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Original Article

A comparative study of variable angle volar plate and bridging external fixator with K-wire augmentation in comminuted distal radius fractures

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ABSTRACT

Purpose: Comminuted intraarticular distal radial fractures are difficult to treat conservatively and require operative treatment. This study compared the functional outcomes between variable angle volar plating and external fixator with K-wire augmentation in open reduction and internal fixation.

Methods: A total of 62 adult patients with comminuted intraarticular distal radius fracture were randomized into 2 groups: volar plate group and external fixator group. These patients aged between 18 and 60 years had unilateral fractures, and agreed to be included in the study. Patients with a history of fracture, bilateral fracture, associated other injuries, delayed injury for more than 2 weeks, open fracture, pre-existing arthrosis or disability, psychiatric illness and pathological fracture were excluded. Patients were followed up at 6 weeks, 3 months, 6 months and 1 year. The assessment of pain, functional activity, range of motion and grip strength was done at each stage of follow-up. The pain and functional activities were assessed by patient rated wrist evaluation (PRWE) score and disabilities of the arm, shoulder and hand (DASH) score.

Results: Patients in volar plate group had superior PRWE score and DASH score at each stage of follow-up. At 1 year follow-up, the mean PRWE score were 7.48 for volar plate group and 7.35 for external fixator group; while the mean DASH score was 4.65 for volar plate group and 5.61 for external fixator group. They had better flexion and extension range of movement. They also had better pronation and supination range of motion at initial follow-up, however the difference get attenuated by 1 year. Volar plate group had significantly better grip strength than external fixator group. Complication rates were higher in external fixation group.

Conclusion: Fixation with variable angle volar plate results in early wrist mobilization, better range of movement, less pain and disability and early return of function.

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Introduction

Distal radius fracture (DRF) is a common wrist injury and it accounts for about one-sixth of emergency department visits.¹ Most fractures are caused by fall on outstretched hand, of which the pattern, severity and concomitant disco-ligamentous injury depend on the position of the wrist at the moment of hitting the ground and direction of force transmitted.² Comminuted DRFs are usually due to high energy trauma in young and low energy trauma

in elderly, and may present as shear and impacted fractures with displacement of the fragments.³ In spite of availability of various treatment options, none is universally effective for comminuted intraarticular fracture, because of varied fractures patterns. Two commonly used surgical methods are bridging external fixator with or without K-wire augmentation and open reduction and internal fixation by volar locking plates. Bridging external fixator relies on ligamentotaxis to restore displacement for any unstable fracture, which cannot be held by cast.⁴ For many surgeons, locked volar plating is the choice.⁵ Various designs of volar plates are available, often with features specific to each particular plate promoted as being particularly advantageous.⁶ One of them is the variable angle locking support of the subchondral bone. The clinical and

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functional benefit of this has not so far been demonstrated. The purpose of this study is to compare functional outcomes of variable angle volar plate and K-wire augmented bridging external fixator for comminuted intraarticular DRFs.

Methods

It was a hospital based prospective randomized control study, in which 72 patients of AO type C1, C2 and C3 were included between October 2016 and March 2018, after ethical committee approval. Of the total 72 patients, 36 were treated with variable angle locked volar plate and other 36 with external fixator. In 22 patients K-wire augmentation was done in external fixator group. There were 5 drop outs from volar plate group and 3 from external fixator group who did not come for follow-up at desired intervals. Two patients from external fixator group required supplemental volar plate, and they were excluded from the study. Mean age in volar plate group was (35.68 ± 12.83) years and in external fixator group was (34.61 ± 11.57) years ($p = 0.733$) with maximum incidence among 21–30 years age group. Out of 62 patients, 38 (61.3%) were males and 24 (38.7%) were females.

The inclusion criteria were: patients aged between 18 and 60 years, had unilateral fractures, and agreed to be involved in the study. Patients with a history of fractures, bilateral fracture, associated other injuries or fractures of the same limb, injury for more than 2 weeks, open fracture, associated head injury or multi organ injuries, pre-existing arthrosis or disability, associated neuro vascular deficit, psychiatric illness and pathological fracture were excluded. Participants were divided into 2 groups by random number table. One group assigned for using variable angle volar plating, and the other group for bridging external fixator with K-wire augmentation if required.

Surgery was performed under regional or general anaesthesia. Prophylactic antibiotic, 2nd generation Cephalosporin (Cefuroxime) was administered 30 min before incision after skin testing. Surgery was performed by the same team with patient in supine position, pneumatic tourniquet control and fluoroscopic guidance. Radiographic criteria for acceptable reduction were radial inclination of more than 15° , radial shortening of less than 5 mm, sagittal tilt between 15° dorsal and 20° volar, and incongruity of less than 2 mm at articular surface.⁷

The patients in volar plate group were splinted for 2 weeks in short arm cast and external fixation group was splinted in a splint for 7 days. Finger movement in all patients was encouraged immediately. Wrist movement in volar plate group was started after removal of cast and in external fixator group after removal of external fixator. Suture removal was done at 2 weeks when reduction was also checked radiologically. All patients were followed up at 6 weeks, 3 months, 6 months and 1 year, and assessed for grip strength, range of motion (ROM), disability of arm shoulder and hand (DASH) score, patient rated wrist evaluation (PRWE) score and complications.^{8,9} Goniometer was used to measure ROM and grip strength by standard dynamometer with elbow in 90° flexion and shoulder neutrally rotated and adducted.

Surgical method

Open reduction and variable angle volar plating

Long incision about 8 cm was given longitudinally between the radial artery and flexor carpi radialis (FCR) tendon. The FCR sheath was opened and the tendon retracted to the radial side to expose ulnar corner and to the ulnar side to expose radial corner. The median nerve is gently retracted medially to prevent it from inadvertent injury during the procedure. The flexor pollicis longus tendon lies underneath the FCR. This was retracted to ulnar side

revealing the pronator quadratus muscle. The pronator quadratus muscle was elevated from its radial origin and reflected to ulnar side. The attachment of radiocarpal ligaments was preserved to prevent instability. Each fragment was identified, elevated, and reduced and plate was fixed under fluoroscopy.

External fixator

Two 2.5 mm Schanz pins in index metacarpal and two 3.5 mm pins in radius were inserted. After skin incision the subcutaneous tissue is gently dissected with curved artery forceps, and a sleeve is used during drilling to prevent any injury to the superficial branch of the lateral antebrachial cutaneous nerve and the radial sensory nerve. The pins were interconnected with rod and link joints. Reduction was achieved via manual traction and K-wire supplementation was done, when there is unacceptable fragment reduction alone with external fixator. Both K-wire and the external fixator were removed after 6 weeks.

Statistical analysis

Categorical variables were presented as number and percentage and continuous variables were presented as mean \pm standard deviation (SD). Quantitative variables were compared using paired *t*-test for comparison between these groups. A *p* value < 0.05 was considered statistically significant. The data were analysed using Statistical Package for Social Sciences (SPSS) version 22.0.

Results

Of the total 62 patients, 31 were treated with variable angle locked volar plate and other 31 with external fixator. The dominant extremity was affected in 70%. Mean duration of surgery was 62.26 min for volar plate group and 30.81 min for external fixator group. Radiologically, all the fractures united in both groups with acceptable reduction. In volar plate group, 1 patient had superficial postoperative wound infection managed with antibiotics, and 3 developed transient median nerve dysfunction improved after removing cast and steroid treatment for 5 days. In external fixator group, 2 patients developed pin tract infection which was managed on systemic antibiotics and local gentamycin infiltration of pin tract site, 3 developed features related to complex regional pain syndrome (CRPS), and 1 had mild sensory deficit in the area of superficial radial nerve.

In our study, PRWE scores in volar plate group was significantly lower ($p < 0.001$) till 6 months in comparison with external fixation group. At 1 year, although PRWE score was slightly higher in volar plate group, it was not significant (Table 1, Fig. 1). DASH score of volar plate group (Table 2, Fig. 2) was also lower ($p < 0.001$) compared to external fixator group at 6 months. At 1 year, although DASH score was lower in volar plate group, it was not significant.

Volar plate group had a better range of flexion, extension, pronation and supination at 6 weeks, 3 months and 6 months follow-up. At 1 year follow-up, although all ROM was better in volar plate group, supination and pronation were not significant. Patients in volar plate group had a better grip strength than that in external fixator group. The difference was statistically significant ($p < 0.05$) at each follow-up (Table 3).

Discussion

Although conservative treatment is an ever-existing option for DRFs, it's very difficult to achieve reduction and maintain the reduction in the cast, because of collapse, comminution and inadequate ligamentotaxis particularly in case of unstable fractures. The risk of poor outcome increases with malunion and joint incongruity, and surgical interventions are required to maintain a

Table 1
Patient rated wrist evaluation (PRWE) score (means ± SD).

Follow-up time point	Volar plate group (n = 31)			External fixator group (n = 31)			p value
	Pain	Function	PRWE	Pain	Function	PRWE	
6 weeks	25.2 ± 0.1	20.1 ± 2.1	45.5 ± 4.6	29.3 ± 0.2	25.2 ± 3.3	59.9 ± 6.7	<0.001
3 months	14.7 ± 2.4	14.1 ± 2.4	28.9 ± 4.0	20.0 ± 3.3	17.9 ± 2.0	37.8 ± 4.4	<0.001
6 months	7.5 ± 1.6	7.8 ± 2.0	15.3 ± 2.8	8.9 ± 1.8	9.9 ± 1.9	18.7 ± 3.1	<0.001
1 year	3.6 ± 1.2	3.8 ± 0.8	7.4 ± 1.5	3.0 ± 0.8	4.3 ± 1.4	7.3 ± 1.9	0.38

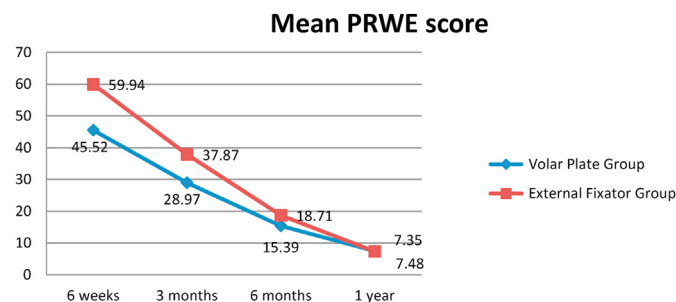


Fig. 1. Mean patient rated wrist evaluation score at each stage of follow-up. PRWE: patient rated wrist evaluation.

satisfactory anatomical position.¹⁰ A meta-analysis by He et al.¹¹ showed that the radiological parameters like radial inclination, radial length and ulnar variance along with ROM can be improved with surgery. Various surgical options include arthroscopic assisted surgery, fragment specific fixation, external fixation, percutaneous pinning and fixed angle or variable angle locked plate.

Arthroscopy has the advantage of under-vision reduction, debridement of debris and concomitant ligamentous repair, but it has high requirements of cost and technique.¹² Fragment specific fixation has an advantage of anatomical reduction and secure fixation of the comminuted fractures, and has also less chance of tendonitis and tendon rupture, due to low profile plate.¹² External fixation is relatively easy to apply, but in many cases it is not enough to perform anatomical joint repair and requires percutaneous fixation. And it also has some potential complications, like pin tract infection, joint over distraction and stiffness, grip strength loss, superficial radial nerve injury and CRPS.¹² Open reduction has the advantage of direct manipulation and reduction. Fixed angled plate has predetermined locking angle, so its precise placement is required for optimal subchondral support across the articular surface. Placement too far or too close leads to intra-articular screws or improper subchondral support respectively, which can subsequently lead to dorsal migration of distal fragments and prominent hardware, loosening of the hardware, tendonitis and sometimes volar carpal subluxation. In contrast, the variable angle mechanism provides the freedom to change freely the angle of the screw, so the plate and screw can be flexibly positioned at the position providing the best support.⁶

In our study, 61.3% were male and 70.0% of the injury is related to the dominant hand. Increased incidence of fracture in dominant

Table 2
Disability of the arm, shoulder and hand (DASH) score (means ± SD).

Follow-up time point	Volar plate group (n = 31)	External fixator group (n = 31)	p value
6 weeks	51.81 ± 3.53	75.35 ± 3.23	<0.001
3 months	19.29 ± 3.85	36.05 ± 3.79	<0.001
6 months	6.63 ± 3.28	17.56 ± 3.88	<0.001
1 year	4.65 ± 1.81	5.61 ± 2.6	0.051

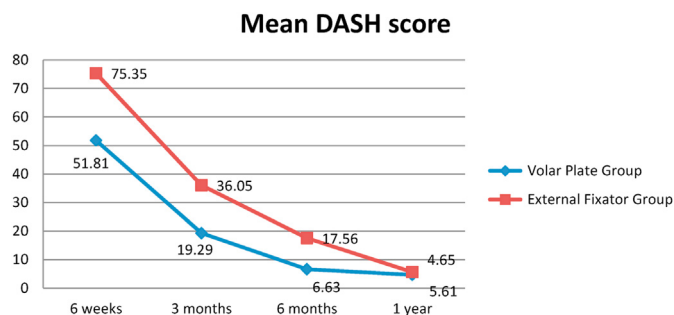


Fig. 2. Mean disability of the arm, shoulder and hand (DASH) score at each stage of follow-up.

hand may be attributed to protective reflex use of dominant hand during fall. Similar incidence was observed in the study by Sharma et al.¹³

The mean PRWE score in volar plate group was 45.52, 28.97 and 15.39 as compared to external fixator group which scored 59.94, 37.87 and 18.71 at 6 weeks, 3 months and 6 months respectively ($p < 0.001$). At 1 year follow-up the score was higher in volar plate group but not statistically significant. Drobetz et al.¹⁴ in 2016 conducted a randomized control trial between volar locking distal radius plating (VLDRP) and other treatment options including external fixation, and they found that PRWE scores were significantly better in VLDRP group than that in the control group at 3 months. The mean score in the VLDRP group was 21 compared to a mean score of 47 in the control group. Wilcke et al.¹⁵ found the similar result that volar plate group had significantly lower PRWE score (9 in volar plate group and 17 in external fixation group) at 6 months, and at 1 year although the score is lower (11 vs. 15) in volar plate group, which is not significant. Grewal et al.¹⁶ found that PRWE detected higher pain and disability with external fixation at the 6 weeks ($p = 0.05$) and 3 months ($p = 0.06$). At 1 year, the differences between the 2 groups were negligible.

Mean DASH score was 51.81, 19.29 and 6.63 for volar plate group, and 75.35, 36.05 and 17.56 for external fixation group at 6 weeks, 3 months and 6 months respectively ($p < 0.001$). At 1 year, DASH score was lower in volar plate group in comparison to external fixation group (4.65 vs. 5.61), but the difference was not significant. The DASH scores were also better in VLDRP group in the study by Drobetz et al.,¹⁴ but this did not reach statistical significance. Wilcke et al.¹⁵ found that patients in volar plate group had a better DASH score (6 vs. 14, $p = 0.008$) as compared to external fixator group at 6

Table 3
ROM and grip strength score (means \pm SD).

Follow-up time point	Volar plate group (n = 31)	External fixator group (n = 31)	p value
6 week			
Flexion	38.55 \pm 4.23	36.19 \pm 1.72	0.006
Extension	47.00 \pm 4.09	34.03 \pm 3.08	<0.001
Pronation	78.26 \pm 6.19	58.32 \pm 2.81	<0.001
Supination	68.29 \pm 9.32	57.61 \pm 5.75	<0.001
Grip strength	11.90 \pm 3.42	9.77 \pm 1.69	0.003
3 months			
Flexion	46.06 \pm 2.18	40.54 \pm 4.15	<0.001
Extension	51.06 \pm 3.01	45.06 \pm 3.84	<0.001
Pronation	75.16 \pm 3.68	69.25 \pm 6.09	<0.001
Supination	71.29 \pm 3.47	64.29 \pm 9.17	<0.001
Grip strength	14.03 \pm 2.22	12.19 \pm 2.53	0.002
6 months			
Flexion	61.84 \pm 5.76	49.58 \pm 2.73	<0.001
Extension	54.03 \pm 6.39	51.23 \pm 1.82	0.022
Pronation	83.03 \pm 4.68	74.26 \pm 3.79	<0.001
Supination	77.84 \pm 6.46	66.58 \pm 3.42	<0.001
Grip strength	22.74 \pm 4.44	17.16 \pm 2.31	<0.001
1 year			
Flexion	67.19 \pm 4.85	63.77 \pm 6.37	0.021
Extension	70.23 \pm 4.43	62.0 \pm 8.09	<0.001
Pronation	85.26 \pm 3.57	83.71 \pm 4.14	0.120
Supination	80.81 \pm 4.85	78.23 \pm 6.26	0.075
Grip strength	32.68 \pm 2.99	26.68 \pm 4.87	<0.001

ROM: range of motion.

months, but at 1 year this difference (7 vs. 11) was not significant. In the study of Rizzo et al.,¹⁷ it was found that mean score of volar plate group was 9 as compared to 23 for external fixator group at final follow-up ($p = 0.015$). However, Egol et al.¹⁸ did not find any significant difference in DASH score in follow-up in his series.

Mean flexion/extension was better in volar plate group. The difference at each stage of follow-up was significant ($p < 0.05$). Mean supination/pronation in volar plate group was better than that in external fixator group. The difference in supination and pronation at 6 weeks, 3 months and 6 months reached statistical significance, but at 1 year this difference gets attenuated. In the similar study of Duramaz et al.¹² flexion, extension, pronation and supination were all significantly better in the volar locking plate group than those in the K-wire-supported bridging external fixator (KW-EF) group. In study of Sharma et al.¹⁴ the internal fixation group has an obvious advantage of ROM score around 3 months over in the external fixation group, and the difference was narrowed by 6 months of follow-up but still statistically significant. In the meta-analysis by Gouk et al.¹⁹ they found that flexion/extension was significant ($p = 0.03$) in favour of open reduction and internal fixation. Pronation/supination is also conducive to open reduction and internal fixation, but it is not statistically significant.

In each stage of follow-up, the grip strength of volar plate group was better than that in external fixator group. Duramaz et al.¹² measured the percentage loss of grip strength in comparison to normal, and they found that the loss was lesser in VLDRP group. Since all the external fixators were applied as bridging external fixator, the wrist was inherently immobilized till their removal. Also the metacarpal pins hinder in the proper grip strengthening exercise. These two factors may explain greater movement loss and diminished grip strength in external fixator group. In contrast, in the study of Sharma et al.,¹³ there was no statistically significant difference in the grip strength of external fixator group at 3 months of follow-up, but the grip strength of external fixator group was significantly better than that of external fixator group at 6 months of follow-up. They postulated that this was due to early start of grip

strength exercises in external fixator group, as compared to volar plate group, which delayed grip strength exercise due to pain. But this was not observed in our study, as all patients tolerated the exercise programme well in volar plate group.

In volar plate group, 1 patient had superficial postoperative wound infection and 3 had transient median nerve dysfunction. In external fixator group, 2 patients developed pin tract infection, 3 developed CRPS, and 1 had mild sensory deficit in the area of superficial radial nerve. The difference in infection was not significant ($p = 0.453$). In the study by Duramaz et al.,¹² the complication rate was significantly higher in KW-EF group than in VLDRP group. In this study, there were 2 patients with median nerve neuropathy, 3 with stage-1 CRPS, and 2 with tendon irritations in VLDRP group, while there was 1 patient with median nerve neuropathy, 6 with pin tract infections, 2 with superficial radial nerve neuropathy, and 12 with stage-1 CRPS in the KW-EF group. Rizzo et al.¹⁷ found no complications in the locked volar plate group, whereas 2 patients had pin tract infections and 1 had prolonged finger stiffness in the external fixation group. Egol et al.¹⁸ in 2008 found that the number of complications between the 2 methods was similar, but there was a greater incidence for re-operation in the volar plate group. Richard et al.²⁰ in 2011 concluded that volar plate fixation has an overall decreased incidence of complications.

The merits of our study were the randomization of patients and a relatively homogenous cohort in both groups. The limitations include small sample size, limited follow-up, inability to blind the surgical team to the study group assignment of the patient, and lastly the cost effectiveness of both groups was not evaluated.

In conclusion, we observed that compared with K-wire augmented bridging external fixator, variable angle volar plating provides improved functional outcomes in short term and almost similar outcomes in long term of PRWE score, DASH score, grip strength and ROM and has fewer complications. Therefore, variable angle volar plate is a better treatment modality for comminuted intra articular DRFs at least in short terms.

Funding

Nil.

Ethical statement

The study was approved by institute ethical committee, Vardhman Mahavir Medical College and Safdarjang Hospital, New Delhi. The written informed consent was obtained from all patients.

Declaration of competing interest

The authors declare that they have no conflicts of interest.

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