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Original Research Article

Functional and radiological outcome in distal radius fractures treated with locking compression plate

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ABSTRACT

Background: Fractures of distal end of radius are one of the most common skeletal injuries encountered in orthopaedics. There are various modalities for treatment like close reduction and cast application, external fixators, ORIF with plate etc. CR and cast application or K-wire fixation, external fixation is associated with immobilisation, wrist stiffness, loss of reduction postoperatively. So we performed volar plating for distal end radius fractures and calculated its results.
Methods: We performed ORIF with plating (Volar approach) in 35 patients (22 male and 13 female) of distal end radius fractures depending on inclusion and exclusion criteria. Fractures were classified according to AO classification. All patients were operated under tourniquet. Results were analysed using Mayo score.
Results: Out of 35 patients, 14 had type A, 16 had type B and 5 had type C fractures (AO classification). Average operative time was 45 minutes and blood loss of 50 ml. Average time to clinico-radiological union was 7 weeks. Average follow up time was 8 months. Average time to wrist mobilisation was 8 days. According to Mayo score, 16 patients had excellent results, 15 had well and 4 had satisfactory results.
Conclusions: Volar plating for fracture distal end radius reduces chances of wrist joint stiffness and loss of reduction and good results can be obtained. So in our opinion, volar plating for treatment of fracture distal end radius is good method with excellent outcomes.

Keywords: Distal end radius fracture, Functional outcome, Volar plating

INTRODUCTION

Fractures of distal end of radius are one of the most common skeletal injuries encountered in orthopaedic departments.[1] They occur most frequently in adult patients after the fourth decade of life and comprise around 10 to 20% of all fractures attended as emergencies. This group also has the highest rate of complications and hand dysfunctions, which affect the capacity to work.[2]

These fractures are often treated with closed reduction and immobilization with cast but the difficulty here is the possibility that displacement may persist even in the least complex fractures. Other problem with this method is immobilization of wrist and forearm for at least 6 weeks and the further time required to regain the functions of forearm, wrist and hand by physiotherapy. During this entire time duration, patient's ability to carry out day to day activities is hampered. Numerous other methods of treating injuries of this nature like closed percutaneous pinning, external fixation, buttress plating have enjoyed recognition from time to time, testifying the fact that there is no ideal modality of treatment.[3]

The functional outcome of treatment of fracture of the distal aspect of the radius is influenced by the anatomical reduction of the articular surface and the extraarticular alignment of the distal part of the radius.[4] By directly restoring the anatomy, plating allows secure internal

fixation with resultant early return of wrist function. The antiglide effect of buttress plates help reduce and stabilize intra articular fractures, however the need for protection of fracture till it consolidates and the chances of loss of reduction are still areas of concern.[5] With this type of plating so more stable locking plates were evolved to overcome this problem. The aim of the present study is to evaluate the functional and radiographic results of volar plates for treating fractures of the distal end of the radius.

METHODS

In this prospective study, fractures of distal radius were treated using volar locking compression plate. This study was conducted in the department of orthopaedics from May 2013 to October 2015. Patients to be included in this study were sorted based on following preset inclusion and exclusion criteria.

Inclusion criteria

- Distal end radius fractures without fractures of distal ulna.
- Compound fractures of distal end radius up to grade I.
- Mature skeleton (Age more than18 years)

Exclusion criteria

- Patients with pathological fractures,
- Open fractures Gustilo and Anderson type II or type III
- Fracture with vascular injury.
- Neurological deficit.
- Ipsilateral fracture of shoulder and elbow
- Contralateral injury to wrist and carpals.
- Immature skeleton

Fracture was classified according to AO system. The study comprised a total of thirty Five patients of fractures of the distal radius were considered according to inclusion and exclusion criteria for the final evaluation of results during May 2013 to October 2015.

Surgical procedure (Volar approach)

Surgery was performed under appropriate anaesthesia i.e. either general anaesthesia or axillary or supra clavicular block under tourniquet control. Open reduction and internal fixation was done using modified Henry approach between the flexor carpi radialis and radial artery.

The pronator quadratus was sharply taken off the radial aspect of the radius and reflected ulnarly to facilitate exposure of the fracture. Under direct visualization and the aid of fluoroscopy, the fracture was then reduced. Depending on the difficulty in achieving the reduction, provisional fixation with k-wires can be occasionally utilized. The plate and screws were placed and the provisional fixation (in use) was removed. The plate was initially secured proximally with a 3.5-mm cortical screw. Upon confirming adequate placement of the plate, a second screw proximal to the fracture was used to firmly secure the hardware. Distal fixation with locking screws was then performed while maintaining the fracture reduced. The remaining proximal fixation was then completed.[6]

Evaluation of outcome

The patients were followed up for minimum of 6 months. Clinical, functional and radiological reviews were performed at periodic intervals.

Clinical and functional

Functional evaluation of the patients was done at the 6 month follow up mostly according to the Mayo score as per Table 1.

Table 1: Mayo score.

Pain intensity	Range of Movement (% of normal side)
No pain - 25	100% - 25
Mild, Occasional – 20	75-99% - 20
Moderate, Tolerable – 15	50-74% - 15
Severe, Intolerable – 0	25-49% - 10
	0-24% - 5
Functional Status	Grip strength (% of normal side)
Regular job – 25	90-100% - 25
Restricted employment- 20	75-89% - 15
Able to work, but unemployed -15	50-74% - 10
Unable to work due to pain -0	25-49% - 5
	0-24% - 0

Interpretation of the Mayo Wrist Score; 91-100 Excellent; 81-90 Good; 61-80 Satisfactory; Below 60 Poor

Radiological

Radiological assessment was done in terms of residual dorsal angulation, radial shortening and loss of radial inclination and the results were graded according to the Lid Strom Criteria.

These parameters were assessed during the follow up of the patient to assess the quality of reduction and the ability of the technique to maintain the reduction. Post-operative radiographs were evaluated in accordance with the Lidstrom anatomical-radiological classification as per Table 2 for fractures of the distal extremity of the radius, as excellent, good, and fair or poor.[7] Statistical analyses of the data were done.

Table 2: Lidstrom classification.

Lidstrom classification
Excellent
Insignificant deformity
- Dorsal angle greater than 0° (neutral) - Radial shortening less than 3 mm - Loss of radial tilt not more than 4°
Good
Small deformity
- Dorsal angle 1-10° - Radial shortening 3-6 mm - Loss of radial tilt 5-9°
Fair
Moderate deformity
- Dorsal angle 11-14° - Radial shortening 7-11 mm - Loss of radial tilt 10-14°
Poor
Severe deformity
- Dorsal angle greater than 15° - Radial shortening greater than 11 mm - Loss of radial inclination greater than 15°

RESULTS

The study comprised a total of thirty five patients of fractures of the distal radius were considered according to inclusion and exclusion criteria for the final evaluation of results during May 2013 to October 2015.

The mean age of the patients taken up for the study was 42.8 years with the youngest patient being 21 years and the oldest being 75 years.

There were 25 female patients (71.4%) and 10 male patients (28.6%). Mode of trauma due to fall 20(57.1%) is more as compare to RTA 15 (42.9%). Left side 19 (54.30%) is involved more as compare to right 16 (45.70%).

Out of 35 patients, 2 patients (5.7%) had an associated injury viz. fracture mandible and fracture tibia and fibula. Out of 35 patients 17 (48.6%) had type B fracture 16 (45.7%) had type A and 2 (5.7%) had type C fracture. Duration of hospital stay ranged from 3 to 6 days with maximum number of patients stay up to 5 days.

Table 3: Patient evaluation with Mayo score.

Pain Intensity	Functional status	Range of movement (% of normal side)	Grip strength (% of normal side)
No pain- 31 patients	Regular job- 35 patients	100% -5 patients	90-100% -18 patients
Mild,occasional- 4 patients	Restricted employement- 0 patient	75-99% -30 patients	75-89% - 15 patients
Moderate, tolerable- 0 Patient	Able to work but unemployed- 0 patient	50-74% - 0 patients	50-74% - 2 patients
Severe,intolerable- 0 patient	Unable to workdue to pain- 0 patient	25-49% - 0 patient 0-24% - 0 patient	25-49% -0 patient 0-24% - 0 patient

Mean range of follow up was 6-10 months and maximum follow up was 14 months and minimum follow up was 6 months. Maximum no. of patients attended follow up within period of 6 to 10 months and that accounted to 48.6% (17 Patients).

Table 4: Functional end result of healed fracture.

Functional Score	Frequency	Percentage
Excellent	16	45.7%
Good	15	42.9%
Satisfactory	4	11.4%
Total	35	100.0%

Most of the fractures united in time duration of 6 to 8 weeks. Minimum time duration of union was 6 weeks. Patients evaluation done as per Mayo score as per Table 3.

Functionally 16 patients (46%) had excellent, 15 well (43%) and 4 patients had satisfactory (11%) restoration of functions as per Table 4.

Radiological evaluation

The scoring was done according to Lidstrom classification as per Table 5-7.

Radial angle

Table 5: Radial angle.

Radial angle	Frequency	Percentage
10 to 14 degree	5	14.3
15-19 degree	14	40
20-25 degree	16	45.7
Total	35	100

Volar tilt

Table 6: Volar tilt presentation.

Volar Tilt (In Degrees)	Frequency	Percent
-5 to 0	0	0%
0 to 5	4	11.40%
6 to 10	30	85.7%
11 to 15	1	2.9%
Total	35	100.0%

Radial length shortening

Table 7: Radial length shortening.

Radial length shortening	Frequency	Percentage
<3mm	23	65.7
3-6mm	9	25.7
>6mm	3	8.6
Total	35	100

Radiologically 19 patients had insignificant deformity 13 had small and 3 had moderate deformity Thus 91% had excellent to good radiological outcome as per Table 8.

Table 8: Radiological outcome of healed fracture.

Radiological score	Frequency	Percent
Excellent	19	54.3%
Good	13	37.1%
Fair	3	8.6%
Total	35	100.0%

Case 1

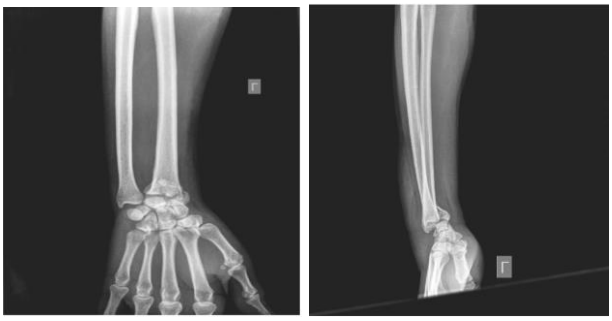

Figure 1: Pre-op x ray.

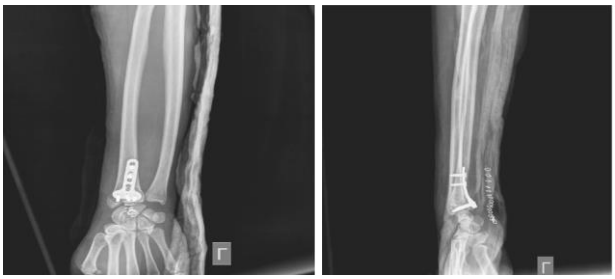

Figure 2: Post- op X ray

Figure 3: Union after 6 weeks.

Figure 4: (A) Dorsiflexion; (B) Palmarflexion.

Figure 5: (A) Supination; (B) Pronation.

Case 2

Figure 6: Pre-operative X rays.

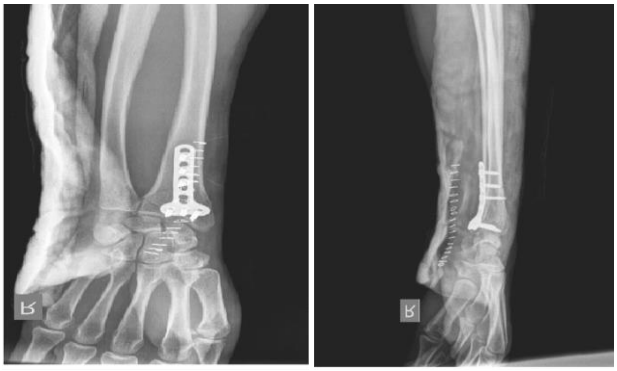

Figure 7: Post-operative X rays.

Figure 8: X rays after union (8 weeks).

Figure 9: Dorsiflexion; (B) Palmarflexion.

Figure 10: (A) Supination; (B) Pronation.

Case 3

Figure 11: Pre-operative X rays.

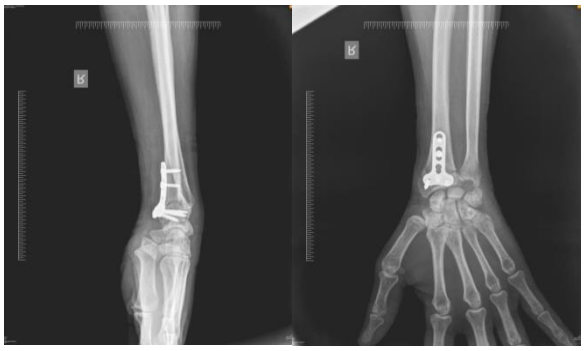

Figure 12: Post-operative X rays.

Figure 13: X-rays after union (6 weeks).

Figure 14: Dorsiflexion; (B) Palmarflexion.

Figure 15: (A) Supination; (B) Pronation.

Complications

In present study out of 35 patients, 3 patients had developed the complication.

1. One had irritation of flexor tendon,
2. One had prominence of hardware and
3. One had superficial infection.

Both patient having irritation of flexor tendon and prominence of hardware advised for implant removal but they did not turn up. The patient having superficial infection treated with oral antibiotics.

DISCUSSION

Over the last decade, several studies have been directed towards clarifying which surgical treatment method would be best for fracture of the distal extremity of the radius. In this context, Osada et al recently documented the increasing popularity of open reduction and internal fixation, especially since the introduction of locked volar plates in 2001.[8] They demonstrated that locked volar plates are well tolerated, allow early mobilization and provide good support for deforming muscle forces after the surgical reduction, even in intra-articular fractures. The majority of the studies have used subjective tools for measuring quality of life, such as the Gartland and Werley calculation and the DASH calculation while others have given greater emphasis to the radiographic parameters obtained after surgical reduction of fractures of the distal extremity of the radius.[7-10]

In present study patients evaluated functionally by Mayo score and radiologically by Lidstrom classification. The average age of the patients in our study was 42.8 years. The eldest patient in the study was 75 years of the age and the youngest patient was 21 years old (mature skeleton) as compare with other studies like Kevin C, Chung et al had average age of the patients was 48.9 years with minimum age 18 years and maximum years 83 years.[11] In Rohit A et al average age of the patients was 57 years with minimum age 17 years and maximum years 79.[12] In Killic A et al average age of the patients was 45 years with minimum age 18 years and maximum years 77.[13] In Anakwe RE et al average age of the patients was 48 years with minimum age 22 years and maximum years 67.[8]

In present study, most of the patients were females 25 (71.4%) as compared with males 10 (28.6%). The study done by Hanae Minegishi et al included most female 12 (80%) and male 3 (20%).[14] In Margaret Fok WM et al study there were 56 (57.7%) male and 41 (42.3%) female while Tank Gyaneshwar study had female 52 (65%) and male was 28 (35%) in number.[15,16]

In the present study, the mode of injury was road traffic accident in 20 patients (57.1%), fall in 15 patients (42.9%). In the study of Ayhan Kilic et al also found road traffic accident in 13 patients (48.1%) and fall in 14 patients (51.9%) while Chung KC et al found 42 patients (48.3%) had road traffic accident and 45 patients (51.7%) had trauma due to fall.[11,13] Arora Rohit et al in his study got 40 patients with road traffic accident and 60 patients due to fall.[12]

In present study, Out of 35 patients, 2 patients (5.7%) had an associated injury. similarly in Jakob M et al study out of 73 patients 21 (28.8%) had associated injury and In Aggrawal AK et al study out 0f 16 patients 10 (62.5%) had associated injuries.[17,18] The percentage of associated injuries was low in our study because of exclusion criteria, while in other studies considered all the varieties of injuries.

In present study, 2mm and 3.5mm size plate was used. Similarly in Aggrawal AK et al study also 3.5 mm size plate was used. In study of Minegishi H et al 2.5mm plate was used. Jakob M, et al in his study plate of 2 mm plate used. While Santiago A et al used 2.4 mm plate size.[14,17-19] The use of 2 mm plate and screws allows more accurate treatment after reconstruction of joint under direct vision and reestablishment of radial length both intermediate and lateral columns can be buttressed and cancellous bone graft may be added where it is needed the 2.0 screws usually give good purchase in distal fragments. A 3.5 mm T plate can be used for the intermediate column but not for the lateral column and also this plate is too big for small fragments and it is difficult to obtain a good purchase in comminuted distal fragments.[20] There is extensive work to show that locked volar plates are well tolerated, allow early movement and maintain position even for intraarticular fractures.[21,22]

Proposed advantages of locked volar plating include improved pull out strength even in osteoporotic bone.[23] Internal fixation using a dorsal plate, which is greatly advocated, achieves anatomical reduction with good stability. However, a variety of complication has been documented, including irritation of subcutaneous tissue, tenosynovitis of extensor muscle, rupture of extensor tendon and even chronic pain.[24] In view of this fixed angle locked volar plate for the distal extremity of radius

have gain much space among orthopedic surgeons, since these not only provide stable fixation but also avoids the above mentioned complication.[25,26] Volar surgical approach that avoids need for an extensive dorsal dissection. The plate is positioned in well-padded area beneath pronater quadrates to avoid flexor tendon irritation and it is thought that patient tolerate volar wrist scar better than dorsal one.[27,28] As they are less obvious and the blood supply to the radius is less likely to be disturbed.

Dorsal plate fixation is biomechanically effective in buttressing a dorsally displaced fracture of distal radius. Osada et al compared the biomechanical properties of dorsal and volar fracture fixation plate designs in a cadaver model.[29] They reported that if the volarily placed titanium symmetry plate was used to fix a colles – type fracture, the distal fragment of radius to develop a dorsal angulations of about 9 degrees if early active mobilization of fingers was initiated during the post-operative period, on the other hand, Leung et al demonstrated no statistical difference between axial loading transmission though the intact radius and a distal radius fracture fix with a volar locking plate.[30] In fact, the volar locking plate showed advantages over dorsal plating in the fixation of dorsally unstable distal radius fracture. In addition, volar plate fixation is a valuable method because of decrease risk of inducing dorsal soft tissue complications. The dorsal approach often needs dissection of the extensor retinaculum and sometime dissection of lister tubercle. Therefore the extensor tendon generally exposed to mechanical attrition by the plates and screw.

In the volar approach, the volar anatomy of the wrist presents and advantage over the dorsal aspect because there is more space between the volar cortex and the flexor tendons the pronator qudratus can also sometime act as a hedge to prevent soft tissue complications. The palmer cortex is relatively flat, and the plate I better contoured for application from this aspect rather than on the dorsal cortex of the distal radius.[31] The volar cortex of the distal radius was very often not as everly communited when compared with dorsal cortex. Anatomical reduction of palmar cortex may avoid the shortening of the radius, which is important for its restoration. The volar plate system used in our study was a locking plate system and this must be one of the reasons for retaining good anatomical reduction.

The optimal placement of distal screw is important they must be inserted at the radius stylloid, beneath the lunate facet, and near the sigmoid notch. Therefore the plate is positioned near the volar radius margin. But fixation implants place over or distally to the watershed line can exert pressure on the flexor tendon and cause injury. The watershed line is defined as a transverse ridge that closures the concave surface of the volar radius distally. Distal to this line, the radius slopes in a dorsodistal direction and become prominent palmarly. The course of flexor pollicis longus tendon is close to the palmar rim of the distal radius. The plate placed very close to the wrist joint can support the palmar aspect of the articular surface. However, it sometimes causes flexor tendon impairment in the very distal area, it is not possible for the reattach pronater quadratus muscle to protect the flexor tendon. As a result the tendon can abrade against the plate and sharp edges of the screw heads. It also must be emphasized that protruding screw heads can cause tendon irritation. To avoid rupture of flexor pollicis longus tendons, care has to be taken especially in a very distal fractures, type C3 fractures and osteoporotic bone. Adequate image intensifier control to verify the extra-articular and subchondral position of screw and plate is also quite important, Jakob M used double plating when open reduction of dorsal displaced fracture of the radius is indicated to restore congruency and extra-articular anatomy.[14,17] The technique using two 2.0 mm titanium plate based on tree–column concept of the distal radius and ulna and they noticed specific complications.

It Is very important to select the proper plate width to provide satisfactory subchondral support across the entire articular surface as well as to capture volar ulnar fragments with atleast one threaded peg. Volar prominence of the plate is often associated with an insufficient fracture reduction and residual dorsal tilt of the dorsal fragment as well as with plate application distal to the watershed line.[15] The use of newer plate may have changed outcomes in some way, however the basic principle of fracture reduction, stable fixation and respect for the soft tissues remain paramount regardless of implant. In study of Agrawal S all the fractures were excess through volar approach and fixed with titanium LCP (2.4mmand 3,5mm distal radius LCP).[3]

If any instability was encountered after volar plate fixation and additional lateral column plate was added to improve stability of construct through same incision as volar plate alone will be inadequate in fixation of fracture with complex pattern. Furthermore, the increase in incidence of sympathetic dystrophy with immobilization over long durations is circumvented by this novel method of fixation. In present study, Most of the fractures were united in the time duration of 6 to 8 weeks. The difference in union rate was due to variable factors, like there was trend towards increasing union time with higher energy fracture type like in type C fracture but this did not prove significant. While in Anakwe RE, et al average time of bony union was 12 weeks.[25] Overall mean time to fracture union was 8.4 weeks (6-28 weeks) in the study of Phadnis J et al.[32] Excessive distraction of the hardware to obtain satisfactory reduction can result in delayed union nonunion complex regional pain syndrome or digital stiffness.[33,34]

Avoidance of malunion is important, since a poor anatomical result adversely affects recovery of function as was reflected in the difficulties patients with malunion had with activities of daily living.

In study of keating malunion with dorsal tilt he also concluded that this could be because of inadequately contouring the plate resulting in exccesive dorsal angulation of the distal fragments.[35] They suggested that restoration of the normal volar tilt is the single most important determinant of functional outcome. Despite the high rate of malunion they noticed and acceptable level of function after rehabilitation.

Present results have been encouraging. The operation is technically demanding, we believe that restoration of joints and the articular anatomy led to desired results of range of movement, grip strength, pain intensity and functional status. Consequently, it seems rational to use LCP for fracture radius with volar approach as an effective treatment method in terms of early functional mobilisation compared to other available methods.

CONCLUSION

Present study documents 89% functional and 91% radiological excellent to good results, suggests that stabilizing the fracture fragments with volar plate and screws in the management of the fractures of distal radius, is an effective method to maintain the reduction till union and prevent collapse of the fracture fragments, even when the fracture is grossly comminuted/intra-articular/unstable and/or the bone is osteoporosed.

The technique emphasizes that open reduction and internal fixation with volar plating has excellent functional outcome with minimal complications thus proving that it is the prime modality of treatment for distal radius fractures. The procedure is applicable for AO types A, B and C fractures of the distal radius, in young patients with a good bone stock as well as in elderly osteoporotic patients.

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