

Original Research Article

Functional outcome of distal radius fractures treated with fixation by percutaneous cannulated screw

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ABSTRACT

Background: In the present study primary objectives were to evaluate the clinical and functional outcome and union rates, whereas secondary objective was to study complications associated with closed reduction percutaneous fixation of displaced unstable fractures of distal radius in adults by using cannulated cancellous (CC) screw.

Methods: Thirty two patients aged more than 18 years, with unstable displaced distal radial fracture were included in this prospective observational study. Patients were treated by closed reduction and percutaneous fixation by CC screw. Radiological parameters like radial inclination, radial height, ulnar variance, volar tilt were measured. Mayo wrist score and range of motion were noted. Patients were followed up for six months. Continuous variables were compared by using paired and unpaired 't' test.

Results: Mean Mayo wrist score at six months post-operative follow-up (82.8) was significantly higher compared to six weeks post-operative follow-up (64.4). Mean early post-operative radial height, mean radial inclination, and mean volar tilt were significantly higher compared to mean six months post-operatively. Mean early post-operative ulnar variance was significantly lower compared to mean six months post-operatively. Mean flexion, mean extension, mean supination, mean pronation, mean radial deviation, and mean ulnar deviation was significantly higher six months post-operative follow-up compared to six week post-operative follow-up. Mean grip strength was significantly higher six months post-operative follow-up compared to six week post-operative follow-up.

Conclusions: Clinical and functional outcomes associated with closed reduction and percutaneous fixation by cannulated cancellous screw was excellent. Mayo wrist score was increased over six months follow up period.

Keywords: Distal radius fractures, Percutaneous cannulated screw, Fernandez classification, Frykman classification, Mayo wrist score, Grip strength

INTRODUCTION

Fracture of the distal radius accounts for approximately one sixth of all the fractures treated in emergency room and an approximate incidence is 1:10,000 people and represent 17% of all skeletal fractures and 75% of forearm fractures.¹⁻⁶

Close reduction and cast immobilization has been mainstay of treatment of these fractures but malunion of fracture and subluxation of distal radio-ulnar joint

resulting in poor functional and cosmetic results is the usual outcome.⁷ Residual deformity of wrist adversely affects wrist and hand function.⁸ It may cause pain, limitation of forearm motion, and decreased grip strength as a result of arthrosis of radiocarpal and distal radioulnar joints.⁹ Restoration of radial length, radial tilt angle and congruity of articular surface is important for good functional results.¹⁰

Percutaneous pinning is an accepted practice, either alone or as supplement to other modes of treatment. But it is

often difficult in case of severely comminuted fracture or in osteoporotic bone.¹¹ Lack of stability, need for restrictive immobilization and skin irritation may limit success of post-operative rehabilitation. Pin migration and breakage, pin tract infection, fracture malunion and nerve injury are common complications.^{12,13}

External fixation, is an excellent mean of overcoming displacing forces of forearm muscles.¹¹ It provides stability even when both volar and dorsal cortices are comminuted.^{1,14} External fixator along with Kirschner (K) wire augmentation can substantially improve stability.¹⁵ However, it may limit early finger motion, leading to wrist and finger stiffness and prolonged rehabilitation to regain finger flexion and wrist motion.¹⁶ It also has significantly higher rates of pin or wire tract infection, median and superficial radial nerve injuries and loss of reduction.^{17,18}

Open reduction and internal fixation is indicated to address unstable distal radius fractures and those with articular incongruity that cannot be anatomically reduced. A stable fixation permits early range of motion.¹⁹ Buttress plate can be applied either volarly or dorsally or even at radial column. But this technique also has its problems, it cannot hold reduction well in severe comminuted fracture, causes tendon irritation and other soft tissue problems.²⁰ It requires a longer operative time²¹ and needs a second operation for implant removal which is as major as first operation.

A variety of treatment options are available for distal radius fractures, but there is a lack of consensus on preferred treatment modality that needs to be followed. There is not enough evidence in the published literature to suggest or recommend any specific treatment for distal radius fractures.^{22,23}

Surgical methods have also evolved, with minimally invasive osteosynthesis techniques and approaches toward soft tissues that are more biological.²⁴ Use of cannulated screw technology is one of such minimally invasive surgical method available for distal radius fractures.²⁵ But there isn't enough clinical study on use of percutaneous cannulated screw for fixation of distal radius fractures. In this study, primary objectives were to evaluate the clinical and functional outcome and union rates whereas secondary objective was to study the complications associated with closed reduction percutaneous fixation of displaced unstable fractures of the distal radius in adults by using cannulated cancellous screw.

METHODS

This prospective observational study was conducted between July 2015 and May 2017. After approval from the scientific advisory committee and institutional ethics committee written informed consent was obtained from all patients. Patients aged more than 18 years, unstable

displaced distal radial fracture with type I and III according to Fernandez classification and all types of fractures according to Frykman classification were included in the study. Patients who had prior surgery for the same fracture on either forearm, open fracture, distal radius fracture with coronal split, fracture of distal radius with dislocation were excluded from this study. Thirty six patients were recruited, four patients were lost to follow-up, hence 32 patients were included and analysed in the present study.

Data were collected by taking history, clinical examination, and investigations as per the study proforma. Post-operatively all cases were followed until fracture union or for period of six months whichever was later. Results were analyzed clinically, functionally and radiologically. Radiological evaluation was done at final follow up and it was compared to that of early postoperative period and contralateral wrist. Mayo wrist score was calculated at each follow up. Postero-anterior and lateral radiographs of the affected wrist were taken and the fracture patterns were classified. Patients were put on a below-elbow slab. Operation was performed under general anaesthesia in 24 cases and brachial block in eight cases ensuring complete aseptic precautions. Affected limb was elevated for 2-3 minutes and exsanguinated. Then a mid-arm pneumatic tourniquet was applied and the limb was placed on a radiolucent side board.

Fracture was disimpacted, and reduction was achieved by pressing distal fragment in volar direction and fracture was locked by pronation. Once acceptable anatomic alignment was achieved, a 2.5 mm K wire was inserted at the tip of radial styloid process just dorsal to first extensor canal, in anatomical snuff box proximal to radial artery. Stab incision was taken over the K wire taking care not to injure tendinous tissues and cutaneous branch of radial nerve. A sleeve was put over K wire and K wire was changed to guide wire for 4 mm cannulated screw through sleeve. A 3.5 mm cannulated drill was used to drill through both the cortices. A 4 mm cannulated cancellous (CC) screw of appropriate length was inserted over the guide wire such that screw got purchase over far cortex of diaphysis. Screws were buried slightly into bone to prevent tendon irritation. Decision to put a second CC screw was taken on checking the stability of fracture under fluoroscope. If required a second CC screw was put over guide wire crossing the first screw in a proximal to distal and radial to ulnar direction from proximal radial side of radius to ulnar corner of radius. In case of intra-articular fracture, a second CC screw was put over the guide wire keeping in mind distal radius fragment to be fixed. In this case the screw was passed from distal to proximal and ulnar to radial direction from dorsal ulnar corner of the distal radius crossing fracture site and getting hold on proximal radial side of radius volarly. One CC screw was used in 29 cases and two CC screws were used in three cases. In this study, we used 4 mm long threaded CC screw in young patients with good

bone quality and fully threaded CC screws in elderly patients with osteoporosis. In one case of intra-articular fracture we used a standard 2.4 mm CC screw as the fragment to be fixed was small but unstable.

Radiological evaluation was done in the early post-operative period which included postero-anterior and lateral X-rays of operated and contralateral wrist. X-ray of contralateral wrist was taken for comparison. Cast was removed on an average of three weeks and patients were advised active physiotherapy of the fingers, wrist, elbow and shoulder with removable protective splint. Resistive exercises were initiated six weeks after surgery and heavy labor was permitted three months after surgery. At each follow up wrist flexion, extension, radial deviation, ulnar deviation, forearm supination and pronation was measured using a standard goniometer. Grip strength values were measured using a hand dynamometer (Qingfeng) for three consecutive times and the mean was noted. Scoring was done as per Mayo wrist score which included subjective and objective criteria.²⁶ Values were compared with uninjured hand. Values of Mayo wrist score at six weeks and six months were compared statistically. Clinical outcome was evaluated by measuring the residual deformity in the form of prominent ulnar styloid, residual dorsal tilt, radial deviation of hand at final follow up. Radiological parameters like radial inclination, radial height, ulnar variance, and volar tilt were measured in the early post-operative period and at final follow up of six months. Values were compared statistically. Complications following the treatment were evaluated at each follow-up.

On the basis of a previously published study, a sample size of 30 patients was calculated by a formula with 80%

power and 5% probability of Type I error to reject null hypothesis.^{27,28} Data collected were entered in the Excel 2007 and analysis of data was done using Statistical Package for Social Sciences (SPSS) version 20, IBM, USA. The data on categorical variables has been shown as n (% of cases) and the data on continuous variables has been presented as mean and standard deviation (SD). The comparison of continuous variables was done using paired and unpaired 't' test. The confidence limit for significance was fixed at 95% level with p value <0.05.

RESULTS

In the present study 32 patients of distal radius fracture treated at Poona Hospital and Research Centre between July 2015 and May 2017 were included. The patients were treated by closed reduction and percutaneous fixation by CC screw. Patients were followed up for six months.

Of 32 cases studied, 5 (15.6%), 8 (25.0%), 9 (28.1%), 7 (21.9%) and 3 (9.46%) were between 18.0–30.0, 31.0–40.0, 41.0–50.0, 51.0–60.0 and 61.0–70.0 years respectively. The mean age was 42.4±11.3 years. Male patients were 13 (40.6%) whereas 19 (59.4%) were females. Of 32 cases, 17 (53.1%), 12 (37.5%) and 3 (9.4%) had fall on outstretched hand, road traffic accidents and sports injury respectively.

As depicted in Table 1, majority of the patients 30/32 (93.8%) had type I Fernandez and type A2 AO classification fracture whereas 28/32 (87.5%) had type I and II fracture as per Frykman classification.

Table 1: Distribution of fracture as per Fernandez, Frykman and AO classification

Type of fracture	No. of cases	% of cases
Fernandez	Type I	30
	Type III	2
Frykman	Type I	12
	Type II	16
	Type III	1
	Type IV	1
	Type VI	2
AO	Type A2	30
	Type C1	2

Thirty (93.7%) had extra articular fractures and 2/32 (6.3%) had intra articular fractures. Of 32 patients, one implant was used in 29 (90.6%) patients whereas 3 (9.4%) required two implants. Duration between injury and surgery was 1-5 days in 29/32 (90.6%) patients whereas it was 6-10 days in 3/32 (9.4%) patients. Mean duration between injury and surgery was 2.8±1.4 days. Average operative time in our study was 28.1 minutes. Duration of hospital stay was 2 days in 27/32 (84.4%) whereas it was 3 days in 5/32 (15.6%) patients. Mean duration of hospital stay was 2.2±0.3 days. Fracture was

united by 3 months in all patients. Only 2/32 (6.3%) patients had wrist movement restriction, one patient had mild occasional pain whereas rest had no complications after surgery.

As depicted in Table 2, the mean±SD of Mayo wrist score at six weeks, and six months were 64.4±4.7, and 82.8±5.7 respectively which was statistically significant. Mean Mayo wrist score at six months was significantly higher compared to six weeks. The mean % improvement

(change) in Mayo wrist score at six months compared to six weeks was 28.6%.

Table 2: The comparison of mean post-operative Mayo wrist scores.

Mean Mayo wrist score (SD)	At 6 weeks	At 6 months	P value
	64.38 (±4.71)	82.81 (±5.67)	0.001

Paired 't' test was used.

Of 32 patients, 3 (9.4%), 19 (59.4%), and 10 (31.2%) had satisfactory, good and excellent functional outcome

respectively. In this study, we achieved fracture union in all the 32 cases by three months follow up. There was no case of loss of reduction/malunion till final follow up.

As evident from Table 3, mean early post-operative radial height, mean radial inclination, and mean volar tilt were significantly higher compared to six months post-operatively. Mean early post-operative ulnar variance was significantly higher six months post-operatively compared to early post-operative. Mean six months post-operative radial height, mean radial inclination, and mean volar tilt were significantly less compared to contra-lateral side. Mean six months post-operative ulnar variance was significantly high compared to contra-lateral side.

Table 3: The comparison of radiological measurements in the early post-operative period and at 6 months follow-up.

Parameters	Early post-operative	6 months post-operative	Contra-lateral side	P values	
	Mean (SD)	Mean (SD)	Mean (SD)	Early post-operative vs. 6 months post-operative	Six months post-operative vs. contra-lateral side
Radial height in mm	9.19 (1.89)	8.66 (2.18)	10.50 (1.02)	0.001*	0.001**
Radial inclination in degree	19.72 (2.77)	19.09 (3.21)	21.88 (1.68)	0.001*	0.001**
Ulnar variance in mm	-0.63 (1.24)	-0.41 (1.04)	-1.22 (0.49)	0.032*	0.001**
Volar tilt in degree	5.84 (6.46)	5.38 (6.22)	10.19 (1.26)	0.030*	0.001**

* Paired 't' test was used; ** Unpaired 't' test was used.

Table 4: The comparison of mean post-operative wrist range of motion parameters and grip strength.

Parameters		6-weeks post-operative	6-months post-operative	P value
		Mean (SD)	Mean (SD)	
Flexion in degree	Injured wrist	51.3 (7.2)	75.7 (6.6)	0.001
	% of uninjured wrist	59.8 (7.6)	88.4 (6.4)	0.001
Extension in degree	Injured wrist	44.2 (6.6)	71.2 (7.2)	0.001
	% of uninjured wrist	56.6 (6.9)	91.3 (7.7)	0.001
Supination in degree	Injured wrist	53.1 (6.6)	73.3 (7.9)	0.001
	% of uninjured wrist	64.2 (7.1)	88.7 (8.7)	0.001
Pronation in degree	Injured wrist	57.9 (7.2)	78.9 (8.2)	0.001
	% of uninjured wrist	67.8 (8.1)	92.4 (8.8)	0.001
Radial deviation in degree	Injured wrist	9.8 (1.6)	16.2 (1.8)	0.001
	% of uninjured wrist	55.6 (7.4)	92.2 (7.8)	0.001
Ulnar deviation in degree	Injured wrist	15.2 (2.2)	24.5 (2.2)	0.001
	% of uninjured wrist	57.0 (6.5)	91.8 (6.3)	0.001
Grip strength in kg	Injured wrist	17.8 (2.9)	29.8 (5.5)	0.001
	% of uninjured wrist	54.5 (2.4)	90.9 (3.1)	0.001

Paired 't' test was used.

As shown in Table 4, mean flexion, mean extension, mean supination, mean pronation, mean radial deviation, and mean ulner deviation was significantly higher six months post-operative follow-up compared to six week post-operatively. Mean grip strength was significantly higher six months post-operative follow-up compared to six weeks post-operatively. We also compared various range of motions and grip strength with percentage of

uninjured wrist. It was found that all the range of motions and grip strength increased of the injured wrist in terms of percentage also when compared to uninjured wrist.

DISCUSSION

In the present study, mean age of the patients was 42.4 years. Nalbantoglu et al, Gereli et al (CRPCS group and

ORPLP group), and Patil et al, reported mean age as 39, 41, 44 and 42.8 years respectively which is comparable to our study.^{21,29,30} Male patients were 40.6% in our study. Nalbantoglu et al, Gereli et al (CRPCS group) and Patil et al reported 45%, 47% and 47.5% male patients respectively which is comparable to our study.^{21,29,30} In this study, the commonest mode of injury (53.1%) was fall on outstretched hand. Patil et al reported fall on outstretched hand in 37.5% of patients.³⁰

In the present study, majority of the patients (93.7%) had type A2 fracture as per AO classification whereas Nalbantoglu et al and Gereli et al reported 80 and 100 percentage type A2 fracture as per AO classification.^{21,29}

Patil et al reported that all 40 (100.0%) patients had extra articular distal 1/3rd radius fracture whereas in our study 93.7% patients had extra articular fractures.³⁰

Of 32 cases studied, we operated 29 cases (90.6%) within five days whereas Nalbantoglu et al and Gereli et al stated that all cases were operated within five days of injury.^{21,29} The delay in the operation of 9.4% cases in the present study was because the patients reported late and some patients had comorbidities like diabetes mellitus, and hypertension.

Average operative time in this study was less (28.1 minutes) than the average operative time as compared to studies conducted by Gereli et al. (CRPCS group 53 minutes, and ORPLP group 77.7 minutes).²¹ This was because Gereli et al used two cannulated screws in all their cases which required more time.²¹ We used one screw in 90.6% case and two screws in 9.4% cases.

According to Mayo wrist score at six months follow up 90.6% patients had good or excellent outcome. Nalbantoglu et al and Patil et al reported good or excellent outcome in 100% and 95% patients respectively.^{29,30} As compared to the present research, Nalbantoglu et al reported higher percentage of patients with excellent or good result.²⁹ This may be because they conducted their study on young, active individuals (18-60 years), whereas we have also included elderly population (age >60 years) with osteoporotic bone quality in our study. Patil et al included eight patients (20%) of elderly age group.³⁰ They reported 75% patients had excellent or good functional outcome. Our findings substantiated the findings of Patil et al that percutaneous CC screw fixation for distal radius fracture is a good treatment modality even for elderly population.³⁰

Table 5: Comparison of range of movement at final follow up.

Mean value at final follow up in degree	Study		
	Nalbantoglu et al ²⁹	Gereli et al CRPCS group ²¹	Present study
Flexion	73	70	75.7
Extension	70	67	71.2
Supination	72.5	69	73.3
Pronation	81	72	78.9
Radial deviation	15.5	14	16.3
Ulnar deviation	28	26	24.5
Grip strength	27.2	20	29.8

Table 6: Comparison of radiological evaluation.

Variables	Study		
	Nalbantoglu et al ²⁹	Gereli et al CRPCS group ²¹	Present study
Radial height (mm)			
Early post-op	12.25	11.8	9.19
Final post-op	11.85	11.4	8.66
Radial inclination (degree)			
Early post-op	21.10	20.9	19.7
Final post-op	20.95	20.5	19.1
Ulnar variance (mm)			
Early post-op	0.00	0.2	-0.63
Final post-op	-0.60	1.0	-0.41
Volar tilt (degree)			
Early post-op	4.90	4.2	5.84
Final post-op	4.85	3.4	5.38

In the present study, mean Mayo wrist score at six months was significantly higher compared to the mean Mayo wrist score at six weeks. Mean % improvement in

Mayo wrist score at six months compared to six weeks was 28.6 %. This may be because we encouraged early mobilization of wrist by removing below elbow cast at

three weeks and starting active physiotherapy of wrist with removable protective splint. Nalbantoglu et al and Gereli et al reported that cast was removed on an average of 2.7 weeks after surgery.^{21,29} They concluded that more improvement was seen from two to six months and a relatively smaller improvement from six to 12 months in the range of motion of wrist and grip strength values. This highlights the importance of early mobilization.

As depicted in Table 5, mean values of range of motion at final follow up were comparable with the studies conducted by Nalbantoglu et al and Gereli et al.^{21,29} In the present study, mean loss in radial inclination, radial height, and volar tilt were small when compared between early post-operative and six month post-operative but they were statistically significant. Table 6 depicts comparison of radiological evaluation with studies conducted by Nalbantoglu et al and Gereli et al.^{21,29} The findings are similar to our study. Even though comparison between radiological parameters of early post-operative and final follow-up was statistically significant, values were close to anatomical parameters (values for contra lateral wrist) and the alignment was maintained at six months follow up.

In this study, we achieved fracture union in all the 32 cases by three months follow up. There was no case of loss of reduction/malunion till final follow up. Nalbantoglu et al, Gereli et al and Patil et al reported fracture union 100%, 100% and 95 % respectively which is comparable to our study.^{21,29,30}

In the present study, clinical outcome was calculated by measuring residual deformity of injured wrist in the form of prominent ulnar styloid, residual dorsal tilt, radial deviation of hand. We did not find any residual deformity in any of our patients. The reason may be we achieved acceptable anatomical reduction during surgery and did a stable fixation with CC screw so that alignment was well maintained.

In this study, there were two cases (6.3%) of wrist stiffness and one case (3.1%) of mild occasional pain. Patil et al reported mild occasional pain and malunion in 17.5% and 5% patients respectively whereas Gereli et al reported tendon irritation in 2.9% cases.^{21,30}

There are few limitations in the present study. Six months follow up was less, longer follow up is required to evaluate the post-operative wrist arthritis and functional outcome. Larger number of sample size would have been better to evaluate functional outcome. Our study had few cases of elderly population, more cases of this age group would be required to better evaluate the effectiveness of this treatment modality in elderly population. Further studies with other treatment modality and larger number of cases including cases of intra articular extension and elderly population should be undertaken to compare and substantiate the efficacy of this technique.

CONCLUSION

Clinical and functional outcomes associated with closed reduction and percutaneous fixation by cannulated cancellous screw was excellent. Progression of Mayo wrist score over the six months follow up period showed a steady increase. Complications associated with this treatment modality were limited.

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