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Dr. Umesh Nagrale
DNB ortho. Senior resident. Department of Orthopaedics, GMC Chandrapur, Maharashtra, India

Dr. Sagar Kadam
DNB Ortho. Senior resident in Government multispeciality hospital Chandigarh, India

Dr. Ravi Bhanushali
DNB Ortho. Senior resident. Bhabha municipal general hospital, Bandra west, Mumbai, Maharashtra, India

Dr Prasannaditya mujumdar
DNB Ortho. Senior resident. Bhabha municipal general hospital, Bandra west, Mumbai, Maharashtra, India

Dr. Avik Sarkar
DNB Ortho. Senior resident. Bhabha municipal general hospital, Bandra west, Mumbai, Maharashtra, India

Dr. Irphan Shaikh
Dnb Ortho. Senior resident. Hinduja hospital, Mumbai, Maharashtra, India

Correspondence
Dr. Sagar Kadam
DNB Ortho. Senior resident in Government multispeciality hospital Chandigarh, India

Outcome of fracture distal radius treated with open reduction internal fixation with volar locking compression plate (A study of 50 cases)

Dr. Umesh Nagrale, Dr. Sagar Kadam, Dr Ravi Bhanushali, Dr. Prasannaditya Mujumdar, Dr. Avik Sarkar and Dr. Irphan Shaikh

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Abstract
Introduction: Fractures of the distal radius constitute one of the most common skeletal injuries treated by Orthopaedic surgeons. These injuries account for one sixth of all fractures and represent 17% of all the fractures evaluated in emergency room. The use of strong implant in the form of Fixed Angle Volar Locking Compression Plate theoretically achieves, maintain the reduction and stability in displaced intra-articular & extra-articular distal radius fractures in both the economically productive young age group as well as in the osteoporotic elderly population with less bone stock.Hence, we have decided to study the results of management of distal radius fractures with the open reduction and internal fixation with Volar locking compression plates.
Aim: To study the results of operative management of distal radius fractures in terms of functional and radiological outcome, with open reduction and internal fixation with Volar locking compression plates.
Materials and Methods: This was a prospective study, where Fifty adult patients with distal radial fractures, treated with a volar locking compression plate using a Modified volar Henry approach(i.e flexor carpi radialis FCR approach), were included in this study. The fracture fragments were analyzed and involvement of radiocarpal and distal radioulnar joints were assessed and classified according to the Frykman's and AO classification. First follow up of patients was done between tenth to fifteenth post-operative days Subsequent follow ups were done for three months at monthly interval.At each follow up clinical and radiological assessment was done using different parameters.Final assessment of the outcome was done after three months, by MAYO WRIST scoring system.
Results and Discussion: In our series, we had 90% excellent, 6% good, 2%, fair and 2% poor result. Patients, who obtained excellent results, had no residual deformities or pain. Range of motion was within the normal functional range. Two patients (4%) had arthritic changes but no other complications. They were operated within 6 days after injury. Radial length, volar tilt and articular step-off were within acceptable limits. They were co-operative to physiotherapy. The results obtained in our series are comparable to other studies undertaken similarly.
Conclusion: Use of locked compression plates in distal radius fractures provided good to excellent results with correction and maintenance of distal radius anatomy. By using these plates, joint motions and daily functioning were recovered in a shorter time.

Keywords: Outcome, fracture distal radius treated, volar locking compression plate

1. Introduction
Fractures of the distal radius constitute one of the most common skeletal injuries treated by Orthopaedic surgeons. These injuries account for one sixth of all fractures and represent 17% of all the fractures evaluated in emergency room [3]. The incidence of these fractures appears to be both age and gender specific. There are three peaks of fracture distribution: Children aged 5-14 years, males under the age of 50, females over the age of 40 years [4]
These fractures represent two very different injuries:

1. An insufficiency fracture in elderly patients associated with all of the risk factors for osteoporosis and has been linked to estrogen withdrawal and reduced bone mineral density in elderly females.
2. The traumatic injury in younger males, where the injury is not as strongly related to

gender, but related to high energy injuries (21% of all fractures) rather than to simple fall [1].

The majority of the fractures in elderly are extra-articular, whereas there is much higher incidence of intra-articular fractures in younger individuals [5]. As the consensus prevails, the vast majority of the distal radius fractures are intra-articular injuries resulting in disruption of both radio-carpal and radio-ulnar joints.

The management of distal radius fractures has undergone an extraordinary evolution over the preceding two decades. Options are: Universal cast treatment, Neutralization with bridging external fixators, Percutaneous pinning with or without cast application, Dorsal buttress plating & Volar locked plating. Although some patients still seem to confirm Abraham colles' famous remarks that casted wrist "*will at some remote period again enjoy perfect freedom in all of its motions and be completely exempt from pain*" [1]

Essentially, we know that elderly patients will tolerate more displacement (and close treatments) than younger patients, but some still have poor outcomes.

Gartland & Werley have emphasized the proclivity of the disrupted articular surfaces for traumatic arthritis[8].Knirk & Jupiter have demonstrated that radio-carpal articular incongruity of as little as 2mm is prone to serious joint deterioration [7]. Fernandez, Trumble and others have reported that as little as 1mm of articular incongruity is associated with worse functional outcome [6, 9].

One constant in the recent literature is that, the specific technique is not as important as attaining anatomical reduction. Both clinical outcome and biomechanical studies demonstrated the most important factors in obtaining good result. These factors are:

- Palmar Tilt (normally- 11 to 14 degrees)
- Radius Height (normally- 10 to13 mm)
- Radius Inclination (normally- 20 to 25 degrees) &
- Ulnar Variance (normally- +/-2mm) [15]

The close treatment options are associated with high incidence of:

- Prolonged immobilization
- Joint stiffness & Deformity
- Decreased Grip strength & Endurance
- Malunion & Cosmetic problems (young patient particularly)
- Flexor tendon problems
- Articular incongruity & Arthritis
- Limited motion & Radio-carpal instability
- Sudeck's osteodystrophy
- Frozen Shoulder
- Compartment Syndrome [2]

Open Reduction and Internal Fixation is an alternative but definitively valid treatment option for displaced intra-articular and extra-articular distal radius fractures, which cannot be taken care of with close manipulation, ligamentotaxis & casting or external fixation. Restoration of the radio-carpal joint stability anatomically, radiologically and restoration of the functions clinically is the prime desire [2].

Operative treatment with internal fixation is increasingly becoming popular as it provides direct control & maintenance of the physio-anatomical parameters, prevents the collapse and spares the bridging of the wrist joint [2].

The distal radius fractures can be accessed with either volar or dorsal approach. Plating technique with volar approach is the preferred one as it avoids the extensor tendon injury as well as avoids difficult dissection and plating on irregular dorsal distal radius surface.

Two types of plate are available

- Conventional plates
- Fixed angle locking compression plates [2]

The use of strong implant in the form of Fixed Angle Volar Locking Compression Plate theoretically achieves, maintain the reduction and stability in displaced intra-articular & extra-articular distal radius fractures in both the economically productive young age group as well as in the osteoporotic elderly population with less bone stock [2]

Hence, we have decided to study the results of management of distal radius fractures with the open reduction and internal fixation with Volar locking compression plates.

Aims and Objectives

- To study the results of operative management of distal radius fractures in terms of functional and radiological outcome, with open reduction and internal fixation with Volar locking compression plates.
- To study the effectiveness and complications of distal radius fractures treated with Volar locking compression plates.
- To learn from our own experience of Volar locking compression plating in view of the available world literature for the better long term results in the future.

2. Materials and Methods

Fifty adult patients with distal radial fractures, treated between APRIL 2015 and MAY 2016 under the Department of Orthopaedics, K.B. Bhabha municipal general hospital, Mumbai were included in this study.

Study Design: A Prospective study.

Inclusion Criteria: Adults (aged over 20 years), both male and female with unstable, comminuted or intra articular fractures of distal end radius, patients with close fractures, patients with Open grade 1 & 2 fractures, patients with displaced fractures.

Exclusion Criteria: Patients aged below 18years, patients medically unfit for surgery, fractures in pregnant females, patients with pathological fractures, patients with open grade 3 fractures, patients with compound fractures associated with vascular injuries, patients not willing for surgery

Pre-Operative Evaluation

Immediate Management

Following admission to the hospital, a careful history was elicited from the patients and / or attendants to reveal the mechanism of injury and the severity of trauma. All patients were thoroughly examined. Their general condition associated systemic diseases and associated injuries were noted. All the findings were duly recorded in the patient proforma.

All patients presented with the involved elbow flexed and the wrist supported by the other hand. Careful inspection of the deformity, swelling and ecchymosis was done. Clinically tenderness, bony irregularity, crepitus and the relative position of radial and ulnar styloid process were elicited. Movements of the wrist and forearm were checked and found to be painful and limited. Distal vascularity was assessed by radial artery pulsations, capillary filling, pallor and par-aesthesia over finger tips.

The involved forearm was immobilized in an above elbow

POP slab and kept elevated. Pain and inflammation were managed using analgesics.

Radiographic Examination
Standard radiographs in PA and lateral views were taken for confirmation of the diagnosis and also to know the type of fracture. Oblique views were also taken in a few patients who had complex comminuted fractures. The fracture fragments were analyzed and involvement of radiocarpal and distal radioulnar joints were assessed and classified according to the Frykman's and AO classification.

Procedure
All cases are treated with a volar locking compression plate using a Modified volar Henry approach (i.e flexor carpi radialis FCR approach)

Instruments and Implants Used
- Locking compression plates (LCP) of varying length.
- 3.5mm LCP drill bit and sleeve system.
- Hand drill / 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.
- Pneumatic tourniquet.

Post-Operative Rehabilitation and Follow-Up
Rehabilitation was started during the fracture immobilization itself. Physical therapy was started to reduce the edema and to maintain the range of motion of the involved joints.
Post-operative pain was treated with simple analgesics such as Paracetamol 500 mg three times daily. Every patient was given splintage with volar splint for a period of three to four weeks. Postoperative xrays were done on the same day of operation. First dressing was done on third postoperative day. Patients were discharged on third to fifth post-operative day with oral antibiotic, analgesic and antacid for five days. First follow up of patients was done between tenth to fifteenth post-operative days for suture removal and sutures were removed when wound dried and healed. Volar splint was reapplied.
Subsequent follow ups were done for three months at monthly interval. At each follow up patients were taught mobilization exercises for wrist, elbow and fingers. Active and Passive range of motion exercises were demonstrated. Patients were encouraged to perform strengthening exercises.
At each follow up clinical and radiological assessment was done using different parameters.
Final assessment of the outcome was done after three months, by MAYO WRIST scoring system [16].

3. Observations and Results
The present study consists of 50 cases of distal radius fractures treated at K.B. Bhabha Municipal General Hospital, Mumbai, Maharashtra. All cases were followed up periodically during the period of April 2015 to May 2016. The following are the observations made to the available data analyzed as follows.

1. Age Incidence
In this series, 8 (16%) patients were between 21-30 years, 15 (30%) between 31-40 years, 17 (34%) between 41-50 years, 7(14%) between 51-60 years and 3 (6%) patients between 61-70 years. The age of the patients ranged from 20-70 years with an average of 42.4 years.

2. Sex Distribution
Out of 50 patients, 40 (80%) were males and 10 (20%) were females (Male: Female - 4:1).

3. Occupation

Table 1

Occupation	No. of Patients	Percentage
Professional	2	4
Sedentary Worker	1	2
Skilled Labourer	12	24
Unskilled Labourer	25	50
Housewife	10	20
Total	50	100

The above table shows that complex distal radial fractures are common in labourers due to fall from height and in vehicular accidents. 20% of the fractures were seen in Housewives. Only one injury was seen in sedentary workers.

3. Side Of Involvement

Table 2

Side	No. of Cases	Percentage
Right	35	70
Left	15	30
Total	50	100

Right side (dominant wrist) was involved in 35 (70%) patients and the left side was involved in 15 (30%) patients.

5. Mode of Injury

Table 3

Mechanism of Injury		No. of Cases	Percentage (%)
High Energy Trauma (37)	Vehicular Accident	10	20
	Fall from Height	20	40
	Assault	3	6
	Others	4	8
Low Energy Trauma (13)	Fall while walking	13	26
Total		50	100

In our study there were 37 (74%) patients with road traffic accidents and 13 (26%) patients fell on their outstretched hand.

4. Type Of Fracture According To Frykman's Classification

Table 4

Type	No. of Cases	Percentage (%)
I	10	20
II	5	10
III	15	30
IV	7	14
V	3	6
VI	0	0
VII	0	0
VIII	10	20
Total	50	100

Of the 20 cases, 10(20%) of the fractures were of Type I Frykman's classification, 5 (10%) of Type II, 15 (30%) of Type III, 7(14%) of Type IV, 3(6%) of Type V and 10(20%) of Type VIII. There were no cases of Type VI and VII fractures.

7. **Ao Classification**

Table 5

AO Type	No. of Cases	Percentage (%)
A1	0	0
A2	5	10
A3	10	20
B1	3	6
B2	10	20
B3	10	20
C1	10	20
C2	2	4
C3	0	0
Total	50	100

Of the 20 cases 5(10%) of the fractures were of AO Type A2, 10(20%) of type A3, 3(6%) of type B1, 10(20%) of type B2, 10(20%) of type B3, 10(20%) of type C1, 2(4%) of type C2. There were no cases of AO type A1 and C3 fractures.

8. Close Or Open Fracture: According To Gustilo And Anderson Classification

Table 6

Type	No. of Cases	Percentage (%)
Close	46	92
Open Type – I	4	8
Open Type – II	0	0
Open Type – III	0	0
TOTAL	50	100

Of the 50 cases, 46 (92%) of the fractures were of Close Type and 4 (8%) were Open Type, which was of Type I of Gustilo and Anderson Classification, 1(5%).

8. Extra articular and intra articular fracture

Table 7

TYPE	No of Cases	Percentage (%)
Extra articular Fractures	15	30
Intra articular Fractures	35	70
Total	50	100

Of the 50 cases, 15(30%) of the fractures were of Extra articular Type and 35 (70%) were Intra articular fractures.

10. Associated Injuries

Table 8

Associated Injuries	No. of Cases	Percentage (%)
Ipsilateral fracture shaft of femur	3	6
Contusional head injury	4	8
Ipsilateral lower third ulna fracture	2	4
Fracture Dislocation elbow	1	2
Fracture Trochanter	2	4
Fracture Shaft Humerus	1	2
Total	13	26

Out of 50 cases, 13 (26%) patients had associated injuries.

11. Surgical Lag Time

Table 9

Surgical Lag Time	No. of Cases	Percentage (%)
1-5 days	45	90
6-10 days	5	10
Total	50	100

Surgery was done between 1-5 days in 45 (90%) patients as an elective procedure. Surgery was delayed upto the 6th day in 5(10%) patients because they were not fit for surgery and operated after they became fit for surgery.

12. Duration of Fracture Union (Radiological)

Table 10

Time of Union (Radiological)	No. of Cases	Percentage (%)
2-3 months	40	80
3-4 months	8	16
>4 months	2	4
Total	50	100

In the present study 40 (80%) patients had union within 2-3 months and 8(15%) patients had union in 3-4 months. There were 2(4%) cases of delayed union.

13. Method of Fixation

Table 11

Time of Union	No. of Cases	Percentage
Volar Plate alone	47	94
Volar plate with CC screw/K-wire fixation of radial styloid	03	6
Total	50	100

In 3 cases of the fractures fixed with volar plate, CC Screw/ K-WIRE was used to augment the fixation of the radial styloid by percutaneous technique.

- **There were no immediate post-operative complications in our series.**
- All patients were mobilized with intermittent use of a fabricated volar splint except two. One patient had an ipsilateral fracture dislocation elbow which was immobilized with an above elbow POP cast, one had an ipsilateral fracture shaft humerus who was given High AE POP Cast and one had ipsilateral fracture ulna who was given AE POP slab.

14. Duration of Splintage

Table 12

Duration of Splintage	No. of Cases	Percentage%
3-4 Weeks	44	88
5-6 weeks	5	10
>6 Weeks	1	2
Total	50	100

The minimum period for which the fracture was splinted in this series was 3 weeks and maximum period was 7 weeks. Only one patient with ipsilateral shaft humerus fracture was

immobilized for 7 weeks. The fabricated volar splint was used intermittently during the day time with the alternate sessions of physiotherapy and was worn during the night as night splint. This devotes stability to the rigid inter-fragmentary fixation which allows early mobilization of the affected extremity.

15. Complications

Table 13

Complications	No. of Cases	Percentage%
Extensor pollicis longus tendon irritation	1	2
Arthritis	2	4
Malunion	1	2
Total	4	8

1 (2%) patient had extensor pollicis longus tendon irritation because of long volar to dorsal screw. 2 (4%) patients developed arthritis of the wrist joint due to improper reduction and articular step. 1(2%) patient had malunion, this might be because of the extensive communition distal end of radius and improper reduction.

16. Duration of Follow Up

Duration	No. of Cases	Percentage%
0-6 months	20	40
6 months - 1 yr.	25	50
l--1 ½ yr.	5	10
Total	50	100

Minimum duration of follow up was 6 months and maximum was 12 months. Mean follow up duration was 9 months.

17. Follow-up

a) Pain

Severity	No. of cases	Operative Percentage%
None	47	94
Mild	2	4
Moderate	1	2
Marked	0	0
Disabled	0	0
Total	50	100

Most of our patients had no pain at the follow-up. This could be due to accurate reduction, soft tissue care especially of flexor tendons and attention to implants especially the screw size.

b) Residual Deformity

	No. of Patients	Percentage%
Residual Deformity	2	4
No Residual Deformity	48	96
Total	50	100

Two of our patients had residual deformity at follow-up. This could be because of extensive comminution at fracture site.

c) Operative wound status

	No. of Patients	Percentage%
Healed	50	100
Puckered	0	0
Total	50	100

None of our patients had puckered scar at the incision site at follow-up. This denotes the meticulous dissection at the time of surgery. All wounds healed primarily and there was no infection in any patient.

18. Wrist Movement

(a) Flexion

Dorsiflexion	No. of Cases	Percentage%
>70°	36	72
50°-70°	12	24
<50°	2	4
Total	50	100
Palmar flexion	**No. of Cases**	**Percentage%**
>60°	46	92
40°-60°	04	8
<40°	00	0
Total	50	100

98% of the total number of patients at final follow up had an excellent range of dorsiflexion as well as palmar flexion. The mean dorsiflexion was 75.2° and mean palmar flexion was 75.1°.

(b) Deviations

Deviation	Radial deviation		Ulnar deviation	
	No.of cases	Percentage%	No.of cases	Percentage%
>= 15°	47	94	49	98
< 15°	3	6	1	2
Total	50	100	50	100

Nearly 98% of the patients had a well preserved range of radio ulnar deviations. Mean radial deviation was 18.4° and mean ulnar deviation was 24.4°.

(c) Pronation

Range	No. of Patients	Percentage%
>70°	40	80
50-70°	08	16
<50°	02	04
Total	50	100

Only 4% of the patients had some restriction of pronation. The mean pronation was 77.8°.

(d) Supination

Range	No. of Patients	Percentage%
>70°	45	90
50-70°	05	10
<50°	00	00
Total	50	100

All patients had an excellent range of supination at final follow up. The mean supination was 78.3°.

19. Grip weakness

Grip Weakness	No. of Patients	Percentage%
No	48	96
Mild	1	2
Moderate	1	2
Severe	0	0
Total	50	100

There was mild weakness in only two cases. Rest of the patients had excellent grip. The mean grip strength was 92.5%.

20. Radiologic Parameters

a) Palmar Angulation (Normal – 11-14 Degrees)

In Degrees	No. of Patients affected wrist	Normal opposite side wrist	Percentage%
11-14	48	50	96
6-11	02	0	4
<6	00	0	0
Dorsal Angulation	00	0	0
Total	50	50	100

96% of the patients regained an anatomical range of palmar angulation of distal radius. The mean palmar angulation was 13.4 degrees.

b) Radial Inclination (Normal – 20-25 Degrees)

In Degrees	No. of Patients	Normal wrist Wrist wrist	Percentage%
<10	00	0	00.0
10-15	01	0	02.0
15-25	49	50	98.0
Total	50	50	100

98% of the patients regained an anatomical Radial Inclination of distal radius. Mean radial inclination was 20 degrees.

c) Radial Height (Normal 10-13 mm)

In mm	No. of Patients	Normal wrist	Percentage%
10-13	48	50	96.0
6-9	2	0	4.0
< 6	0	0	0.0
Total	50	50	100

96% of the patients regained the Anatomical Radial Height. Mean radial height was 12 mm.

d) Ulnar Variance (Normal 0 to +/- 2mm)

In mm	No. of Patients	Normal wrist	Percentage%
> 2	2	0	4
</= 2	48	50	96
Total	50	50	100

There were two cases of ulnar variance of +3mm post fixation in this series.

21. Ability to go back to Work

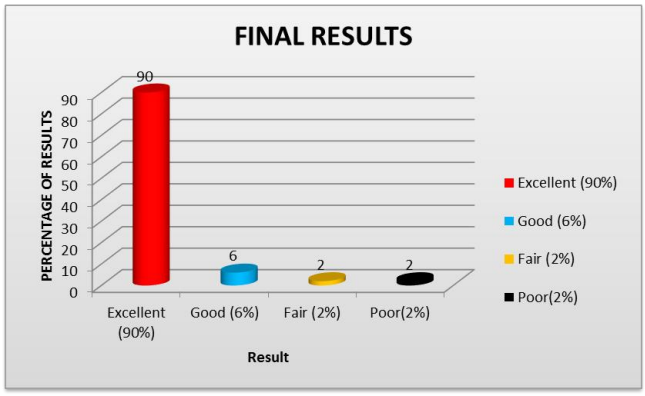
	No. of Patients	Total (%)
Back to work (same occupation)	49	98
Back to work (patient had to change the occupation)	1	2
Patient is unable to work	0	0
Total	50	100

All the patients were able to go back to their original work except one who developed radioulnar synostosis, who had to change the occupation from bus conductor to office clerk.

22. Overall Results

TYPE	No. of Patients	Percentage%
Excellent	45	90
Good	3	6
Fair	1	2
Poor	1	2
Total	50	100

The assessment of results made using the scoring system according to Mayo wrist score, based on objective and subjective criteria, residual deformity and complications.



4. Discussion and Analysis

More than 200 years have passed since Colles' described the fracture of the distal end of the radius. It is remarkable that this common fracture remains one of the most challenging of the fractures to treat. There is no consensus regarding the description of the condition and the appropriate outcome.

Distal radius fractures are the most frequently seen upper extremity fractures. The main objective of its treatment is the re-establishment of anatomic integrity and functioning. In unstable intra-articular fractures, re-establishment of intra-articular integrity of the wrist and maintaining the radial length are often not possible with close methods. In such cases, where an open reduction is required, various surgical methods and fixation materials can be used. A better understanding of wrist anatomy and functioning through the studies conducted in the recent years, as well as the increasing expectations of patients have expanded the borders of surgical treatment. Besides, improvements in fixation materials have provided new opportunities.

Due to their intra-articular and unstable nature, B and C type of AO system distal radius fractures are treated surgically. Today, open positioning and plate fixation are widely recognized surgical methods. Locked plates are in the progress of replacing conventional buttress plates. While facilitating the positioning, those anatomical plates with screw-plate interlocking feature have more biomechanical

strength against forces applied on the fracture surfaces. Because of their biomechanical strength, locked plates are preferred in osteoporotic and/or multiple fractures.

However, there is no consensus neither about how to approach to distal radius nor the positioning of the plate. During the recent years, volar approach has become more popular.

The present study was undertaken to assess the functional outcome of operative management of distal radius fractures using a volar locked compression plate.

We evaluated our results and compared them with those obtained by various other studies utilizing different modalities of treatment.

Our analysis is as follows:

1. Age distribution

In our study, distal radius fracture was more common in the 3rd to 5th decade with an average of 42.4 years. Most of the intra articular, comminuted and unstable fractures requiring operative management occurred in young individuals were due to high energy trauma such as road traffic accident and fall from tree.

S. No	Series	Minimum age in years	Maximum age in years	Average age in years
1	KK Wong *et al.*(2005) [10]	35	92	58.6
2	Ahyan KILIC *et al.*(2009) [11]	18	77	45
3	RE Anakwe *et al.*(2010) [12]	22	67	48
4	Paritosh Gogna *et al.* (2013) [13]	18	81	44.12
5	Margaret W.M. Fok *et al.* (2013) [14]	18	76	50.3
6	Present Study (2016)	20	70	42.4

The average age of 42.2 yrs in our study is comparable to the studies of Ahyan KILIC *et al.* (2009), RE Anakwe *et al.* (2010) and Paritosh Gogna *et al.* (2013) who had an average age of 45 yrs,48 yrs and 44.12 yrs respectively.

2. Sex distribution

Our study had a male preponderance with 40 male patients and 10 female patients and is comparable to the following previous studies mentioned in the table below.

S. No	Series	Male	Female	Total
1.	KK Wong *et al.*(2005) [10]	11	19	30
2.	Ahyan KILIC *et al.*(2009) [11]	15	12	27
3.	RE Anakwe *et al.*(2010) [12]	8	13	21
4.	Paritosh Gogna *et al.* (2013) [13]	23	10	33
5.	Margaret W.M. Fok *et al.* (2013) [14]	56	41	97
6.	Present Study (2016)	40	10	50

Increased incidence in males is probably due to their involvement in outdoor activities, riding vehicles and heavy manual labour.

3. Involved side

The right side was involved in 35 of the cases in our study.

S. No	Series	Right	Left	Total
1.	KK Wong *et al.*(2005) [10]	15	15	30
2.	Ahyan KILIC *et al.*(2009) [11]	13	8	27
3.	RE Anakwe *et al.*(2010) [12]	15	6	21
4.	Paritosh Gogna *et al.* (2013) [13]	23	10	33
5.	Margaret W.M. Fok *et al.* (2013) [14]	46+2	47+2	97
6.	Present Study (2016)	35	15	50

All the above series had increased involvement of the right wrist in their series which was also the case in our series, except the studies by KK Wong *et al.* (2005) & Margaret W.M. Fok *et al.* (2013) which showed equal laterality. Margaret W.M. Fok *et al.* (2013) had two cases with bilateral involvement.

4. Mode of injury

In our study, 74% of the patients had high energy trauma and 26% had a low energy trauma. The results are comparable with other studies.

S. No	Series	High Energy Trauma (RTA or MVA)	Low Energy Trauma (Fall While Walking/ from height)	TOTAL
1.	KK Wong *et al.*(2005) [10]	25	5	30
2.	Ahyan KILIC *et al.*(2009) [11]	All fractures were due to fall		27
3.	RE Anakwe *et al.*(2010) [12]	14	17	31
4.	Paritosh Gogna *et al.* (2013) [13]	26	7	33
5.	Margaret W.M. Fok *et al.* (2013) [14]	46(~50%)	47(~50%)	97
6.	Present Study (2016)	37	13	50

5. Type of fracture

Based on AO classification, we had 2 (10%) A2 type fractures, 4 (20%) A3, 1 (5%) B1, 4 (20%) B2, 4 (20%) B3, 4 (20%) C1, and 1 (5%) C2 fractures. Comparison with other studies is shown in tabulated form.

Sr.No.	Series	No. of cases									TOTAL
		A1	A2	A3	B1	B2	B3	C1	C2	C3	
1.	KK Wong *et al.*(2005) [10]	1	0	0	0	0	0	4	14	11	30
2.	AhyanKILIC *et al.*(2009) [11]	0	0	0	0	3	2	2	14	6	27
3.	RE Anakwe *et al.* (2010) [12]	0	0	0	0	0	0	4	8	9	21
4.	Paritosh Gogna *et al.* (2013) [13]	0	7	0	0	0	0	0	8	18	33
5.	Margaret W.M. Fok *et al.* (2013) [14]	0	0	0	0	0	0	15	44	42	97
								four were lost to follow up			
6.	Present study (2016)	0	5	10	3	10	10	10	2	0	50

Our series had maximum number of cases of AO type A3, B2, B3 and C1 type of fractures. Other series had maximum number of AOtype C1, C2 and C3.

6. Fracture Union Time

S. No	Series	Mean Union Time
1.	KK Wong *et al.*(2005) [10]	Not determined
2.	Ahyan KILIC *et al.*(2009) [11]	6.5 weeks
3.	RE Anakwe *et al.*(2010) [12]	12 weeks
4.	Paritosh Gogna *et al.* (2013) [13]	9.6 weeks
5.	Margaret W.M. Fok *et al.* (2013) [14]	15 weeks
6.	Present Study (2016)	12 weeks

In our series the mean fracture union time is comparable with the studies mentioned above. This might be attributed to the exact joint fracture reduction and fixation. KK Wong *et al.* (2005) failed to determine time of fracture because radiographs were not taken frequently enough in their study. Ahyan KILIC *et al.* (2009) had remarkably less mean union time which was 6.5 weeks.

7. Grip Strength

S. No	Series	Grip Strength
1.	KK Wong *et al.*(2005) [10]	67.85%
2.	Ahyan KILIC *et al.*(2009) [11]	72.4%
3.	RE Anakwe *et al.*(2010) [12]	90%
4.	Paritosh Gogna *et al.* (2013) [13]	92.26%
5.	Margaret W.M. Fok *et al.* (2013) [14]	81%
6.	Present Study(2016)	92.5%

The result of grip strength achieved in our series is comparable to the reference studies. But the grip strength achieved in studies by KK Wong *et al.* (2005) Ahyan KILIC *et al.* (2009) was comparitevly less.

8. Complications

We encountered a complication rate of 8%, out of which 1 case (2%) had extensor pollicis longus tendon irritation, caused by long volar to dorsal screw, 2 (4%) cases developed arthritis of wrist joint secondary to improper reduction and articular step-off.

One patient in our series developed malunion due to excessive comminution in bones, distal radius.

KK Wong *et al.* (2005) [10] reported two patients (6.6%) with carpal tunnel syndrome, four patients (13.33%) with hypertrophic scar, one patient (3.3%) with attrition rupture of extensor pollicis tendon. There was no nonunion or wound infection in this study.

Ahyan KILIC *et al.* (2009) [11] reported ten patients (7.4%) who had intraarticular incongruity, one patient (3.7%) with screw impingement, which was removed later on.

R.E. Anakwe *et al.*, (2010) [12] reported no complication and Paritosh Gogna *et al.* (2013) [13] reported 9.9% loss of reduction, there was no hardware related complication or nonunion.

Margaret W.M. Fok *et al.*

3 (2013) [14] reported two (2.06%) cases of complex regional pain syndrome (CRPS), one (1.03%) case with 2 mm of radial shortening,one case with displacement of dorsolunar fragment and six (6.18%) patients developed complication of distal radioulnar joint (DRUJ) instability.

9. Radiological parameter

In our study palmar angulation was 11-14 degree (96%-46 patients), radial inclination 15-25degree (98%-49 patients), radial height 10-13mm (96%-48 patients) & ulanr variance </=2mm (96%-48 patients)

This was compared with other studies

KK Wong *et al.* (2005)[10] mean palmar angulation was above 8 degree,mean radial inclination was 22degree,radial shortening 1 mm(i.e between 10-13mm)

Ahyan KILIC *et al.* (2009)[11] showed that ulnar variance became equal to unaffected side in 77.8%(n=21)patients while 0.4mm in 22.2%(n=6)patients, radial inclination was similar to unaffected side(20-25degree) in 48.2 %(n=13)while 51.8%(n=14) showed 26.8degree,radial height similar to unaffected side(10-13mm) in 40.7%(n=11) patients

Paritosh Gogna *et al.* (2013) [13] showed palmar angulation5.86° ± 6.74°, Radial inclination 23.42°± 3.65°, Radial height 12.51±2.77 mm & ulnar variance−0.77±0.88 mm

Margaret W.M. Fok *et al.* (2013) [14] the average palmar angulation was 6.7° (range, 2° of dorsal tilt to 15° of volar tilt), radial inclination averaged 20.2° (range, 20-25°), radial shortening averaged 0.7 mm (range, 0-2 mm) i.e radial height within 10-13mm.

10. Results

In our series, we had 90% excellent, 6% good, 2%, fair and 2% poor result. Patients, who obtained excellent results, had no residual deformities or pain. Range of motion was within the normal functional range. Two patients (4%) had arthritic changes but no other complications. They were operated within 6 days after injury. Radial length, volar tilt and articular step-off were within acceptable limits. They were co-operative to physiotherapy.

Patients with good results had minimal residual deformities, pain and slight limitation of movement. Rests of their findings were within acceptable parameters.

Patient with poor result, along with residual deformity, pain and limitation of movements also had pain in the distal radio-ulnar joint and minimal complications. Few of his movements were less than that required for normal function.

Patient with fair result had malunion.

The results of our study are compared with the other studies as follows.

S. No	Series	Excellent	Good	Fair	Poor	Total
1	KK Wong *et al.*(2005)	80%	15%	5%	0%	100%
2	Ahyan KILIC *et al.*(2009)	44.40%	44.40%	11.11%	0%	100%
3	RE Anakwe *et al.*(2010)	91.50%	9.50%	0%	0%	100%
4	Paritosh Gogna *et al.* (2013)	83%	17%	0%	0%	100%
5	Margaret W.M. Fok *et al.* (2013)	84%	12%	4%	0%	100%
6	Present Study(2014)	90%	6%	2%	2%	100%

Conclusion

In the subjects of our study, a successful anatomic alignment was acquired with volar approach, regardless of the direction of fracture angulation. The patients who were young adults in majority, went back to their daily activities with 90% recovery. Use of locked compression plates in distal radius fractures provided good to excellent results with correction and maintenance of distal radius anatomy. By using these plates, joint motions and daily functioning were recovered in a shorter time.

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