



E-ISSN: 2395-1958  
P-ISSN: 2706-6630  
IJOS 2021; 7(1): 599-604  
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[www.orthopaper.com](http://www.orthopaper.com)  
Received: 07-11-2020  
Accepted: 12-12-2020

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## Clinical outcome of distal radius fractures fixed with volar plating

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DOI: <https://doi.org/10.22271/ortho.2021.v7.i1j.2546>

### Abstract

**Introduction:** There is an increase in the incidence of fracture of distal radius with the increase in life expectancy and also in young due to increased incidence of road traffic accidents and sports related trauma. They account for approximately one sixth of all fractures seen and treated. This study is intended to analyse the clinical outcome of open reduction and internal fixation of fractures using volar plate and screws.

**Aims:** To Study the clinical outcome of intra and extra articular fracture of distal end of radius treated with open reduction and internal fixation by plating through a volar approach.

**Methodology:** Prospective study conducted in during the period from June 2018 to November 2020. Patients attending to the Department of Orthopaedics at OPD or emergency department where chosen for the study based on previously stipulated inclusion and exclusion criteria. 30 patients underwent open reduction and plate osteosynthesis by a volar approach. They were then followed up for a period of 1 year and progress was monitored. Clinical, functional and radiological assessment were made by standard scoring systems at the end of the follow up period and compared.

**Results:** It was inferred that volar plating showed good to excellent results in a distal radius fracture at the end of 1 year. We also inferred that a good radiological result was important to achieve a good clinical and functional outcome.

**Conclusion:** Hence we suggest volar plate fixation for distal radius fractures, particularly in intra articular fractures, with stress on anatomical reduction of fracture.

**Keywords:** Volar plating, distal radius, life expectancy

### Introduction

There is an increase in the incidence of fracture of distal radius with the increase in life expectancy and also in young due to increased incidence of road traffic accidents and sports related trauma. They account for approximately one sixth of all fractures seen and treated. The ultimate goal of outcome in these fractures has frequently been revisited as newer methods of treatment have been developed. The preservation of integrity of the three columns of distal radius, each with distinct function, restores radial length, radial tilt angle and congruity of articular surfaces for good functional results in the form of normal anatomy with early functional recovery, full and painless motion of the wrist and prevention of late osteoarthritis [1]. With ongoing controversies and differences regarding the optimal surgical treatment for unstable distal radius intra and extra articular fractures, methods like percutaneous direct pinning, external fixator and internal fixation with plates and screws do not have standard protocols or definitive indications. Moreover they have their own complications ranging from infection to superficial nerve neuropraxias, a cumbersome external frame, pin track infection, pin loosening and loss of fracture reduction, neuropathies involving the radial and median nerves, tendon rupture, metacarpal fractures, reflex sympathetic dystrophy and non-union. ORIF with plate osteosynthesis promises to be a good option allowing accurate fracture reduction and early mobilization. Hence this study is intended to analyse the clinical outcome of open reduction and internal fixation of fractures using volar plate and screws [2].

## Methodology

It is a Prospective and hospital based study conducted during the period from June 2018 to November 2020. Patients attending to the Department of Orthopaedics who are diagnosed with distal radius fracture, and fulfilling the said criteria and willing for the surgery & study, will be included in the study. A total of 30 patients were included in the study. Case history will be recorded in a specially designed Case Record Form (CRF) by taking history of illness and by doing detailed clinical examination, radiological examination and relevant investigations. Finally after the diagnosis patients are selected for the study depending on the inclusion and exclusion criteria. Post-operative evaluation of clinical and functional outcome using the demerit system of gartl and and werley with sarmiento *et al.* s modification <sup>[3]</sup> will be done. Post operatively all the cases are followed for the minimum period of 12 months, at 6 weeks, 6 months and 12 months. Results are analyzed both clinically & radiologically using appropriate statistical methods.

## Inclusion Criteria

1. Patients with intraarticular and extraarticular distal radius fractures.
2. Patient aged more than 18 years.

## Exclusion criteria

1. Open fractures
2. Fracture beyond 3 cm from distal articular surfaces of radius (diaphyseal extension).
3. Fractures with history of trauma > 3weeks.
4. Associated Carpal fractures
5. Neurovascular injury

After admission to the hospital, a careful history was taken from the patients and / or relatives to reveal the mechanism of injury and the severity of trauma. Patients were thoroughly examined for their general condition, associated systemic diseases and associated injuries were noted. All the findings were recorded in the patient proforma. All patients given adequate analgesics and the injured wrist was immobilised in a radio-opaque splint temporarily. They were evaluated with plain radiographs of the wrist and forearm, AP and lateral views. They were classified based on Frykman's classification of distal radius fractures. Once evaluated they were immobilised in a below elbow volar slab for volar barton fractures and above elbow slab for unstable fractures. They were then evaluated comprehensively for surgical fitness. Once deemed fit to undergo surgery, they were taken up for surgery on an elective basis.

## Technique

Under anaesthesia patient was positioned supine on operating table with the limb placed on the arm board. Parts were painted and draped. A pneumatic mid-arm tourniquet was used in some cases, which was according to the surgeon's preference. Using Henrys volar approach to the wrist, incision taken over the FCR tendon or just lateral to it. FCR sheath was opened. Plane created between the brachioradialis and the FCR. The FCR and the median nerve were retracted medially. The radial artery along with the brachioradialis was retracted laterally, exposing the pronator quadratus muscle. The PQ muscle was elevated from its radial origin and reflected ulnarly to expose the distal radius. The volar aspect of the radius was exposed subperiosteally <sup>[4]</sup>. The plate was placed directly on the radius following fracture reduction, and plate

placement was confirmed with intra-operative fluoroscopy. After fixation, the pronator quadratus was reattached to its radial insertion. The operating surgeons determined the choice of implant. Bone-grafting was not performed. Postoperatively, the wrist was immobilized in a volar pop splint for average of 4 weeks. Patients were instructed in active and passive finger motion. Antibiotic prophylaxis was given for 48 to 72 hours. Sutures were removed after an average of 12 days.

## Results

A total of 30 patients were included in the study. Among them 24 patients completed the intended one year follow up. The other 6 patients were followed up for a period of at least eight months. Patients were evaluated in terms of clinical outcome and by radiological parameters.

**Table 1:** Demographic distribution of patients

Sex	No of patients	% of patients
Male	25	83.33
Female	5	16.67
<b>Age groups</b>		
<=30yrs	10	33.33
31-40yrs	12	40.00
>=41yrs	8	26.67
Mean age	36.23	
SD age	10.39	
<b>Time since injury</b>		
1-5days	17	56.67
6-10days	9	30.00
>=11days	4	13.33
Mean time since injury	5.57	
SD	3.55	
<b>Mode of injury</b>		
RTA	25	83.33
Fall from height	1	3.33
Slip and fall	4	13.33
<b>Sides affected</b>		
Left side	18	60.00
Right side	12	40.00
<b>Dominance</b>		
Dominant	13	43.33
Non-dominant	17	56.67
<b>Implant status</b>		
Locking	27	90.00
Non locking	3	10.00

A total of 30 patients were analysed. 83.33 % (25) of them were males and 16.67% were females.

Age wise distribution showed that 33.33% of the patients were among the age group between 18 and 30. 40% of them were between the age of 31 and 40. 26.67% of them were over the age of 40 years. The analysis of the time taken from the injury to surgery revealed that 56.67% of the patients were operated within 5 days. 30% of them were operated between 6 to 10 days from the day of injury. 4 patients (13.33%) were operated after 11 days or more after injury.

83.33% of the injuries occurred due to road traffic accidents. 13.33% of them slipped and fell injuring the wrist and one patient fell from a height (3.33%).

The left wrist was injured in 60% (18) of the patients and the right was injured in the rest 40 % (12) of them.

In 13 patients (43.33%) the dominant hand was affected and in 17(56.67) of them the non-dominant side was affected.

A fixed angle locking plate was used in 27(90%) patients and a non-locking buttress plate was used in the remaining 3(10%) of them.

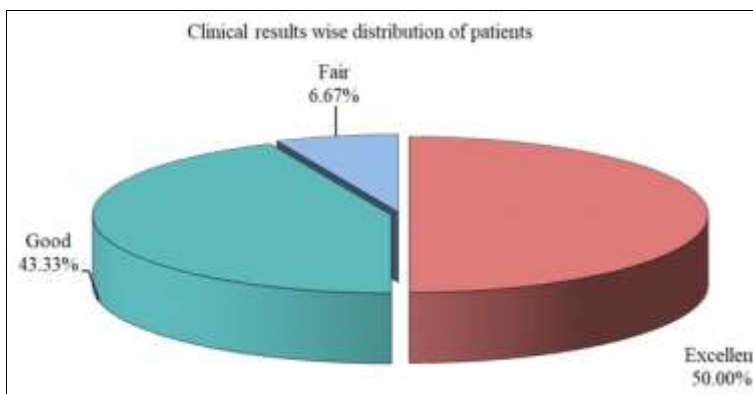
**Table 2:** Frykman’s classification wise distribution of patients

Frykman’s classification	No of patients	% of patients
I	0	0.00
II	2	6.67
III	6	20.00
IV	9	30.00
V	3	10.00
VI	0	0.00
VII	3	10.00
VIII	7	23.33
Total	30	100.00

Among the total 30 patients 2 patients had a type II Frykman’s fracture, 6 had type III, 9 had type IV, 3 had type V, 3 had type VII and 7 patients had type VIII fractures.

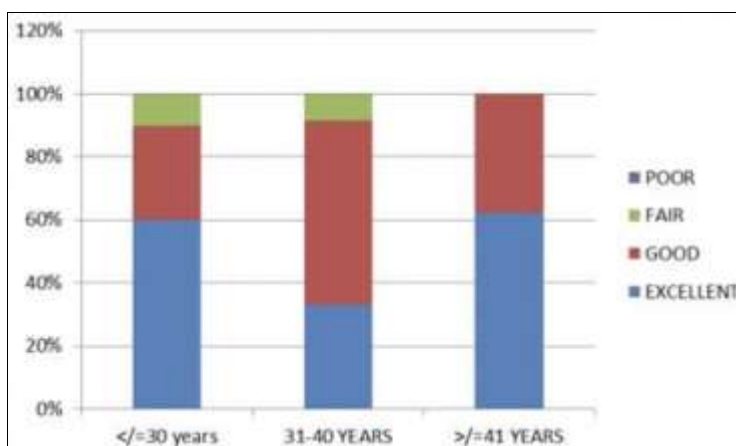
**Table 3:** Clinical outcome- demerit system of Gartland and Werley criteria (clinical) wise distribution of patients

Demerit system of Gartland and Werley criteria	No of patients	% of patients
Score 0	3	10.00
Score 1	3	10.00
Score 2	9	30.00
Score 3	3	10.00
Score 4	2	6.67
Score 5	4	13.33
Score 6	1	3.33
Score 7	2	6.67
Score 8	1	3.33
Score 10	2	6.67
Total	30	100.00
Mean		3.53
SD		2.76



**Fig 1:** Clinical results - distribution of patients

When the results were analysed 50% of the patients had excellent result as per the Gartland and Werley demerit scoring system, 43,33% of the patients had good results and 6.67% of them had fair results.



Chi square value- 2.963 p value-0.564

**Fig 2:** Association between age and clinical outcome

Chi square test was applied to analyse the association between different age group and clinical outcome based on the Gartland and Werley criteria. Patients were divided into three age groups. 30 years or less, 31 to 40 years, 41 or more years. 60% of the patients below or equal to 30 years had excellent results, 30% of them had good outcome and 10% had fair

outcome. 33.3% of the patients between 31 to 40 years had excellent outcome, 58.3% had good and 8.3% had fair outcome. Among patients who were above or equal to 41 years, 62.5% of them had excellent results, 37.5% of them had good result.

**Table 3:** Association between type of fracture with clinical outcome and radiological outcome

Association between type of fracture and clinical outcome	Excellent	Good	Fair	Poor
I and II	1(50%)	1(50%)	0(0%)	0(0%)
III and IV	8(53.3%)	6(40%)	1(6.7%)	0(0%)
V and VI	2(66.7%)	1(33.3%)	0(0%)	0(0%)
VII and VIII	4(40%)	5(50%)	1(10%)	0(0%)
Association between type of fracture and radiological outcome				
I and II	2(100%)	0	0	0
III and IV	7(46.7%)	8(53.3%)	0	0
V and VI	2(66.7%)	1(33.3%)	0	0
VII and VIII	4(40%)	6(60%)	0	0

There were two extra articular fractures (type I/ II) with one excellent and good outcome each. Type III and IV fractures had 53.3% excellent outcome,

All type I or II fractures had excellent result according of Sarmiento’s modification of the Lind Storm criteria. 46.7% and 53.3% of the type III and IV fractures had excellent and good outcome respectively. 66.7% and 33.3% of type V and VI fractures had excellent and good outcome respectively. Among the type VII and VIII fractures, 40% had excellent radiological outcome and 60% had good outcome.

Among the 30 patients studied one of them had arthritic changes and one of them had an implant failure

**Table 4:** Agreement between clinical and radiological results

Result-clinical	Result-radiological				
	Excellent	Good	Fair	Total	%
Excellent	14	1	0	15	50.00
Good	1	12	0	13	43.33
Fair	0	2	0	2	6.67
Grand Total	15	15	0	30	100.00

The correlation between the radiological and the clinical outcome was made using kappa statistics, which showed a 93.33% agreement between the two and with a p value of 0.0001.

**Table 5:** Association between clinical and radiological results with status of implant

Result-clinical	Locking	%	Non-locking	%	Total	%
Excellent	13	48.15	2	66.67	15	50.00
Good	12	44.44	1	33.33	13	43.33
Fair	2	7.41	0	0.00	2	6.67
Chi-square=0.4842 P = 0.7851						
Association between radiological results with status of implant						
Excellent	13	48.15	2	66.67	15	50.00
Good	14	51.85	1	33.33	15	50.00
Fair	0	0.00	0	0.00	0	0.00
Chi-square with Yates's correction = 0.0001 P = 1.0000						

Chi square test applied to study the correlation of implant used and the clinical outcome showed a p value of 0.7851

Chi-square test applied to correlate the implant used and the radiological outcome. The p value was 1.0.

**Discussion**

Distal radial fractures are one of the most common injuries

encountered in orthopaedic practice. Up until a few decades ago, distal radius fractures were usually regarded as ‘Colles’ fracture. The treatment was mainly manipulation and casting, proposed by Abraham Colles’ [5] however they would heal with a deformity but with acceptable functional deficits. The expected and acceptable outcome of the fractures would be based on various factors such as age of the patient, occupation and hand dominance. Fracture union is no longer the only goal, as the restoration of normal anatomy with early functional recovery, and restoration of full range of motion of wrist and forearm are the ultimate goals of treatment. With better understanding of the various fracture types, classification such as Frykman [6] and Melone [7] were developed. There was a need for better modality of treatment according to individual fracture pattern to obtain better functional results.

Our study was a prospective study into determining the clinical outcome of distal radius fractures fixed with volar plating. The objective was to determine the clinical, functional and radiological outcome of distal radius fractures fixed with volar plating and to analyse the possible correlation between them. Both intra and extra articular fractures of the distal end of radius were included in the study. However there were only 2 extra articular fractures among 30 patients studied. All fractures in our study were approached using the Henry’s volar approach to the distal radius and fixed with either a fixed angle locking plate or a nonlocking buttress plate. Clinical-functional outcome in our study was assessed by Gartland and Werley demerit scoring system. The scoring system consists of subscales that evaluate objective findings, subjective assessment in addition to complications and residual deformity. The radiological outcome was assessed based on Sarmiento *et al.* [8] modification of the Lind Storm criteria. It takes into account the radial inclination, radial length, residual dorsal (radial tilt) and residual deformity [8]. The data collected was analysed using mean and S.D for variables such as demography. Kappa statistics applied to analyse correlation between radiological and clinical outcome, chi-square test applied for analysis of association between clinical outcome and variables such as implant selection. A p value of <0.05 has been taken as statistically significant.

We have compared the results of our study to other studies, both western and Indian studies.

The mean age of patients in our study was 36.23 years with highest demographical distribution was between 31 to 40

years (12) (40%). And another 10 patients were below 30 years of age. The western studies showed a higher mean age group (51 to 68 years) and the Indian studies including our study showed a lower mean age group (36 to 39 years). This maybe because the most common mechanism of injury Indian studies was high velocity injury (RTA). 83.33% of the patients in our study were males and 16.67% were females. This might be correlated to the mode of injury, RTA being the most common mode of injury at 83.33%, most of them were due to motorcycle accidents. This may be correlated with young adults being most commonly injured. 16.66% of them were due to other mechanisms which include slip and fall and fall from a great height. The western studies show the women being more commonly effected and Indian studies show that males are more commonly being effected. High velocity injury including RTA and fall from height are the most common mechanism of injuries in the Indian studies, however low velocity injuries are the most common mechanism in the western population. This shows that fractures in women due to low velocity injury is more common in the western population and incidence of high velocity trauma causing distal radius fractures in younger male are higher in Indian population. This goes to show that the injury occurs most commonly in the working age group, thus causing significant financial implications on the patient and the family in our set up.

Gerald Gruber *et al.* [9] reported a median time taken for surgery since the time of injury as 6 hours. The range was 6 to 29 hrs. Tamara D. Rosental *et al.* [10] performed the surgery in all patients within a week except one. P. Ravi Shankar *et al.* [11] reported that 50% of the patients were operated within 1- 2 days of injury, 33.3% of them between 3-4 days and 16.6% of them between 5-6 days of injury. The average duration from date of injury to date of surgery was 2.7 days. The average time take from the day of injury to the day of surgery in our study was 5.57 days. Majority (56.67%) of them were operated with in the first 5 days of the injury, 30% between 6-10 days and 13.3% (4) of them were operated after 11 or more days from the day of injury. The delay in surgery in those 4 patients was due to associated injury such as head injury and abdominal injury. The western studies had shorter time duration between the injury and surgery as compared to our study. This is probably due to delay in presentation to a tertiary care set up like our hospital. Only two among the 30 patients studied had an extra-articular fracture (both type II Frykman's) and 28 of them were intra articular fractures. 15 patients (50%) of them had involvement of the radio carpal joint alone (type III and IV), 3 of them had involvement of the DRUJ alone (type V and VI), and 10 patients had fractures involving both DRUJ and radiocarpal joints. Left side was affected more often (60%) and 56.67% of the times the affected side was the non-dominant side in our study.

Gruber *et al.* [9] reported 48% of the injuries occurring in dominant side and 52% injuries of the non-dominant side. G.K. Satpathy *et al.* [12] reported 61.6% of the injuries occurring in the dominant side. Locking plates were used in 27 patients and non-locking plates were used in 3 patients. However no statistically significant correlation was found between choice of implant and clinical outcome (chi-square 0.4842 with  $p=0.7851$ ) or radiological outcome (chi-square with yate's correlation=0.0001,  $p=1.000$ ). Since only in 3 cases of non-locking implant was used the statistics may not be significant. Arvind K. Bohra *et al.* [13] conducted a comparative study of operative treatment of distal radial fracture by locking and non-locking plates. They also found

no difference in functional or radiological outcome between the two groups. As per Gartland and Werley score, excellent results were achieved in 15 patients (50%), good results were achieved in 13 patients (43.33%) and fair result was achieved in 2 patients. Excellent and good results may be considered as favourable outcomes. We compared results of our study to these studies.

**Table 6:** Clinical outcome based on gatland and werley scoring

Study	Excellent	Good	Fair	Poor
Gruber <i>et al.</i> (Austria) [9]	94%	do	NIL	NIL
Tamara D. Rosental <i>et al.</i> (Austria) [10]	66%	34%	NIL	NIL
G.K. Satpathy <i>et al.</i> (India) [12]	75%	16%	6%	3%
Anil Solanki <i>et al.</i> (India) [14]	72.5%	20%	3%	NIL
Our study	50%	43.3%	6.67%	NIL

Clinical outcome of our study is comparable with these studies. We achieved 93.3% good or excellent results for the thirty patients included which is similar to the above mentioned studies. However we encountered lesser proportion of excellent result as compared to the other studies, probably due to a shorter duration of follow up.

As per Lind storm criteria, excellent radiological results were achieved in 15 patients (50%) and good results were achieved in other 15 of them. P. Ravi Shankar *et al.* obtained excellent radiological outcome in 87.5% of the patients and good results in 12.5% of them. In 2009 Jupiter *et al.* [29] studied the outcome of operative management of the distal radius fracture with 2.4mm locking plate in 150 patients. They reported 8 cases of major complications which included 2 cases of tendon rupture, 2 cases of loss of reduction, 2 cases of screw loosening. 27% patients showed an increase of at least one grade in radiologic signs of arthritis in two years. Tun Lin Foo *et al.* [15] studied rate of mechanical failure of the distal radial volar locking plate in 2009-10. Among the 374 cases included in the study, mechanical failure was encountered were screw pull-out (5) plate bending (2) screw breakage (1) screw loosening (1) Gruber *et al.* reported an overall incidence of complications as 9% (5). 2 tendon ruptures, 2 median nerve paraesthesia and 1 plate loosening. Only two patients developed complications in our study, i.e wrist arthritis and another incidence of screw placement in the joint, considered as implant failure. Both patients only attained a fair result clinically, despite good radiological result. We did not encounter any tendon related or neurological complications as reported by most authors. However the incidence of hardware related complication and arthritis of the wrist are comparable. We have followed up the patients for only one year. Hence the possibility of increase in incidence due to late complications such as arthritis implant failure cannot be ruled out. The association between the clinical and radiological outcome was done using kappa statistics, which revealed an agreement of 93.33% between them, with a significant p value of 0.0001. This is hence a positive correlation showing that a better radiological result ensures a better functional outcome. The association between age and clinical outcome based on Gartland and Werley criteria was analysed using chi square test. Patients were divided into three age groups. 30 years or less, 31 to 40 years, 41 or more years. The chi square value was 2.963 and P value was 0.564. Hence there was no statistically significant association between age and clinical outcome in our study. The chi square value for association of type of fracture based on Frykman's classification and clinical outcome was 1.131 and the P value was a statistically insignificant 0.980. Association between type of fracture and

radiological outcome had a chi square value of 2.8 and P value of 0.423, which was again statistically insignificant. Hence we did not find any correlation between type of fractures and clinical or radiological outcome.

### Conclusion

Distal radius fractures occur most commonly among the young adults, who are of the working age group. There has been a change in demographics, with high velocity trauma i.e RTA being the most common mechanism in our geographical distribution. Perhaps that is also the reason why males are injured more often than females. There is a strong correlation between the radiological results and the clinical functional outcome in our study group, who have undergone open reduction and plate osteosynthesis. However we did not find any statistically significant association between age, type of fracture and clinical and radiological outcome. Thus intra operative fracture reduction and proper reconstruction of the anatomy is the key for good clinical and functional outcomes, also stressing on the placement of screws in relation to the articular surface.

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