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A Prospective Study on Functional Evaluation of Volar Locking Plate Fixation of Distal Radius Fractures

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Abstract

Introduction: *We report case series showing functional evaluation of volar locking plate fixation of distal radius fractures. Considering the high frequency of distal end radius fractures and scarcity of data regarding the optimal treatment, the present study was undertaken to assess functional evaluation of fractures of lower end radius treated with volar locking plate fixation followed by early mobilization of wrist joint.*

Material And Methods: *A Prospective study of 30 patients with distal radius fractures treated with open reduction and internal fixation with volar locking plates in all the patients coming at rockland hospital qutub institutional area,new delhi.*

Results: *In the present study 76.7% of the patients were males and 23.3% of the patients were females. The male to female ratio was 3.3:1. Mean age of the study population was 46.20 ± 14.63. In the present study 40% of patients presented with right sided distal radius fractures and 60% of patients presented with left sided distal radius fractures In the present study majority of the patients that is 53% reported mode of injury as road traffic accident 47% reported mode of fall on outstretched hand. In present study 40% of patients presented with frykman's grade III, 20 % of patients presented with grade I, 16.67% of patients presented with grade I and 13.33% with grade VII. In the Present study clinical union was noted among 70% of the patients at second follow up. In the study radiological union was noted among 60% of patients at second follow up and in the remaining 40% of patients radiological union was seen during third follow up. In the study during the third follow up most of the patients had QUICK DASH score of ≤ 25(67%). The mean average score was 19.00 ± 10.147.*

In the present study the functional outcome based on quick dash score was excellent in 67% of the patients and while good outcomes were noted among 33% of patients.

Conclusion: *It is concluded that the internal fixation with volar locking plate is the good option for the fixation having excellent functional results.*

Keywords: *Distal radius fracture ,volar locking plate, Functional results.*

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I. Introduction

Distal radius fracture is the most common orthopedic injury with a bimodal distribution have an approximate incidence of 1:10,000 people and represent 17% are of skeletal and 74% of forearm fractures.

Even though these fractures are so common, significant controversy exists concerning the best method of treatment. Over the last two decades, there has been a significant rise in the interest level and understanding of the importance of treatment of distal radius fracture's.

Multiple complications like stiffness, cut-out, breakout, malunion, peripheral nerve palsy, trigger digit, tendon rupture, infection and carpal-tunnel syndrome also reported.

Recent advances in implants and techniques, such as locked plates, have changes the orthopedic treatment of these fractures. However, controversy still exists regarding the complications associated with current implants and fracture patterns that are not amenable to those surgical techniques.

The development of locking plates allows fixation of fractures with any direction of displacement through a volar approach, and the implant is placed on the tension side of the fracture.

There are several theoretical advantages to approaching and fixing the radius through a volar approach; 1) more space is available, the flexor tendons are farther from the bone and pronator quadratus is interposed. 2) The volar cortex is typically less comminuted than the dorsal cortex, which makes reduction of the fracture easier. 3) Volar scars are better tolerated as they are less obvious and the blood supply to the radius is less likely to be disturbed. 4) Potential earlier return to self-care, work and sport 5) Diminished frequency and duration of formal occupational therapy, 6) potentially less overall pain, 7) Decreased risk of displacement, 8) potential cost savings secondary to a diminished need for radiographs.

Various treatment options are available for fracture distal end of radius ranging from plaster cast immobilization, use of intrafocal, extrafocal or intramedullary percutaneous Kirschner wires, dorsal and volar locking plates and external fixation.[3]

II. Material And Method

The study was conducted on 30 patients who underwent open reduction internal fixation using volar locking plate at rockland hospital, New Delhi after obtaining informed consent from study subject.

Study design: It was an interventional prospective study. The sample size was calculated using data from previous studies.

Study location: Department of Orthopedics surgery, Rockland Hospital, Qutab institutionl area , New Delhi - 110016, INDIA.

Study duration: The study was done for a period of 2 years between March 2016 to March 2018.

Sample size: 30 patients

INCLUSION CRITERIA:

1. Patients with distal radius fractures classified as Frykman group 1,3,5,7
2. Patients aged > 18 yrs

EXCLUSION CRITERIA:

1. Patients with Compound fractures
2. Patients with associated injuries in the same forearm.

III. Methodology

Pre-Operative Evaluation:

The patients will be admitted and evaluated thoroughly thereafter, using clinical history and examination as well as investigations.

The history will comprise patient details like age, sex, occupation, education. The onset and duration of symptoms will be elicited, as also the mode of trauma and the patient's description of the mechanism of injury.

Clinical examination will proceed from general to regional. Any abnormal finding apart from proximal humerus fracture will be documented.

1. Systemic examination
2. Local examination

- Limb Involved: Right or left

Inspection:

- Condition of skin.
- Swelling.
- Deformity of shoulder.
- Any other relevant finding on inspection.

Palpation:

- Tenderness
- Crepitus
- Circulatory status
- Neurological defecit

Radiography will include standard anteroposterior view of wrist CT scan will be done if X-Rays are inconclusive.

Diagnosis: Clinical and Radiological.

All the patients were subjected to clinical examination. Radiographic evaluation of the affected & the normal side was done at the time of injury with the anterio-posterior and lateral views. The radiographs were assessed in terms of loss of palmar tilt or presence of dorsal tilt, radial shortening and loss of radial inclination. Fractures were classified as according to the AO Classification into type A (extra-articular), type B (partial articular) or type C (complete articular). After pre-anaesthetic evaluation patients were taken up for surgery.

PROCEDURE:
All cases are treated with a volar locking compression plate using a volar Modified Henry's approach.
INSTRUMENTS AND IMPLANT'S USED :

- Locking compression plates of varying length
- 3.5mm LCP drill bit and sleeve system
- Power drill
- Tap for 3.5mm cortical screws and 3.5mm depth gauge
- Hexagonal screw driver for 3.5mm cortical screws and locking screw driver
- General instruments like retractors, periosteal elevators, reduction clamps, bone levers etc.
- Esmarch bandage.

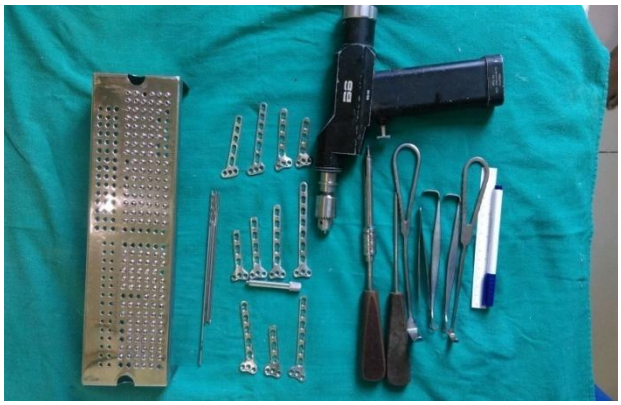
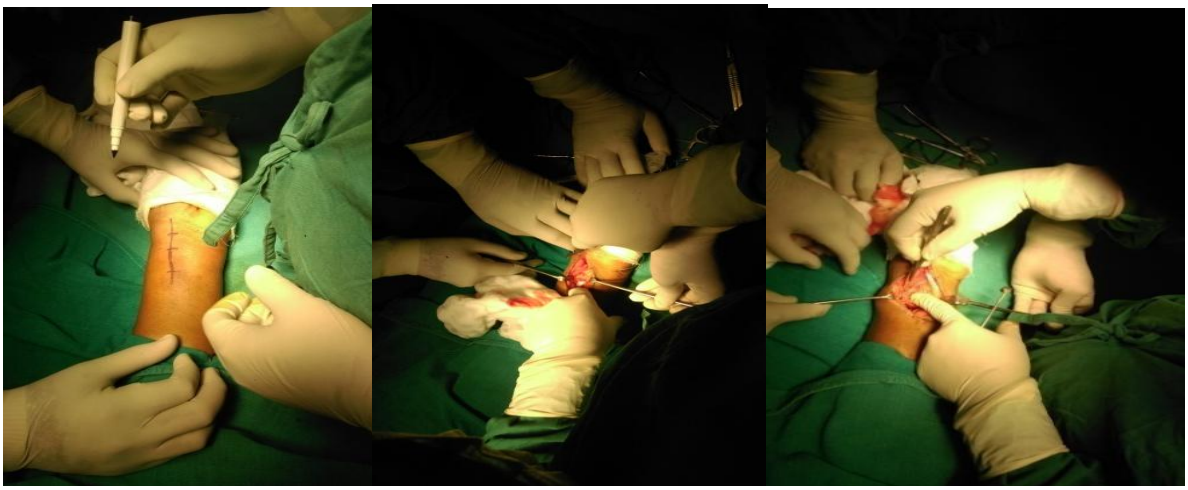


Fig. 1. Instrumentation required for LCP application

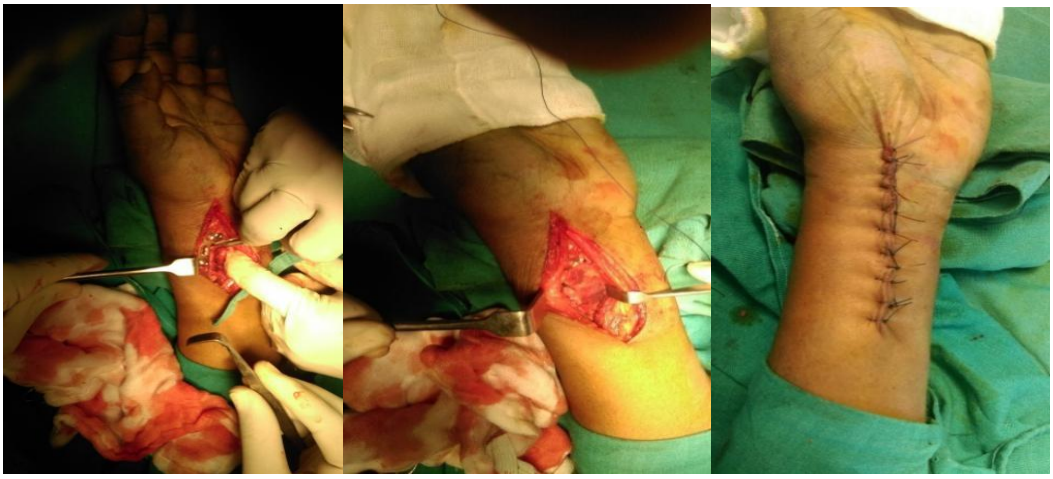
Technique:

The incision for volar fixation of the distal radius is typically performed through the distal extent of the modified Henry's approach. An incision is made between the flexor carpi radialis (FCR) tendon and the radial artery. This interval is developed, revealing the flexor pollicis longus (FPL) muscle at the proximal extent of the wound and the pronator quadratus muscle more distally. The radial artery is carefully retracted radially, while the tendons of the flexor carpi radialis (FCR) radially and flexor pollicis longus (FPL) ulnar side.

A B C



D E F



A) Skin incision site ,
B) Plain between FCR and radial artery,
C) Fracture reduction ,
D) Post reduction plate fixation ,
E) pronator quadratus re sutured
F) skin closure

The pronator quadratus is divided at its most radial aspect, leaving a small cuff of muscle for later reattachment. Any elevation of the muscle of the FPL should be performed at its most radial aspect, as it receives its innervation from the anterior interosseous nerve on its ulnar side. After the pronator quadratus has been divided and elevated, the fracture is readily visualized, and reduction maneuvers can be accomplished under direct vision.

After exposure and debridement of the fracture site, the fracture is reduced and provisionally fixed under fluoroscopy with K-wires, reduction forceps or suture fixation. Reduction aids should be placed so as not to interfere with placement of the plate. The appropriate plate is selected following fracture reduction. First a standard cortical screw was applied to the most distal oval hole of the vertical limb of the plate in order to temporarily secure the plate to the proximal fragment. This allowed concomitant proximal and distal plate adjustment. After fixing the distal fragment with subchondral locking screws, radial length was gained, when necessary, by pushing the plate distally. The first, standard screw can be either left in situ or exchanged with another locking screw. The oval hole is a combination hole designed for locking head screw placement at the distal end and standard screw placement at the proximal end of the same hole.

The optimal placement of the distal screws is important. They must be inserted at the radial styloid, beneath the lunate facet, and near the sigmoid notch. The distal screws can be of either monocortical or bicortical engagement. More volar tilt can be achieved during distal screw placement when the wrist is volarly flexed as much as possible by an assistant. Moreover, radial length can be further improved by pushing the whole plating system distally while using the oval plate hole and screw as a glide.

The final position of the plate was confirmed using fluoroscopy.

Pronator quadratus muscle was used at the time of closure, to cover, in part, the implants that were applied to the anterior surface of the radius.

Once stable fixation was achieved and hemostasis secured, the wound was closed in layers and sterile compression dressing was applied. The tourniquet was removed and capillary refilling was checked in the fingers. The operated limb was supported with an elbow sling pouch.

Post-operative care, Follow up:

Follow-up of patients was done at six weeks, three months and six months following the surgery.

Assessment:

For all subjects, radiographs were performed at the end of six weeks, three months and six months follow-up. Patients were evaluated based on the following parameters at the time of discharge and all the three follow ups;

Range of motion

- Wrist - Flexion, extension, supination, pronation, ulnar deviation and radial deviation
- Elbow - Flexion, extension, supination and pronation.

Final outcome was evaluated by QUICK DASH evaluation questionnaire.
QUICK DASH evaluation questionnaire: The *QuickD*ASH consists of 11 items to measure physical function and symptoms in Upper limb musculoskeletal disorders.

No	Items	Scoring
1	Opening of jar	1 2 3 4 5
2	Pain intensity	1 2 3 4 5
3	Tingling intensity	1 2 3 4 5
4	Sleeping	1 2 3 4 5
5	Social activities	1 2 3 4 5
6	Washing once back	1 2 3 4 5
7	Forceful recreation	1 2 3 4 5
8	Heavy chores	1 2 3 4 5
9	Carry a bag	1 2 3 4 5
10	Use a knife	1 2 3 4 5
11	Limited in work	1 2 3 4 5

Each item has five response options1 = no difficulty 2 = mild difficulty
3= moderate difficulty, 4 = severe difficulty , 5 = unable to perform
From the item scores, a summative score is calculated. The final score ranges between 0 (no disability) and 100 (the greatest possible disability). Only one missing item can be tolerated and if two or more items are missing, the score cannot be calculated.[72] Based on the QuickDASH score the functional outcome among patients was graded as below.

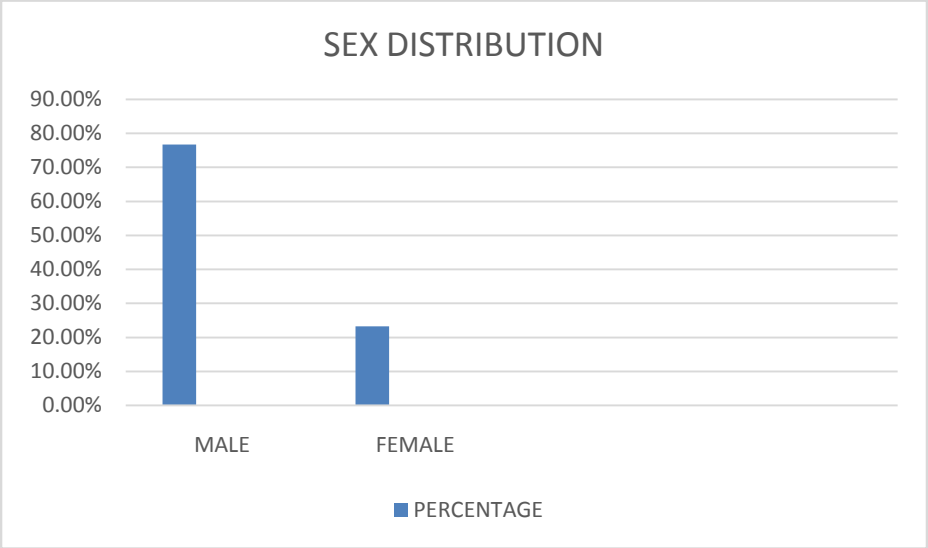
- Excellent outcome Score between 0 to 25
- Good outcome Score between 25.1 to 50.0

IV. Observation And Result

This prospective study was conducted in the Department of Orthopaedics, Rockland Hospital, B – 33 – 34, Qutub Institutional Area, Tara Crescent Road, New Delhi – 110 016. From March 2016 to March 2018. A total of 30 cases who sustained fractures of lower end of radius were included in the study.
The data was analysed and the observations were tabulated as below.

Table1 . Sex distribution

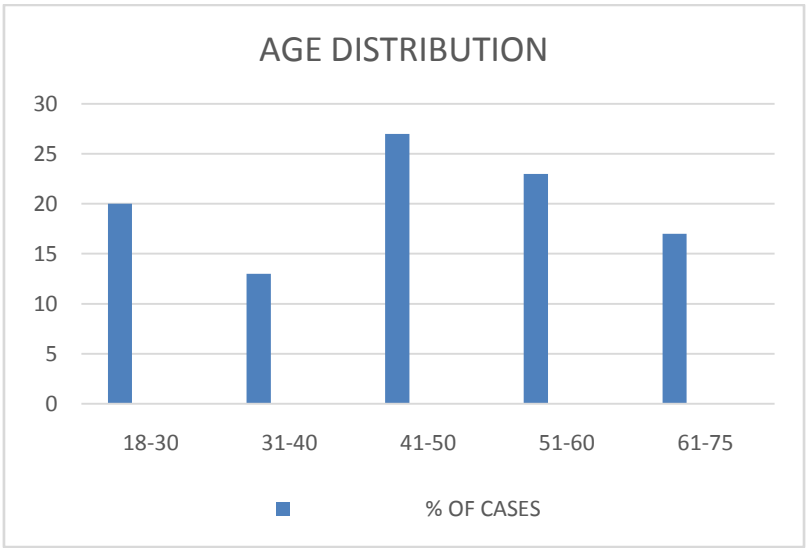
Sex	Number of cases	Percentage
Male	**23**	**76.07**
Female	**07**	**23.03**
Total	**30**	**100.00**



In the present study 76.7% of the patients were males and 23.3% of the patients were females. The male to female ratio was 3.3:1

Table 2. Age distribution

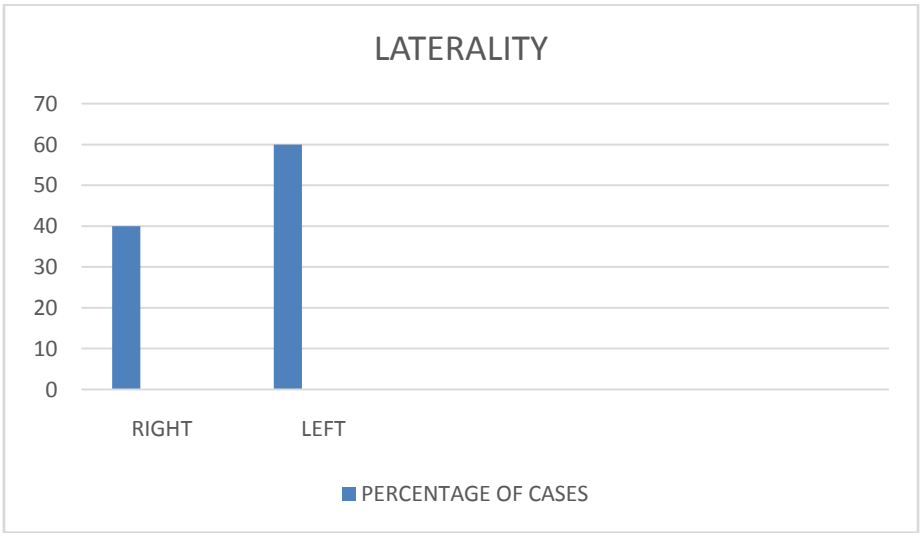
Age group (years)	Number of cases	Percentage
18 to 30	6	20.00
31 to 40	4	13.00
41 to 50	8	27.00
51 to 60	7	23.00
61 to 75	5	17.00
Total	30	100.00



Mean age of the study population was 46.20 ± 14.63

Table3 . Laterality

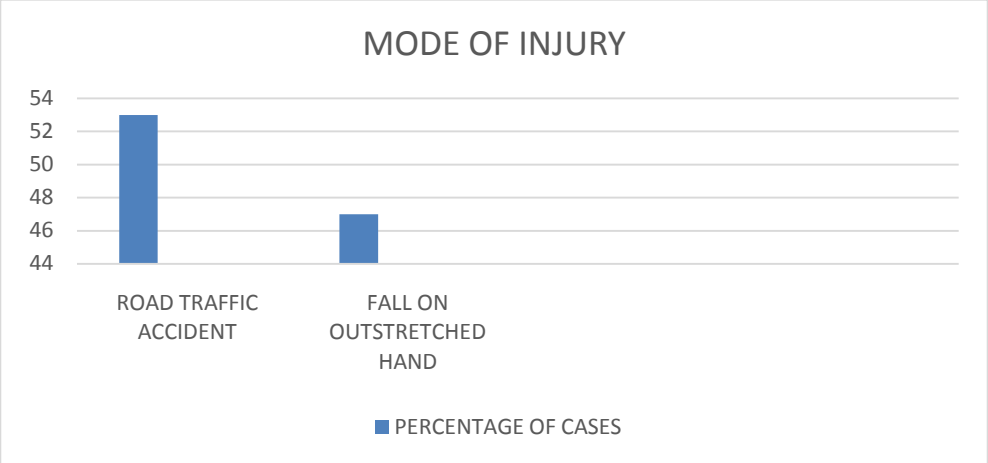
Side	Number of cases	Percentage
Right	12	40.00
Left	18	60.00
Total	30	100.00



In the present study 40% of patients presented with right sided distal radius fractures and 60% of patients presented with left sided distal radius fractures.

Table4 . Mode of injury

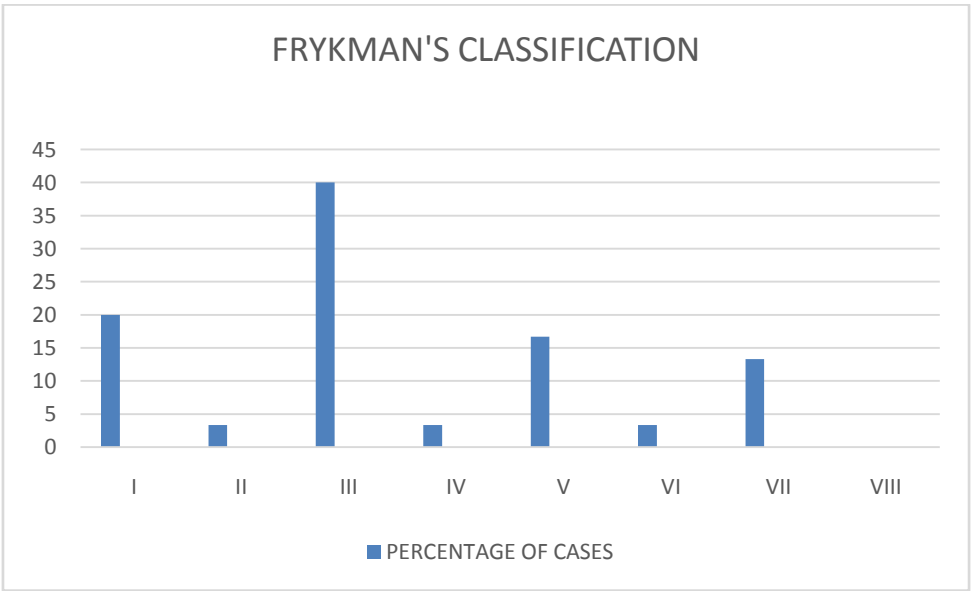
Side	Number of cases	Percentage
Road traffic accident	16	53.00
Fall on out stretched hand	14	47.00
Total	30	100.00



In the present study majority of the patients that is 53% reported mode of injury as road traffic accident 47% reported mode of fall on outstretched hand

Table 5.Frykman's Classification

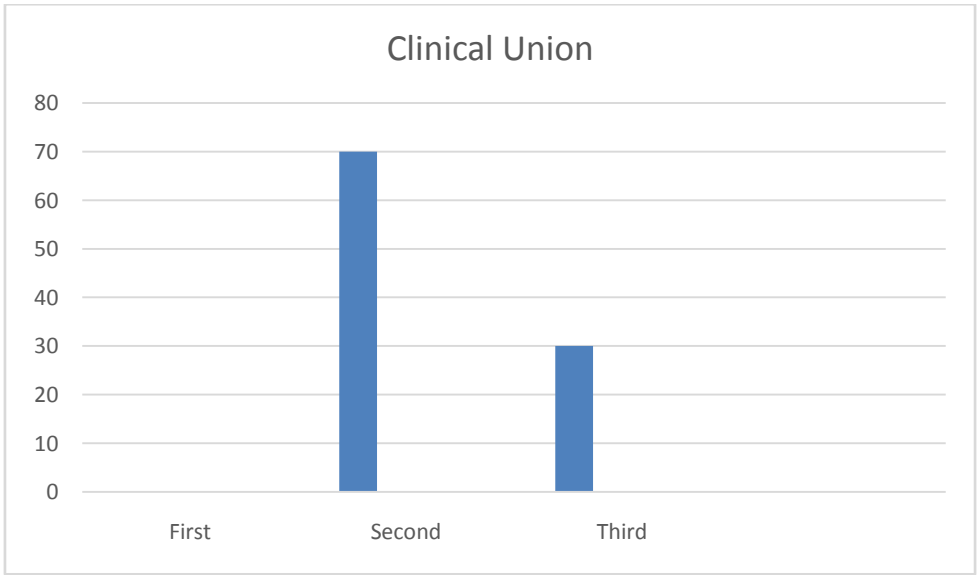
Classification	Number of cases	Percentage
I	06	20.00
II	1	3.33
III	12	40.00
IV	1	3.33
V	5	16.67
VI	1	3.33
VII	4	13.33
VIII	0	0.00
Total	30	100.00



In present study 40% of patients presented with frykman's grade III, 20 % of patients presented with grade I, 16.67% of patients presented with grade I and 13.33% with grade VII.

Table6 . Clinical Union

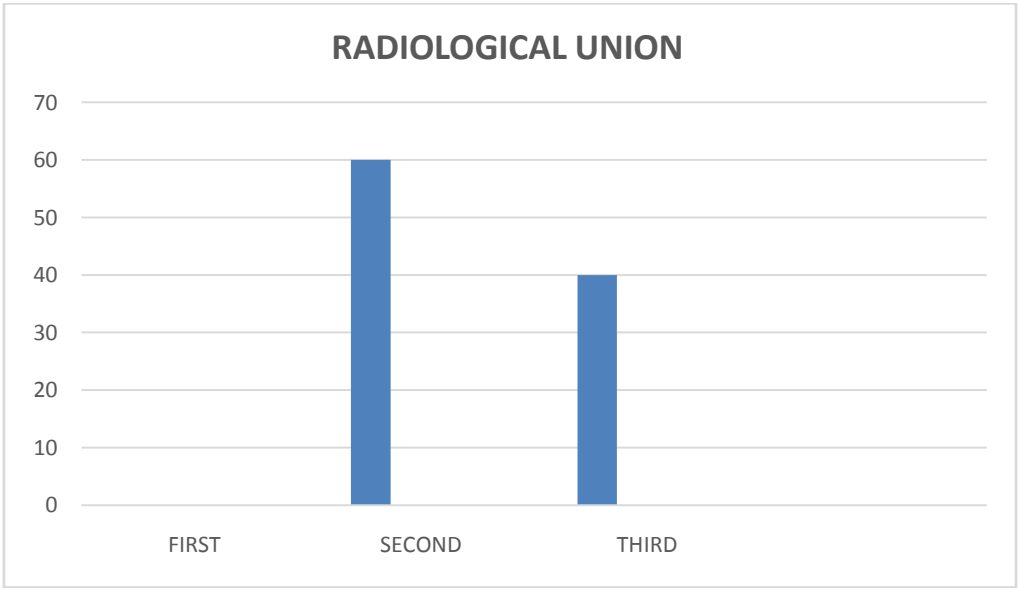
Follow up	Number of cases	Percentage
First	0	0.00
Second	21	70.00
Third	09	30.00
Total	30	100.00



In the Present study clinical union was noted among 70% of the patients at second follow up.

Table 7 .Radiological Union

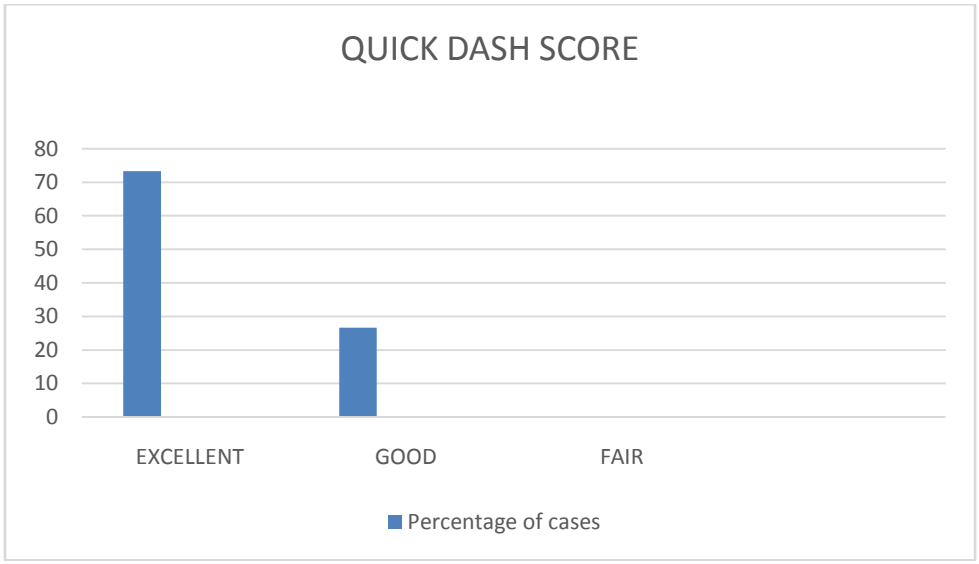
Follow up	Number of cases	Percentage
First	0	0.00
Second	18	60.00
Third	12	40.00
Total	30	100.00



In the study radiological union was noted among 60% of patients at second follow up and in the remaining 40% of patients radiological union was seen during third follow up.

Table 8 .QUICK DASH score

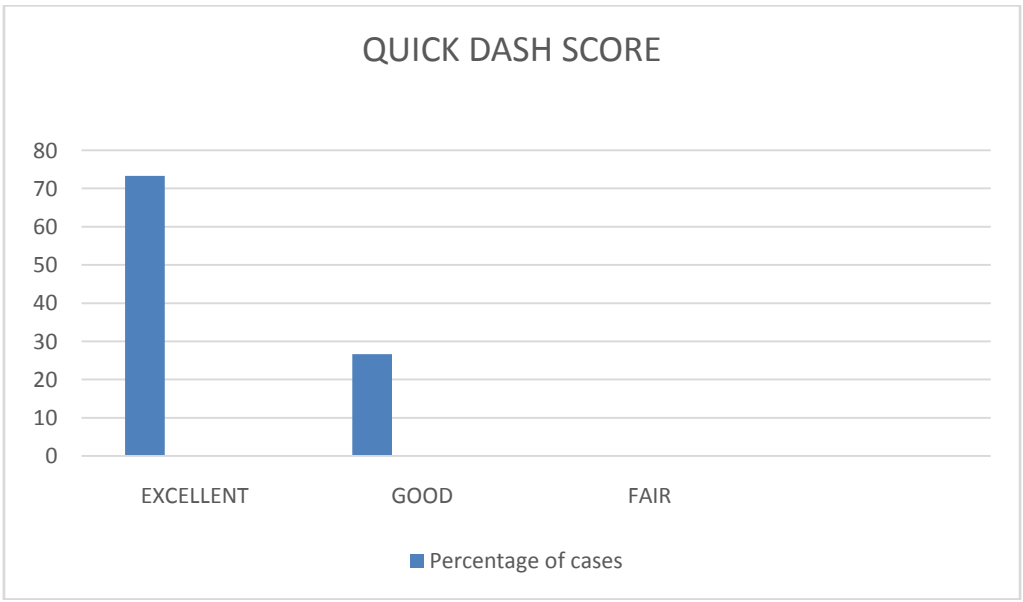
Score	Number of cases	Percentage
≤ 25	20	67.0
26 to 50	10	33.0
51 to 75	-	-
Total	30	100.00



In the study during the third follow up most of the patients had QUICK DASH score of ≤ 25(67%). The mean average score was 19.00 ± 10.147.

Table 9.Final Outcome

Outcome	Number of cases	Percentage
Excellent	20	67.0
Good	10	33.0
Fair	-	-
Total	30	100.00



In the present study the functional outcome based on quick dash score was excellent in 67% of the patients and while good outcomes were noted among 33% of patients

V. Discussion

An anatomical reduction of the articular surface with a stable fixation is the main goal in the treatment of intraarticular distal radius fractures. Improper reduction or residual intraarticular incongruity leads to secondary arthritis and poor functional outcome in the long term .Various treatment modalities have been described for distal radius fracture fixation[3-9] .

Plating allows direct visualization of fracture fragments and restoration of the anatomy, decreased morbidity by allowing early mobilization, and early return of wrist function. Locking plates address intra-articular and metaphyseal comminution and are very helpful in osteoporotic fractures preventing late collapse of fracture fragments.

Biochemical studies comparing volar fixed angle locking plates with that of conventional dorsal plates report volar fixed angled plates to be superior in terms of their strength. Dorsal plating of distal radius has not gained popularity due the fact that, inspite of dorsal plating, the volar collapse of fracture occurred.

Keeping in mind the various possible advantages of volor locking plate a prospective study was conducted at Rockland Hospital, on distal radiusfractures by using volar locking plate.

The study has been conducted from March 2016 to March 2018 at Rockland hospitals, New Delhi with approval of ethical committee. A total of 30 patients who sustained fractures of lower end of radius came to the orthopedic emergency at Rockland hospitals, New Delhi from March 2016 to March 2018 were studied.

Age distribution:

The average age in present series of 30 patients analyzed was 46.2 years which was consistent with the age incidence in studies done by Kilic A et al ,But Yukichi zenkeet al, TamaraD et al, Lorano Calderonsa et al and ChengKC et al noted higher mean age in their series.

AGE DISTRIBUTION

Series	Mean average age in years
Yukichi zenke et al[73]	63.5years
Tamara D et al[74]	51years
Lozano-Calderon sa, et al[75]	51 years
Kilic A et al[76]	45 years
Chung KC et al[77]	48.9 years
Present study	46.2 years

Chart no 1

Sex distribution:

In our study there is male predominance in the incidence of distal radius fractures of male 23(76.7%) and female 7(23.3%) male to female ratio 3.3 : 1, this can be attributed to the working group of population in which males are predominant working group

Most of literature reported female predominance[7,9,62] but Kilic A et al[59] who reported male predominance and Egol et al[38] reported equal incidence of male and female.

SEX DISTRIBUTION

Series	Males %	Females %
Yukichi zenke et al[73]	25	75
Marco Rizzo. Brain A. Katt. Joshua T[79]	39	61
Tamara D et al[74]	30	70
K Egol et al	50	50
Present study	23	7

Involved side:

In our study left sided fractures were more when compared to right side 60% and 40% respectively, The left predominance in our study suggests non availability of dominant hand as protection during the RTA. Similar reported by Rohit Arora et al and Yukichi et al . Tamara D et al reported a predominance of right sided fractures.

INVOLVED SIDE

Series	Right n = patients	Left n = patients
Rohit Arora et al[81]	15	21
Tamara D et al[74]	18	5
Yukichi Zenke et al[73]	31	35
Present study	18	12

Mode of injury:

The mode of injury in our series was road traffic accident and the second most common is fall on out stretched hand and majority of them occurred in work place akin to male preponderance, this also can be attributed to the work group i.e. males when compared to females who reside at work for domestic reasons.

Fracture type:

In present study has classified fractures with respect to frykman classification the predominant types of fractures involved were type III ,type I , type V, type VII in the incidence 40%,20%,16.67%,13.33% respectively.

Complications:

In present study there was no any major complications ,only two patients developed stiffness of wrist but improved by physical therapy.

In various studies several complication noted as CTS, tendon rupture, infection ,trigger digit [.50-55]

Series	% of complications
Yukichi Zenke et al[73]	3%
RohitArora et al[81]	36%
Satake Hiroshi et al	7.5%
Phadnis J et al	15%
Present study	6.67%

Reduction achieved:

In our study the average radial inclination preoperatively was 7.77±5.84 degrees, the average postoperative radial inclination was 18.40±3.30 degrees.The average radial inclination achieved was 10.63±2.54 degrees.

K. Egol et al reported a pre reduction radial inclination of 14.6±8degrees and 13.8±7.9degrees in external fixation and volar plate fixation groups respectively, they reported a postoperative reduction of values of 18.8±6.5degrees in external fixation group and 17.1±4.7 degrees in plating group postoperatively these results are similar to our study.

Yukichi Zenke et al reported the mean radial inclination angle was 26±3.1degrees and 25.9±3degrees immediately after surgery at the final follow up in mipo group and conservative group respectively.

Tamara D et al reported an immediate postoperative radial inclination was 22±3degrees in the orif group and 21±3degrees in the crpp group.

Marco Rizzo. Brain A. Katt. Joshua T reported a postoperative radial inclination of 23degrees with volar plate and 21degrees with external fixator group with no significant P value.

RADIAL INCLINATION

Series	Mean average radial inclination
K. Egol et al[80]	17.1±4.7 degrees
Yukichi Zenke et al[73]	25.9±3degrees
Tamara D et al[74]	22±3degrees
Marco Rizzo. Brain A. Katt. Joshua T others[79]	23degrees
Present study	18.40±3.30 degrees

In our study preoperative mean radial length 3.0±3.051mm was observed preoperatively with an immediate postoperative radial length of 9.17±1.84mm , we achieved a mean correction of 6.17±1.21mm during the surgical procedure.

K . Egol et al reported a mean radial length of 7±4.2mm pre reduction value in external fixation group, 6.9±4.2mm in volar plating group preoperatively they achieved a radial length of 9.5±3.5mm in external fixation group and 9.3±3mm in volar plating group they showed no statistical significance in achieving radial length.

Yukichi Zenke et al described ulnar variance instead of radial length for both preoperative and postoperatively for both conventional group and mipo group.

Tamara D et al reported an immediate postoperative reduction of radial height to 11±2mm in orif group as well as crpp group and their results did not change throughout the follow up.

Marco Rizzo. Brain A. Katt . Joshua T et al reported an immediate postoperative radial height of 11mm in volar plate group and 10mm in external fixation/pinning group.

RADIAL LENGTH

Series	Mean radial length(mm)
K . Egol et al[80]	9.3±3mm
Tamara D et al[74]	11±2mm
Marco Rizzo . Brain A. Katt . Joshua T others[79]	11mm
Present study	9.17±1.84mm

Range of motion:

The mean range of motion achieved in our study was as follows palmar flexion of 77.33±3.144degrees, dorsiflexion of 72.67±4.097degrees, radial deviation of 19.00±4.983degrees, ulnar deviation of 34.17±5.584degrees, supination of 75.00±4.355degrees, pronation of 69.53±6.044degrees. these results were taken at 6months postoperatively and were compared with the normal side.

K . Egol et al reported a palmar flexion of 80±17.8degrees,extension of 81±12.1degrees, radial deviation of 73±8.1degrees, ulnar deviation of 70±5.8degrees, supination of 85±12.8degrees, and pronation of 95±14.6degrees at 6 months interval they required 34.2±16.7 physiotherapy sessions to attain range of motion described at 6months.

We did not used that much number of physiotherapy sessions.we used one physiotherapy session for 2 weeks and advised patients practice at home.

Yukichi Zenke et al at the end of their study reported only flexion and extension and pronation and supination in both conventional groups 86.0±6.7degrees,68.3±5.6degrees,88.8±3.4degrees,88.2±5.7degrees respectively and in mipo groups 86.5±6.7degrees, 67.2±6.7degrees, 88.9±3.2degrees, 88.6±4.3degrees respectively.

Tamara D et al reported the range of motion at 12 weeks as flexion 58±13degrees,extension 58±14degrees, radial deviation 22±9degrees,ulnar deviation 35±6degrees,supination 84±13degrees&pronation 85±11degrees and showed a significant P value these values approximate our values at 6months duration post operatively.

Marco Rizzo. Brain A. Katt . Joshua T others flexion of 64^0,extension of 69^0,radial deviation of 23^0, ulnar deviation of 34^0,pronation of 78^0 and supination of 76^0at their final follow up these values approximate our values at 6 months duration post operatively.

RANGE OF MOTION

Series	Pf(deg)	Df(deg)	Rd(deg)	Ud(deg)	Sup(deg)	Pro(deg)
K . Egol et al[90]	80±17.8	81±12.1	73±8.1	70±5.8	85±12.8	95±14.6
Yukichi Zenke et al[83]	86.0±6.7	68.3±5.6			88.2±5.7	88.8±3.4
Tamara D et al[84]	58±13	58±14	22±9	35±6	84±13	85±11
Marco Rizzo.et al.,[89]	64	69	23	34	76	78
Present study	77.33±3.144degrees	72.67±4.097degrees	19.00±4.983degrees	34.17±5.584degrees	75.00±4.355degrees	69.53±6.044degrees

Each patient Quick DASH score were taken at 6weeks,3months& 6months interval along with range of motion.

Phadnis J et al in 2011 reported 74% of the patients with good or excellent DASH and MAYO score. K .Egol et al showed a mean DASH score of at 6months was higher in external fixator group compare to volar locking plate . Yukichi Zenke et al evaluated DASH scores 5.6±6.3 in the conventional group and 4.2±6.8 in the mipo group at 12 weeks.Tamara D et al recorded a DASH score is lower in ORIF group compare with CRPP group.

In present study Quick DASH score at 6months follow up is 19.00±10.15.

SCORE

Series	Score
K .Egol et al[80]	25.0±21.7
Yukichi Zenke et al[73]	5.6±6.3
Tamara D et al[74]	11±13
Present study	19.00±10.15

VI. Conclusion

- A total of 30 patients underwent open reduction internal fixation using volar locking plate.
- The mean age in the present study was 46.20 years with a male prepondernace patients.
- In present study ,the predominant Frykman's type of fracture involved were type 3,type 1, type 5 , type7 in the incidence 40%, 20 %,16.67%, 13.33% respectively.
- Left sided fractures (60%)were more when compaired to right side(40%).
- The most common mode of trauma was observed to be road traffic accident .
- Volar modified Henry's approach was used in all of the cases.
- None of the patients developed any significant immediate post-opertive complications only two patients developed joint stiffness.
- Most of the fractures were anatomically aligned .
- All the fractures in the present study united radiologically in an average time of 12.32 weeks.

- Patients did not suffer any limitation in perfomring day to day activities postoperatively after complete recovery.
- Majority of the patients in the present study achieved excellent(72%) to good(28%) Quick DASH score.

Recommendation

1. Volar locking plate is a safe and effective option for the treatment of distal radius fracture has excellent functional outcome with minimal complications.
2. Adequate surgical skills and surgeon's experience with surgical technique are necessary to achieve correct implant fixation and avoid these intraoperative errors.
3. The limitation of our study was a smaller sample size and short term follow up 6 months. We suggest a large sample size and longer follow up period will further validate the result obtained here in.

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