean difference of 3.82°. For all the above data P value is < 0.01 so there is significant difference between the two group at 1% level of significant that means we may say that with 99% confidence, there is significant difference between mean of normal and malunited group. Correlation analysis between normal and malunited distal radius shows that the radial length and radial inclination of malunited distal radius had negative correlation with radial length and radial inclination of normal distal radius. At the same time ulnar variance and palmar tilt of malunited distal radius had positive correlation with ulnar variance and palmar tilt of normal distal radius.

In our study inter-group correlation analysis of malunited distal radius parameters shows that the radial length mean

Table 1 – Age group of the 34 patients (shows malunion of distal radius) and their percentage.

S. no.	Age group (year)	Number of patients	Percentage of patients (%)
1	Below 50 years	17	50
2	Above 50 years	17	50

Table 2 – Descriptive statistical data (parameters) of distal radial in middle age group (30–50 year) females.

S.no.	Parameter	Distal radius	Number of patient	Mean (mm)	S.D.	Mean difference of normal and malunited distal radius	P value
1.	Radial length	Normal	17	10.21	1.39	2.59	$P < 0.0001$
		Malunited	17	7.62	0.93		
2	Radial inclination	Normal	17	21.00	0.70	9.35	$P < 0.0001$
		Malunited	17	11.65	0.50		
3.	Ulnar variance	Normal	17	0.36	0.00	1.20	$P < 0.0001$
		Malunited	17	1.58	0.29		
4.	Palmar tilt	Normal	17	9.47	0.51	3.82	$P < 0.0001$
		Malunited	17	13.29	2.22		

*Since $P < 0.01$, so there is significant difference between two group at 1% level of significance that means we may say with 99% confidence, that there is significant difference between means of normal group and malunion group.

difference was 0.1294 mm and P value <0.64 which is less significant, while the radial inclination shows the mean difference. 700° and P value <0.0188 is also less significant that signify that radial inclination radial length are closely correlated and both reflects the consequence of axial compression. However there was statistically significant P value ($P < 0.01$) of ulnar variance and palmar tilt of malunited distal radius in between two age group. Finally in our entire patient there was radial shortening with resultant positive ulnar variance ($P < 0.01$).

54 patients (based on the Michigan hands outcomes, MHQ) and 78 patients (based on the Disabilities of the arm, shoulder and hand, DASH questionnaire) had satisfactory functional results. Normal wrist flexion, extension, forearm pronation and supination and grip strength of hand was recorded for 78 of our patients. Twelve patients could not achieve both their normal wrist motion and grip strength at the end of our study. The middle age group up to 50 years regained their normal wrist mobility and grip strength earlier (at 16th–20th week) and older age group above 50 year regained their full normal wrist motion and grip strength at 20th–24th week of follow up. This aspect of our study resembles to some extent the study done by Foldhazy and Tornkvist who observed that recovery of grip strength was slower than that of range of motion. Elderly patients recovered more slowly than young middle age patients. Patients over 60 years of age recovered slower in both mobility and strength.[14]

We have checked the normality of data and found that our data are approximately normally distributed for both the group. Student t-test was used to compare measurements of the normal and malunited distal radius. Spearman's rank correlation was used to assess the relationship between the various measurements of normal and malunited distal radius. The data was analyzed utilizing SPSS version 20.0. Comparison of means was carried out using the independent t-test with significance set at $P < 1\%$ (pre-assigned value).

4. Discussion

Distal radius fractures are a common injury particularly in the elderly population. The incidence appeared to be both gender and age specific. Higher incidence of distal radius fractures in females is also reported by some other studies.[15–17] Interestingly it was found that in older patients with extra-articular fractures, the influence of the radiological parameters for malunited distal radius was less obvious than in younger patients but regained their full normal wrist motion and grip strength late at 20th–24th week of follow up as compared to the younger age group up to 50 years who regained their normal wrist mobility and grip strength earlier (at 16th–20th week).

In different studies of Colles fractures treated with closed reduction and plaster determined that for ulnar wrist pain important factor was incongruity of the distal radioulnar joint (DRUJ) secondary to residual dorsal angulation of the radius.[18] Others have found that an increase in the ulnar variance was the most important radiologic parameter affecting outcome.[19]

Table 3 – Descriptive statistical data (parameters) of distal radial in old age group (50–84 year) females.

S.no.	Parameter	Distal radius	Number of patient	Mean (mm)	S.D.	Mean difference of normal and malunited distal radius	P value
1.	Radial Length	Normal	17	9.97	1.31	2.47	$P < 0.0001$
		Malunited	17	7.50	0.93		
2	Radial Inclination	Normal	17	21.17	0.69	9.36	$P < 0.0001$
		Malunited	17	12.35	1.05		
3.	Ulnar variance	Normal	17	0.32	0.00	1.85	$P < 0.0001$
		Malunited	17	2.20	0.27		
4.	Palmar tilt	Normal	17	10.06	0.66	5.59	$P < 0.0001$
		Malunited	17	15.65	2.47		

*Since $P < 0.01$, so there is significant difference between two group at 1% level of significance that means we may say with 99% confidence, that there is significant difference between means of normal group and malunion group.

Ulnocarpal impingement and DRUJ incongruency are related to the amount of radial shortening and are a common cause of ulnar sided wrist pain.[20] In young patients, DRUJ instability is another cause of residual pain following a distal radius fracture. Hove et al found that the total movement in all directions was diminished with an ulna plus deformity and that pronation and supination were related to the initial radial length and dorsal angulation.[21] Fujii et al determined that fractures that had healed with 6 mm or more of radial shortening were likely to have a poor functional outcome.[22] More than 10° of dorsal tilt leads to a dorsal carpal shift with compressive forces, which causes pain and insecurity with gripping. This has been associated with increased difficulty with everyday activities and work.[23] Dorsal angulation of >20° and reduction of the radial angle to less than 10° can result in a reduction in grip strength.[24] Kelley et al studied 30 elderly patients with moderately displaced Colles' fractures (10°–30° of dorsal angulation and 5 mm of radial shortening). In his study two thirds of the correction of dorsal angulation achieved by manipulation was lost by 5 weeks. They concluded that up to 30° of dorsal angulation and 5 mm of radial shortening may be accepted in selected elderly patients.[25]

5. Conclusion

The ultimate aim of treatment radiologically and functionally is restoration of the normal anatomical alignment and a pain free, mobile wrist joint without functional limitation. The quality of reduction is assessed mainly by degree of restoration of radial angle of inclination and palmar tilt. Knowledge about reference values of morphometry of distal radioulnar joint of normal hand is important for surgical correction of opposite malunited distal radius and for better functional outcome. Idea about these normal reference values of distal radioulnar joint in a patient are important because there are conflicting views in literature regarding the acceptable radiological indices according to races for surgeon faced with malunited fracture distal radius or displaced radial fracture. In our study radial shortening, decreased radial inclination and increased ulnar variance & palmer tilt are present in most of malunited distal radius. In this study radiographs were assessed and the overall alignment of the fracture was considered 'unacceptable 'if the dorsal tilt was >10° or palmer tilt was >25°, if the radial inclination was<15° and radial shortening> 2–5.0 mm or if there was ≥3 mm of positive ulnar variance and found that patients at all ages had good functional outcome of their fracture healed with acceptable malalignment. In middle age group impact of malalignment of the distal radius was associated with a higher risk of poor outcome, but the impact diminished as the age is more than 60 years. Most of our patients with radial shortening and increased dorsal tilt have pain and diminished grip strength therefore; restoration of radial length has been considered the most important determinant of functional outcome.

Conflicts of interest

The author has none to declare.

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