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Dr. Nipun Aggarwal
Assistant Professor,
Department of Orthopaedics,
Maharishi Markandeshwar Institute of Medical Sciences and Research (MMIMSR), Mullana, Ambala, Haryana, India

Dr. Jashandeep Singh Chahal
Senior Resident,
Department of Orthopaedics,
Maharishi Markandeshwar Institute of Medical Sciences and Research (MMIMSR), Mullana, Ambala, Haryana, India

Dr. Pravendra Singh
Assistant Professor,
Department of Orthopaedics,
Maharishi Markandeshwar Institute of Medical Sciences and Research (MMIMSR), Mullana, Ambala, Haryana, India

Dr. Shristi Singh
2nd Year Resident,
Department of Orthopaedics,
Maharishi Markandeshwar Institute of Medical Sciences and Research (MMIMSR), Mullana, Ambala, Haryana, India

Corresponding Author:
Dr. Shristi Singh
2nd Year Resident,
Department of Orthopaedics,
Maharishi Markandeshwar Institute of Medical Sciences and Research (MMIMSR), Mullana, Ambala, Haryana, India

Correlation between radiographic and functional outcome of distal radius fracture managed by closed reduction and plaster of Paris cast application: A prospective study

Dr. Nipun Aggarwal, Dr. Jashandeep Singh Chahal, Dr. Pravendra Singh and Dr. Shristi Singh

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Abstract
Background: This study was conducted to determine whether radiological parameters correlate with functional outcome in patients with a fracture of the distal radius managed by closed reduction and pop cast application.
Methods: This prospective study included all trauma cases which were presented to the Maharishi Markandeshwar institute of medical sciences and research, Mullana, Ambala, Haryana over a one year period. Radiographs in postero-anterior (PA), lateral views were used to visualise a suspected fracture of the distal radius. The information were recorded on an electronic spreadsheet. Cases were excluded if they did not meet the definition our inclusion and exclusion criteria. Patients were managed with above elbow pop cast for 3 weeks and further below elbow cast for 2-3 weeks. Mobilization was started after confirming clinic radiological union. Radiographs were taken at 3 months, 6 months and 12 months duration post reduction. Functional outcome was measured using Disability of Arm, Shoulder and Hand questioner score (DASH score) and patient rated wrist evaluation (PRWE).
Results: A total of 146 patients were included. In our study we got 67.2% Excellent, 16% good, 15% fair and 3% poor results. In this study we analyzed PRWE score after 3 months, 6 months and 12 months for function outcomes. The mean difference of PRWE score between after three months (23.21±23.1) and after six months (15.03±32.1) the p value was 0.001, which was significant. The mean difference of PRWE score between after 6 months (15.03±32.1) and 12 months (5.11±43.1) the p value was 0.011, which was significant. The mean difference of PRWE score between after three months (23.21±23.1) and 12 months (5.11±43.1) p value was <0.001, which was significant. It means we found grossly improvement in patients as per PRWE score between 3 months and 12 months duration.
Conclusion: According to our study the functional outcome of patients was found to be not in correlation with radiological outcome and radiological parameters might not provide the most appropriate measure of patient outcome following even a displaced fracture of the distal radius fracture.

Keywords: Distal end radius fracture, closed reduction, plaster of Paris

Introduction
Distal radius fractures are the most common fractures of the upper extremity seen in clinical practice, compromising of more than 16% of all fractures [1]. The commonest mode of injury is a fall on outstretched hand although it is not uncommon in high-energy trauma patients. Distal radius fractures have been a subject of ongoing discussion for over two hundred years [1]. Distal radial fractures have a bimodal type of age distribution with high-energy trauma contributing in younger and low energy trauma in elderly population. Females are more liable to distal radius fractures when compared with males [2] mainly because of more severe osteoporosis and a higher liability of elderly women to falls [3] compared to the age - matched men. Closed reduction and casting has been the most commonly employed treatment modality but the subsequent malunion and distal radio-ulnar joint subluxation results in poor radiological and functional outcomes. Although many treatment modalities are available there is no consensus on the optimum treatment of these injuries [4]. The radius is the larger of the

two bones of the forearm. The end toward the wrist is called the distal end. A fracture of the distal radius occurs when the area of the radius near the wrist breaks. Distal radius fractures are very common. Fractures of the distal radius constitute one of the most common skeletal injuries treated by Orthopaedic surgeons. They make up 8%-15% of all bony injuries in adults [5]. No consensus has been reached on classification systems, indications for surgery, or a particular choice of surgery since the orthopedic community first rejected Colles' contention that all distal radius fractures (DRFs) heal well. Gartland and Werley are generally credited with starting the revolution in 1951 with their paper examining more than 1000 DRFs, and Jupiter brought the discussion into the modern era with his 1986 paper in the Journal of Bone and Joint Surgery that emphasized the importance of reduction (Leung *et al.*, 2013) [7]. Over decades, surgical approaches such as open reduction and internal fixation have seen increasing use, but recent studies with one-year follow-up show no significant differences between surgical intervention and closed reduction with cast immobilization in terms of functional outcome. Additionally, complications such as tendon afflictions and further surgery can arise from surgical intervention. Therefore, closed reduction and cast immobilization remains an important treatment option in a majority of cases. However, the optimal method of closed reduction remains to be determined [7, 8, 9]. A very commonly used method of closed reduction is manual traction (MT). An assistant provides counter-traction while the operator provides traction and manipulates the bone fragments into position. Even though it has been the most commonly used method for at least the better part of a century, the evidence of its effectiveness is ambiguous, and by the 1950s it was already being postulated that the method might damage the soft tissues surrounding the fracture [5, 6]. Ponteau[7] (1783), a French surgeon described the fracture pattern earlier but, Abraham Colles [8] (2006) is widely credited for the description of the most common type of distal radius fracture. In 1854, Smith [9] (1995) claimed that a fall on the back of a flexed wrist results in palmar displaced distal radius fractures. Another method is mechanical reduction by finger-trap traction (FTT) which dispenses with the need for an assistant as the forearm is suspended by finger-traps in the radial fingers. Countertraction is provided by weights suspended on the arm near the elbow joint. This restores the longitudinal axis without further actions, and the operator can then apply manual dorsal pressure to the fragments, if necessary, to restore the volar tilt of the wrist. Several study authors have recommended this procedure as a more gentle method of reduction [10, 7, 11]. Historically, radiographic deformity was considered to correspond to a poor functional outcome. The correlation between the degree of radiographic deformity and functional outcome of distal radius fracture is controversial. In this study we evaluate functional outcomes at follow up duration and correlate radiological parameter.

Material

The present study was conducted in the Department of Orthopaedics, Maharishi Markandeshwar Institute of medical sciences and research, Mullana, Ambala, Haryana. It includes cases which presented in OPD of department of Orthopaedics and Emergency over a one year period were identified. It is a major private hospital accepting all traumas.

Fig 1: Showing traction method in case of distal end radius fracture

Inclusion criteria: Age more than 18 years, closed fractures, isolated distal radius fractures.

Exclusion criteria: Open fractures, Pathological fractures, bilateral distal radius fractures, fractures more than 3 weeks old.

Sample size: In a study (Masood *et al.*, 2016), the outcome of treatment of distal radial fractures was excellent or good in 92% patients. The sample is calculated by using the following formula (Charan and Biswas, 2013). N=4pq/d2, Where n is the required sample size, P=Prevalence of cause, Q=1-p, d=Precision Taking 80% power, 5% significance level with 0.07 precision, N=4*0.455*0.08/(0.07*0.07)=146 the calculated sample size is 146.

Methods

All cases which were presented to the Maharishi Markandeshwar institute of medical sciences and research, Mullana over a one year period were identified. Radiographs in postero-anterior (PA), lateral views were used to visualise a suspected fracture of the distal radius. The information were recorded on an electronic spreadsheet.

Patients were managed with above elbow pop cast for 3 weeks and further below elbow cast for 2-3 weeks. Mobilization was started after confirming clinic radiological union. Radiographs were taken at 3 months, 6 months and 12 months duration post reduction. Functional outcome was measured using Disability of Arm, Shoulder and Hand questioner score (DASH score) and patient rated wrist evaluation (PRWE)

Table 1: Showing the grading system of DASH score

Grading	DASH Score
Excellent	0-5
Good	6-15
Satisfactory	15-35
Poor	>35

Following radiologic measurements quantifying the orientation of the distal radius were used

1. **Dorsal/Palmar Tilt:** On true lateral view line is drawn connecting the most distal points of the volar and dorsal lips of radius. The dorsal and palmar tilt is the angle created with longitudinal axis of the radius.
2. **Radial Length:** This is measured on the PA radiograph.

It is the distance in millimeters between a line drawn perpendicular to the long axis of the radius and tangential to the most distal point of the ulnar head and a line drawn perpendicular to the long axis of the radius and at the level of the tip of the radial styloid.

3. **Ulnar variance:** This is a measure of radial shortening and should not be confused with the measurement of radial length. Ulnar variance is the vertical distance between a line parallel to the medial corner of the articular surface of the radius and a line parallel to the most distal point of the articular surface of the ulnar head, both of which are perpendicular to the long axis of the radius.
4. **Radial inclination:** On the PA view the radius inclines toward the ulna. This is measured by the angle between a line drawn from the tip of the radial styloid to the medial corner of the articular surface of the radius and a line drawn perpendicular to the long axis of the radius.

Ethical Considerations: Informed consent was obtained from all the participants. Ethical approval for the study was obtained from the Institutional Ethical Committee.

Statistical evaluation: The collected data was entered Microsoft Excel computer program. An analysis was performed using IBM SPSS 21 version by entering the value of parameters from Microsoft Excel computer program to identify any relationships between different variables. The chi-squared and Fisher's exact test were used for correlation between categorical variables and the t-test was for correlation between continuous variables. A p value of<0.05 was considered statistically significant with a 95% confidence interval applied. A cost analysis was also performed using information from the hospital. The Unpaired t- test was used to compare continuous variables between the groups. One way analysis of variance (ANOVA) followed by Tukey's post hoc comparisons was used to continuous variables amomg the groups. All the analysis was carried out on IBM SPSS 21.0 version (Chicago, Inc., USA).

DASH score calculation: The response to the first 30 items of the DASH are added to form the raw, or actual, score0. A minimum score is 30; a maximum is 150. The range of the scores, therefore—from 30 to 150— equals 120.The raw score is then transformed to a zero-to-100 scale. To transform the score to the zero-to-100 scale, you subtract the minimum possible score, or 30, from the raw score and divide by 1.2, which is the possible score range (120) divided by 100.

Dash score = Raw score - 30 (minimum score)/ 1.2 (range of scores ÷ 100)

Fig 2: Showing radiographic evaluation of distal end radius

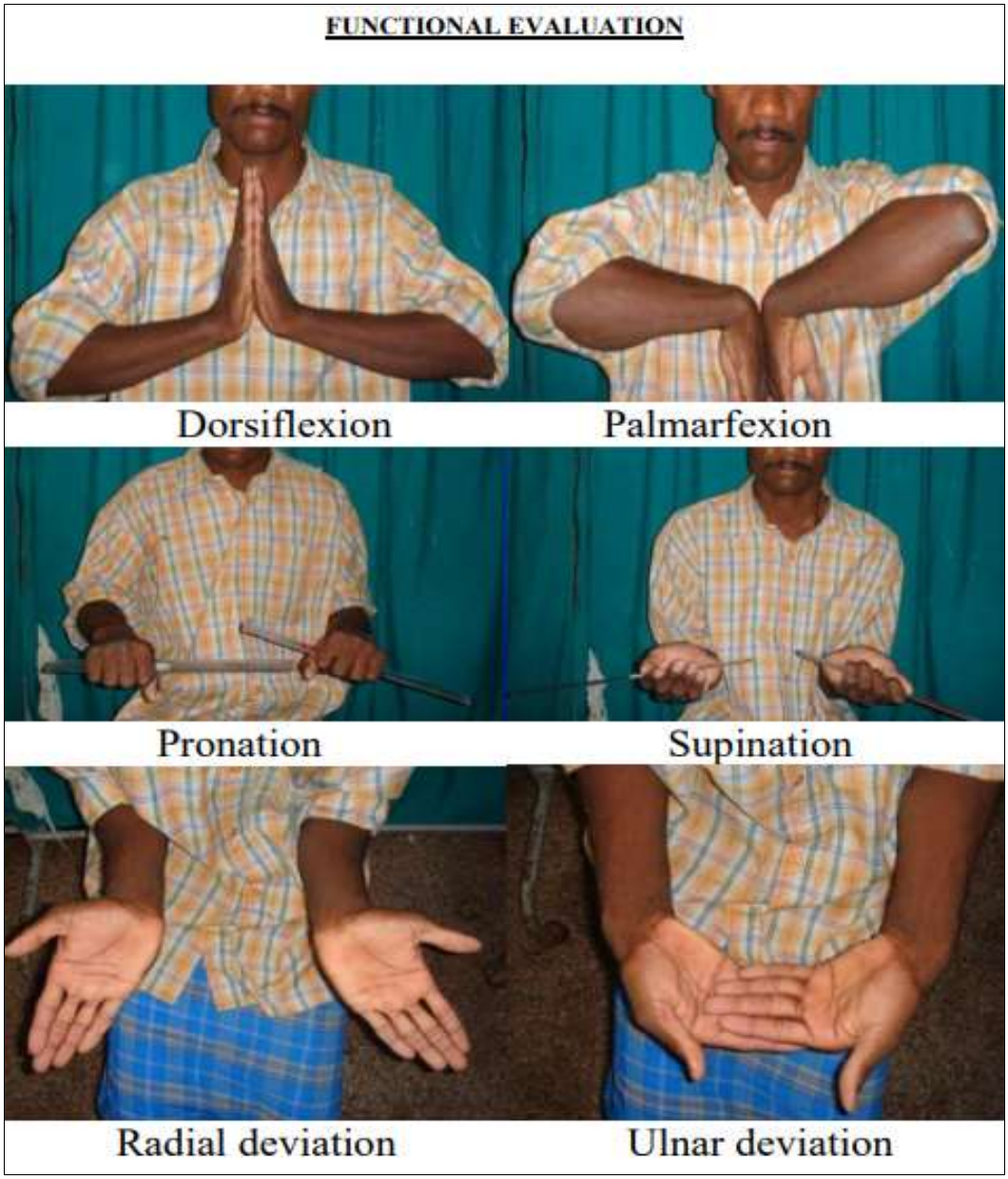

Fig 3: Showing functional evaluation of wrist range of motion

PRWE score calculation

Computing the Subscales Pain Score = Sum of the 5 pain items (out of 50) Best Score = 0, Worst Score = 50 Function Score = Sum of the 10 function items, Divided by 2 (out of 50) Best Score = 0, Worst Score = 50 Computing the Total Score Total Score = Sum of pain + function scores Best Score = 0, Worst Score = 100 Interpretation: The total PRWE score rates pain and disability equally. Higher score indicates more pain and functional disability (e.g., 0 = no disability).

Results

The present study was conducted in the Department of Orthopaedics, Maharishi Markandeshwar Institute of medical sciences and research, Mullana, Ambala, Haryana, India with the Aim to conduct a study to determine whether radiological parameters correlate with functional outcome in patients with a fracture of the distal radius managed by closed reduction and pop cast application. A total of 146 patients were included.

Fig 4: Showing pre-reduction and post-reduction, 3 months and 6 months follow up xrays of two patients with distal end radius fracture

Table 1a: Sex Distribution

Sex	Number of Patients
Male	87
Female	59
Total	146

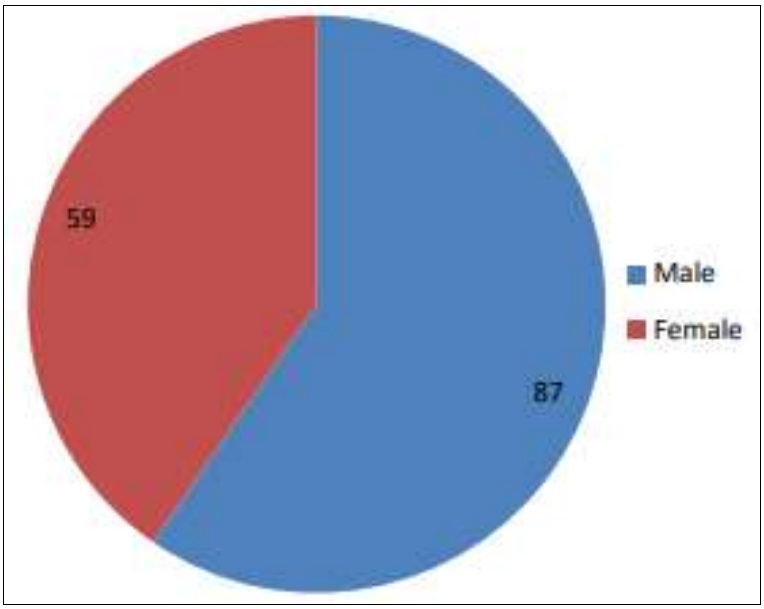

Fig 5: Sex Distribution

Table 1 and Figure 5 shows that out of 146 cases 87 were male and 59 were female.

Table 2: Patients distribution with age Groups

Age Group	Number of patients		'Faisal
	Male	Female	
18 to 30 years	12	11	23
31 to 40 years	12	12	24
41 to 50 years	17	19	36
51 to 60 years	33	16	49
•:- 60 years	13	1	14
Mean age	47.44±22.3	41.36±19.5	45.19. ±22.3

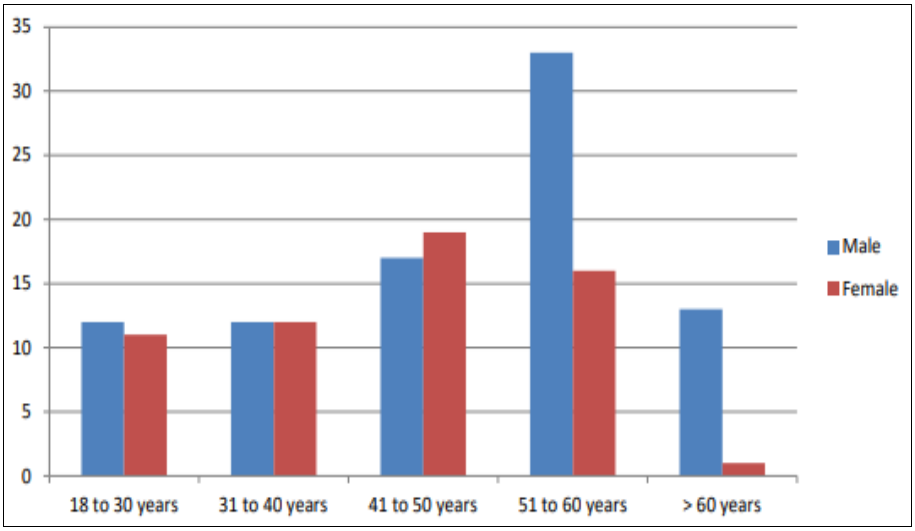

Fig 6: Patients distribution with age Groups

Table 2 and figure 6 shows that out of 20 cases of 18 to 30 years age group 12 were male and 11 were female. Out of 24 cases of 31 to 40 years age group 12 were male and 12 were female. Out of 36 cases of 41 to 50 years age groups 17 were male and 19 were female. Among 49 cases of 51 to 60 years age group 33 were male and 16 were female and among 14 cases of above 60 years, 13 were male and one was female.

Table 3: Mechanism of injury

Mechanism of Injury	No of cases	%
High velocity injury	102	69.8
Trivial fall at home	44	30.2
Total	146	100

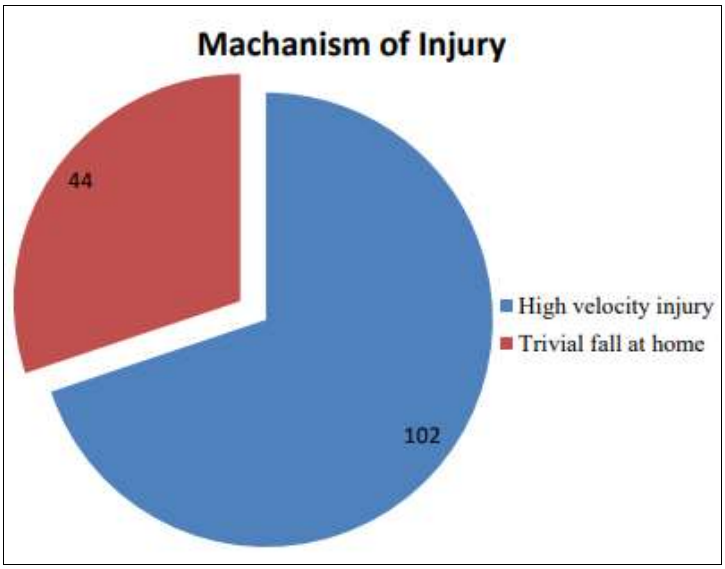

Fig 7: Mechanism of injury

Table 3 and Figure 7 shows that mechanism of injury of cases. Among 146 cases 102 cases have found high velocity injury and 44 cases were found Trivial fall at home.

DASH

Table 4: Comparison of DASH Score in different follow up duration

Duration	DASH Score (Mend ± SD)	p value
After 3 month	36.10±16.2	0.021
After 6 month	17.71±11.8	
After 6 month	17.71±11.8	0.011
After 12 month	8.88±16.2	
After 3 month	36.10±16.2	<0.001
After 12 month	8.88±16.2	

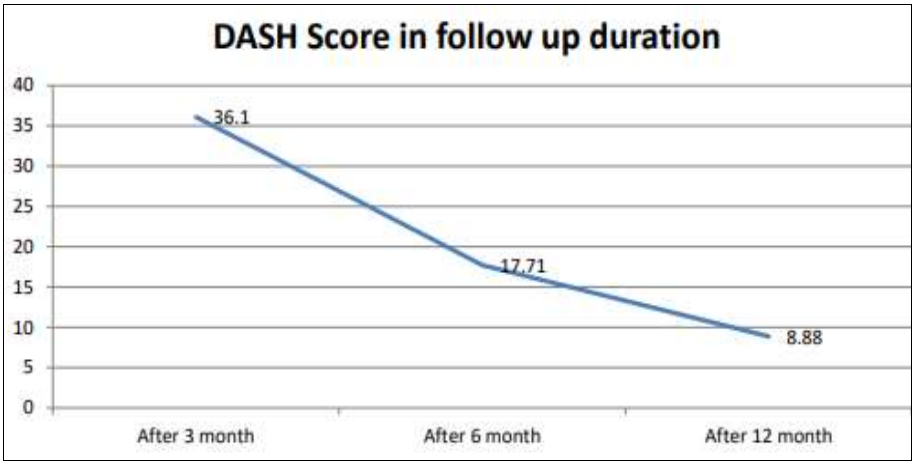

Fig 8: Comparison of DASH Score between Three months, Six Months & 12 Months

Table 4 and Figure 8 shows that comparison of mean DASH score between follow-up duration and found gross difference in mean DASH score after three months, 6 months and 12 months for function outcomes. The mean difference of DASH score between after three months (36.10±16.2) and after six months (17.71±11.8) we found the p value was 0.021, which was significant. The mean difference of DASH score between after six months (17.71±11.8) and 12 months (8.88+16.2) p value was 0.011, which was significant. The mean difference of DASH score between after three months (36.10±16.2) and 12 months (8.88±16.2) p value was <0.001, which was highly significant.

Table 5: DASH Score grading of different follow up duration

DASH Score Group	No of patients after 3 months	No of patients after 6 months	No of patients after 12 months
Excellent (0 to 5)	4	24	72
Good (6 to 15)	12	39	17
Satisfactory (15 to 35)	63	62	15
Poor (>35)	61	7	3
Total	140	132	107

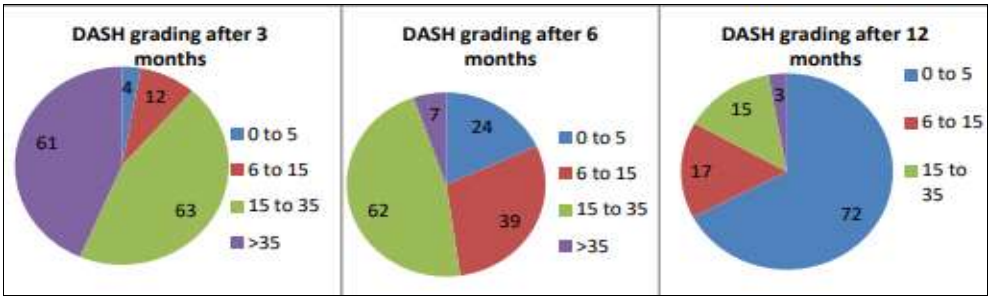

Fig 9: DASH Score grading of follow up duration

Table 5 and figure 9 shows that improve patients as per various grading of DASH score in different follow up stage and found major changes. After 3 months 4 patients in excellent (0-5 DASH) grade group, 12 patients were Good (6-15 DASH) grade group, 63 patients were found in satisfactory (15-35 DASH) grade group and 61 patients found poor (>35 DASH) grade. After 6 months 24 patients in excellent (0-5 DASH) grade group, 39 patients were Good (6-15 DASH) grade group, 62 patients were found in satisfactory (15-35 DASH) grade group and 7 patients found poor (>35 DASH) grade. After 12 months 72 patients in excellent (0-5 DASH) grade group, 17 patients were Good (6-15 DASH) grade group, 15 patients were found in satisfactory (15-35 DASH) grade group and 3 patients found poor (>35 DASH) grade

PRWE

Table 6: Improvement in patients as per various PRWE Score group in follow up duration

PRWE Score Group	No of patients after 3 months	No of patients after 6 months	No of patients after 12 months
<5	6	27	78
6-10	27	34	23
11 - 20	47	49	3
21 - 50	55	17	2
>50	5	5	1
N-146	140	132	107

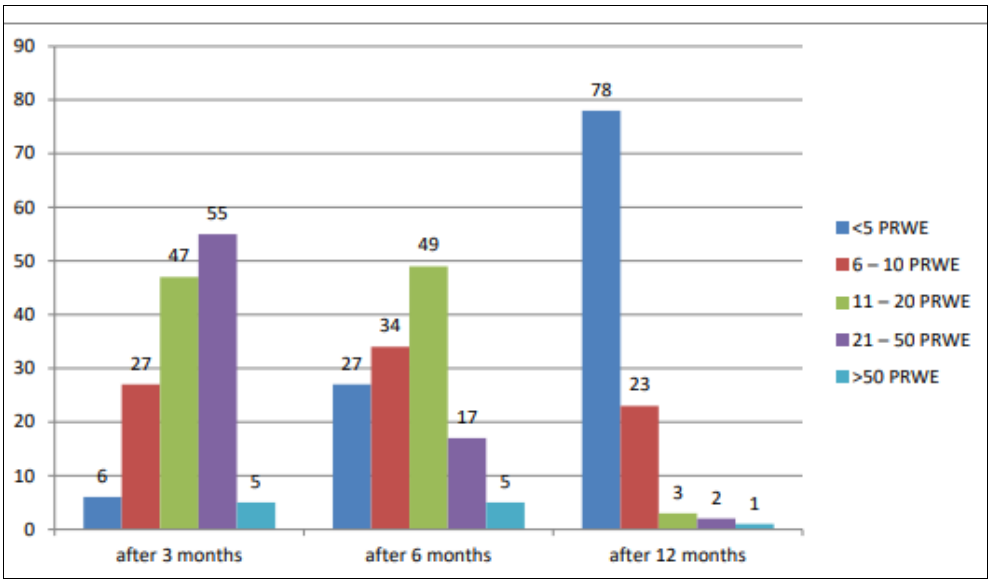

Fig 10: Improvement in patients as per various PRWE Score groups in follow up duration

Table 6 and figure 10 shows that improvement in patients as per various groups of PRWE score in different follow up stage and found major changes in patients in different follow up stage. In PRWE score groups <5, 6-10, 11-20, 21-50 and 50 groups no of patients after three months 6,27, 47, 55 & 5 where after 6 months of follow up 27, 34, 49, 17 & 5 and after twelve months 78, 23, 3, 2, 1 respectively.

Table 7: Mean difference of PRWE Score at Three Months, Six Months and Twelve Months

PRWE Score Duration	Mean	p value
After 3 month	23 21±23.1	0.001
After 6 month	15.03±32.1	
After 6 month	15.03±32.1	0.001
After 12 month	5.11±43.1	
After 3 month	23 21±23.1	<0.001
After 12 month	5.11±43.1	

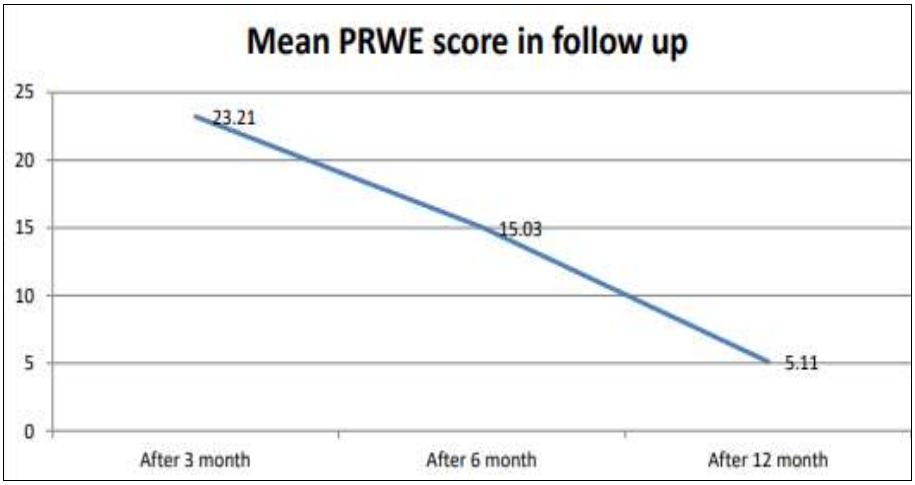

Fig 11: Mean difference of PRWE Score at Three Months, Six Months and Twelve Months

In this study we analyzed PRWE score after three months, 6 months and 12 months for function outcomes. The mean difference of PRWE score between after three months (23.21+23.1) and after six months (15.03±32.1) the p value was 0.001, which was significant. The mean difference of PRWE score between after six months (15.03±32.1) and 12 months (5.11+43.1) p value was 0.011, which was significant. The mean difference of PRWE score between after three months (23.21+23.1) and 12 months (5.11+43.1) p value was <0.001, which was highly significant. It means we found grossly improvement in patients as per PRWE score between 3 months and 12 months duration.

Discussion

The patients in this study, with a mean age of 44.6±22.3 years, had a good overall long-term functional outcome after a DRF. In this study we treated non-operatively Distal Radius fractures had better DASH, PRWE score after a mean follow-up of 3 months, 6 months and 12 months indicating better wrist function with less pain. In multiple linear regression analysis this difference was only statistically significant in follow up duration. Most of previous studies on patient-reported functional outcome presented results obtained after 3, 6, or 12 months of follow-up. Our study assessed patient-reported functional outcomes at a mean of DASH score, PRWE score and radiological evaluation. We found a significant difference in functional outcome between the follow-up duration, in favor of non-operative treatment. The rise of intra articular distal radius fractures and its various presentations of complexity in even younger individuals are predominantly due to high energy trauma especially road traffic accidents [12]. Over the past quarter century a number of classification have been evolved in an attempt to have more accurate representations of the type and extent of fracture pattern of distal Radius. Developed a classification system based on the presence but not on extent of the fracture site. In 1965 Older classified fracture of the distal radius that was based on extent of displacement, dorsal angulation, shortening of the distal fragment and presence of comminution of the dorsal cortex [14]. Frykman later in 1968 made a classification of Colles fracture that identified the involvement of Radiocarpal and radioulnar joint as well as presence or absence of Ulnar styloid fracture [15]. We in our study have followed the universal classification system followed by AO. This is a working treatment related classification. The age group of patients taken in our study ranged from 18 years to maximum of 70 years with mean age group of 45.9 years. It was seen that distal radius fractures were more common in second and third decade of life with an average of 44.6 years. Our study had a male predominance. The incidence of fractures in our study was more common in males (87/146) which can be attributed to the risk of injury due to occupation involving heavy labour and laborious life led by them. The result of high incidence of fractures in males was also reported by other research like Leung [6] *et al.* in 1989(males-73.6%), Jain BK *et al.* in 1998 (males 63.63%), Yamamoto66 *et al.* in 2003(males-54.5), Nagi ON *et al.* in 2004 (males-88.5) were supported to our study. The contrast result of high incidence of female were reported in few studies like Arora *et al.* in 2007 and Anakwe *et al.* in 2010 had increased female preponderance. In our present study incidence in males was 59.58% which corresponds with most of the studies. The mechanism of injury out of 146 cases in our study, 102 were following high velocity injury and 44 following trivial fall at home. Most of the intraarticular, comminuted and unstable fractures of the distal radius occurring in young individuals are following high velocity injuries like road traffic accidents. Fractures in old persons usually occur following a trivial fall and are of stable variety. The recent studies like Gunaki RB *et al.* in 1998 (HVI-60%), Yamamoto *et al.* in 2003(HVI-59.45%), Aggarwal *et al.* in 2004 (HVI-52%) there is increased number of fractures following high velocity trauma were almost similar to our study. We have to defer from older studies like Nelaton *et al.* that most fractures of distal Radius occurs due to fall on outstretched hand. Nowadays due to increase in motor vehicles and fast way of life these fractures

are more common following high velocity injury. In our study we noted that the dominant hand was involved in 73% of cases. This can be explained by the natural protective reflex of a person to break his momentum by stretching out the dominant hand. In studies by Leung [6] in 1989 (Dominant hand-61.11%), Mannur *et al.* in 2001 (Dominant Hand-55%), Kevin C Chung *et al.* in 2006(Dominant hand-57.47%) and Arora Rohit *et al.* in 2007 (Dominant hand-61.4%) it was seen that there was more fractures in the dominant upper limb than in the other. Our data was found to be consistent with most contemporary data available.

Functional Outcome

In our study the functional outcome was done by following the point system of DASH Score, PRWE Score and Radiological evaluation. All over 146 cases after 3 months 140 cases, after 6 months 132 and after 12 months 107 cases present for follow up. Patients who did not came for follow-up may be recovered in that duration or may be any other reason. In our study we found gross difference in DASH score after three months, 6 months and 12 months for function outcomes. The mean difference of DASH score between after three months (36.10±16.2) and after six months (17.71±11.8) we found the p value was 0.021, which was significant. The mean difference of DASH score between after six months (17.71±11.8) and 12 months (8.88±16.2) p value was 0.011, which was significant. The mean difference of DASH score between after three months (36.10±16.2) and 12 months (8.88±16.2) p-value was <0.001, which was highly significant.

To our knowledge no other studies have reported on the long-term follow-up patient-reported functional outcome in favour of non-operative treatment. In our study we got 67.2% Excellent, 16% good, 15% fair and 3% poor results. In this study we analyzed PRWE score after 3 months, 6 months and 12 months for function outcomes. The mean difference of PRWE score between after three months (23.21± 23.21) and after six months (15.03±32.1) the p value was 0.001, which was significant. The mean difference of PRWE score between after six months (15.03± 2.1) and 12 months (5.11±43.1) p value was 0.011, which was significant. The mean difference of PRWE score between after three months (23.21±23.1) and 12 months (5.11±43.1) p value was <0.001, which was highly significant. It means we found grossly improvement in patients as per PRWE score between 3 months and 12 months duration. Patients with good results had minimal residual deformity, pain and slight limitation. In patients with fair results, along with residual deformity, pain and limitation of movements also had pain in the distal radioulnar joint and minimal complications. Few of their movements were less than that required for normal function.

Limitations

This study has some limitations. First, we had missing some data because some patients did not come at follow up duration, those patients functional outcomes had improve or any other reason. DASH scores, PRWE Score and radiological evaluations were not complete during the entire follow-up of all 146 cases. There were 146 eligible patients but our response rate yielded a sample of only 107 at after 12 months. To be able to observe the effect that we observed in function by perceived deformity to a level of significance, we would need a much large sample size. Only three participants reported that they were bothered by the appearance of their wrist.

Conclusion

Distal radius fractures are most common fractures of upper extremity. Most common mode of injury now days are road traffic accident in young individuals following trivial fall in elderly. Distal radius fractures from very long time are being managed by conservative methods but due to advancement in surgical skills, availability of infrastructure, affordability of patient difference in opinion and management has been developed in recent past. In our center patients after getting diagnosed clinically and radiologically, who met inclusion criteria and giving consent being managed by closed reduction and Plaster of paris cast application. Low functional demanding patients and patients above 50 years have opted for conservative management. Even patients with high functional demand after been managed with closed reduction have found to have good functional outcome as compared to operative management. Our observations conclude that beyond radiological limits also functional outcome came out to be good which raises concerns about the use of radiological parameters to determine management, and to act as surrogates for successful treatment, in patients with a fracture of the distal radius. Restoration of 'normal 'radiographic parameters may not be necessary to achieve a satisfactory functional outcome for the patient. According to our study the functional outcome of patients was found to be not in correlation with radiological outcome and radiological parameters might not provide the most appropriate measure of patient outcome following even a displaced fracture of the distal radius fracture. In present scenario conservative management with plaster of Paris cast application still considered preferred method over operative intervention by maximum orthopaedic surgeons.

Conflict of Interest

Not available.

Financial Support

Not available.

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