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Functionaloutcome of Fracture Distal Radius Treated With Open Reduction Internal Fixation with Volar Locking Compression Plate

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ABSTRACT: Background: Management of fractures of distal end radius has remained a controversial issue. They are treated via a variety of methods, but the best of treatment has not been defined yet. There are various modalities for treatment like close reduction and cast application, external fixators, ORIF with plate etc. Closed reduction and cast application or K-wire fixation, external fixation is associated with immobilisation, wrist stiffness, loss of reduction postoperatively [1,2] This study was performed to evaluate outcomes of volar locking plate in surgical management of such fractures.

Material and Methods: In this prospective study 50 patients aged above 20 years of fracture distal end radius were treated with open reduction and internal fixation with volar locking plates, followed by early mobilization. Fractures were classified according to AO classification. All patients were operated under tourniquet. Patients were followed up regularly and functional assessment were done monthly for 3 months using Mayo wrist score.

Results: Out of 50 patients, 15 had type A, 23 had type B and 12 had type C fractures (AO classification). 4% of fractures were open type 1 and rest were close. Average time to clinico-radiological union was 12 weeks. Average follow up time was 9 months. Average time to wrist mobilisation was 7 days. According to Mayo score, 45 patients had excellent results, 3 had good, 1 had fair and 1 had poor results. No major complications were observed in the present study. 1 patient developed irritation of extensor pollicis longus tendon, 2 patients developed grade 1 radiocarpal arthritis, 1 patient developed malunion.

Conclusion : Locking compression plate provides stable fixation for early mobilization of patient, leading to early resumption to pre trauma functional level of an individual with minimal complications. 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

I. 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 [2].

The incidence of these fractures appears to be both age and gender specific. There are three peaks of fracture distribution [3]:

1. Children aged 5-14 years
2. Males under the age of 50
3. Females over the age of 40 years

These fractures represent two very different injuries [4,5,6]:

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.

The majority of the fractures in elderly are extra-articular, whereas there is much higher incidence of intra-articular fractures in younger individuals.

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.

Both clinical outcome and biomechanical studies demonstrated the most important factors in obtaining good result. These factors are[7]:

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

The close treatment options are associated with high incidence of [1,2]:

- Prolonged immobilization
- Jointstiffness & 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

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 [8,9].

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 [8].

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.

The use of strong implant in the form of Fixed Angle Volar Locking Compression Plate theoretically achieves, maintainthe 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 [10]

II. MATERIALS AND METHODS:

This prospective study was conducted in Department of Orthopedics of our institute for 50 patients. The plan of study was duly approved by institutional ethical committee of our college. Inclusion criteria included patients with adults (aged over 20 years), both male and female with unstable,comminuted or intra articular fractures of distal end radius, closed fractures, open grade 1 & 2 fractures, Displaced fractures and exclusion criteria were Patients aged below 18 years, medically unfit for surgery, fractures in pregnant females, Pathological fractures, Open grade 3 fractures, Compound fractures associated with vascular injuries, Patients not willing for surgery.

Radiological examination was carried out for knowing the type of fracture. Fractures were then classified according to the AO classification system depending upon the degree of comminution. After taking detailed informed and written consent all patients were operated using either regional block or general anaesthesia. Patient was placed supine on orthopedic table with radiolucent operating side table. Dissection was done using standard modified henry's approach. Open reduction and fixation was done using appropriate sized plate depending on the fracture pattern. The reduction, plate and screw's position and length was confirmed per operatively under image intensifier. After confirmation of position of plate, fracture fragments were fixed using appropriate sized screws [11].

Post operatively all patients received broad spectrum intravenous antibiotics for a minimum of 5 days and then shifted to oral antibiotics till suture removal. On first post op day post-operative X-ray forearm with wrist (AP and Lateral view) was done and fingers, elbow and shoulder physiotherapy was started. sutures were removed on 14th post-operative day. Gentle wrist exercises were started after suture removal as per tolerance and compliance of the patient [11,12].

Regular follow ups were done monthly for 9 months for clinical and radiological assessment. The outcomes were evaluated clinically in terms of pain, range of motions and complications [13]. Radiological assessment was done for fracture union and anatomical parameters like volar tilt, radial inclination and ulnar variance. The value and practice of active physiotherapy was reinforced at each follow up. Final evaluation of the patient was done at 3 months as per MAYO Score.

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Category	Score	Findings
Pain (25 points)	25	No pain
	20	Mild pain with vigorous activities
	20	Pain only with weather changes
	15	Moderate pain with vigorous activities
	10	Mild pain with activities of daily living
	5	Moderate pain with activities of daily living
	0	Pain at rest
Satisfaction (25 points)	25	Very satisfied
	20	Moderately satisfied
	10	No satisfied, but working
	0	No satisfied, unable to work
Range of motion (25 points)	25	100% percentage of normal
	20	75~99% percentage of normal
	10	50~74% percentage of normal
	5	25~49% percentage of normal
	0	0~24% percentage of normal
Grip strength (25 points)	25	100% percentage of normal
	15	75~99% percentage of normal
	10	50~74% percentage of normal
	5	25~49% percentage of normal
	0	0~24% percentage of normal

Final result (total points)	
90~100	Excellent
80~89	Good
65~79	Fair
<65	Poor

Radiological assessment was done in terms of palmar angulation, radial height, radial inclination and ulnar variance. 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 and statistical analyses of the data were done.

III. OBSERVATIONS AND RESULTS:

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.

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

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

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

Of the 50 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.

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.

15(30%) of the fractures were of Extra articular Type and 35 (70%) were Intra articular fractures. Surgery was done between 1-5 days in 45 (90%) patients as an elective procedure.

Surgery was delayed upto the 6^{th} day in 5 (10%) patients because they were not fit for surgery and operated after they became fit for surgery.

In the present study 40 (80%) patients had union within 2-3 months,8(15%) patients had union in 3-4 months and 2(4%) cases of delayed union. 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.
Minimum duration of follow up was 6 months and maximum was 12 months. Mean follow up duration was 9 months.

IV. FOLLOWUP

Pain

Severity	No. of cases	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.

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.

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.

Wrist Movement
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

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<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°.
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°.

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°.

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°.

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%.

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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	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

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</= 2	48	50	96
TOTAL	50	50	100

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

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.

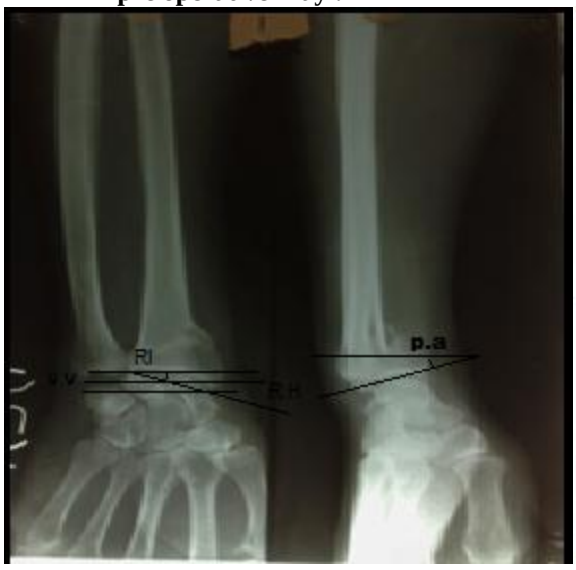
V. OVERALL RESULTS

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

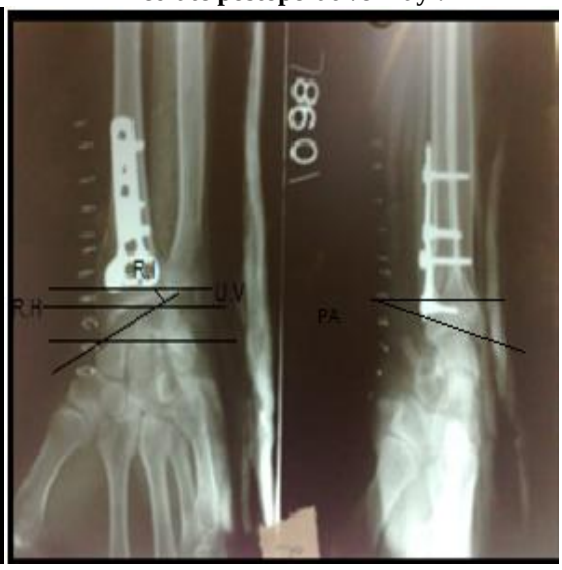
The assessment of results made using the scoring system according to Mayo wrist score, based on objective and subjective criteria, residual deformity and complications.

PICTURES:

pre operative xray :



Immediate postoperative xray :



FRACTURE TYPE- AO Type B2

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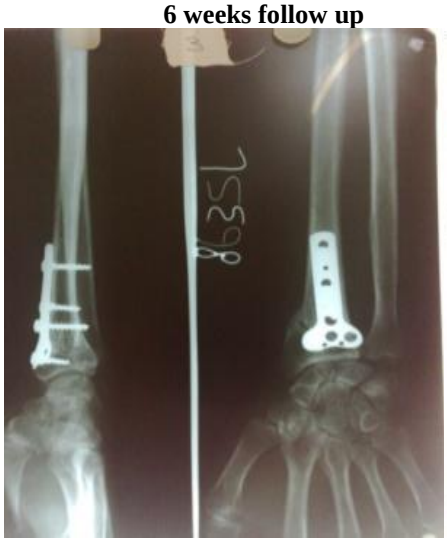
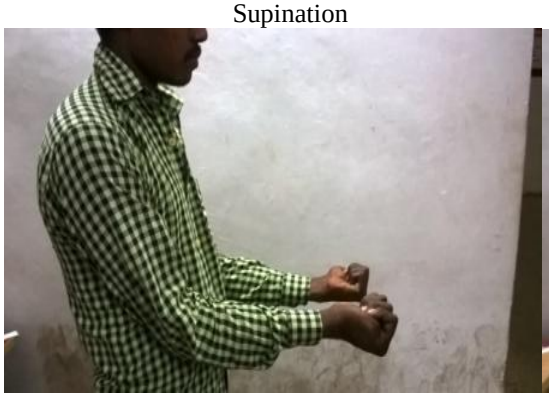
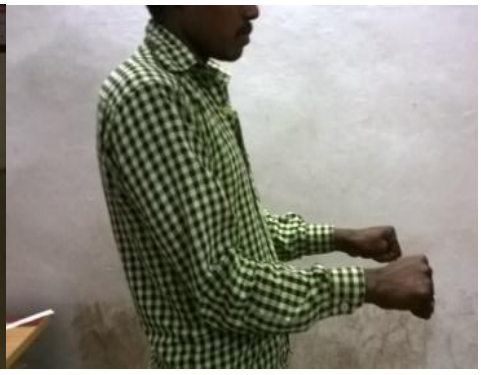
FRYKMEN Type-3
Immediate postoperative: PA16,RI-21,RH-12,UV-Nil

6 weeks follow up **6 months follow up**




Dorsiflexion Plamar flexion


Supination Pronation

Radial deviation Ulnar deviation

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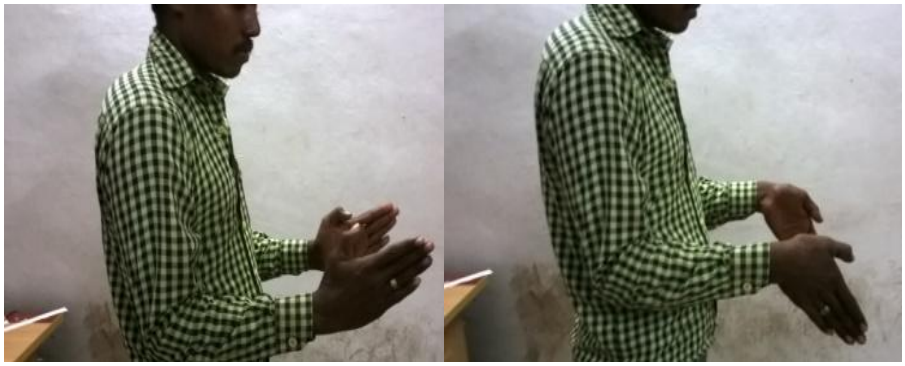

VI. DISCUSSION:

The management of fractures of distal radius has always been a debatable and challenging issue for orthopaedic surgeons. The results of conservative management of these fractures have historically been unsatisfactory and many studies have reported better results with operative management [14,15].

The ultimate goal is to achieve proper reconstruction of disrupted anatomy and allow quick return of function without complications. In this context, Osada et al documented the increasing popularity of open reduction and internal fixation, especially since the introduction of locked volar plates in 2001 [16]. 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 volar cortex of the distal radius was very often not as 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.

As a result conservative treatment is generally reserved for patients with minimally displaced fractures or for those who could not bear the stress of surgery.

Additional possible advantages of these plates include decreased soft tissue complications and absence of secondary displacement of fracture fragments even in the absence of adequate contouring of plates. 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 [17,18].

Concern with regard to volar prominence of the plate, beyond the volar rim of the distal radius, has been voiced by previous authors. Arora et al defined the watershed line as a transverse ridge that closures the concave surface of the volar radius distally and stated that implants placed over or distal to this line can cause flexor tendon complications [19]. This concern was also raised by Cross and Schmidt [20] who reported flexor digitorum profundus and flexor pollicis longus (FPL) ruptures where no fracture collapse had occurred.

In 2011, Soong et al published the grading system used in this study and showed a tendency for flexor tendon complications if the distal plate extended beyond the volar rim of the distal radius [21]. In addition, a detailed anatomical study of the macroscopic and histologic structure of the volar aspect of the distal radius concluded that the medial and lateral bony prominences on the volar radius should be key structures for accurate plate placement to avoid flexor tendon injury[18]. We identified a statistically significant association between a prominent plate position and flexor tendoncomplications and were able to estimate the odds ratio of developing a flexor tendon rupture or symptomatic tenosynovitis to be (5.8) .

The present study was therefore conducted in a prospective manner to evaluate the role of Volar locking compression plates in distal end radius fractures.

All patients had union radiologically at three months X-ray. However, union probably had occurred much earlier than three months. Similarly in the study conducted by Kwan et al. all fractures united at the three months follow up and in the study conducted by Wong KK et al [22 ,23]. The time to union could not be determined because radiographs could not be taken frequently enough; some fractures healed long before the final radiographic assessment .

There were minor variations in the

anatomical parameters (volar tilt, radial inclination and ulnar variance) in our study which were comparable with the other studies has not affected functional results significantly. However, significant variation in anatomy (post reduction) may result in cosmetic deformity, poor functional results and early symptomatic osteoarthritis.

Minor complications were reported in 5 of the patients (16.67%) enumerated and were resolved as detailed earlier. No major complications like deep infection, finger stiffness, tendon ruptures, nerve injury, vessel injury, non-union,implant failure were observed in the present study.

According to Mayo score, 45 patients had excellent results, 3 had good, 1 had fair and 1 had poor results. No major complications were observed in the present study. 1 patient developed irritation of extensor pollicis longus tendon, 2 patients developed grade 1 radiocarpal arthritis, 1 patient developed malunion. Sugun et al. reported excellent scores in 14 of their patients, good in 11, satisfactory in 20 and poor in one of their patient according to the MAYO wrist scores[24].

According to MAYO wrist score Agarwala et al[25] reported excellent/good result in 88% and satisfactory result in 12% of patients and similar results were obtained in the study done by Chavhan et al[26]. Results obtained in the present study are similar & comparable to the results reported in the literature in terms of union, anatomical parameters and functions with special feature of minimal complications.

VII. CONCLUSION

Distal radius fractures are more common in 3rd to 5th decades. Male preponderance is due to their involvement in heavy manual labour, outdoor activities and riding vehicles. Most of the fractures in the younger individuals were due to motor vehicle accidents or high energy trauma which were usually intra-articular and displaced . The fractures occurring in the older individuals were due to trivial fall on outstretched hand causing extra articular fracture in the osteoporotic bone.

Locked plates that are widely used provided successful results especially for the treatment of intraarticular unstable fractures of distal radius. This method, which is effective in anatomic realignment, allowed early joint motion, owing to its fixation strength. Close placement of screws to joint interface and screwing capability in different directions are its biomechanical superiorities. Volar approach provides both access with minimal surgical trauma on distal radius and fixation with a better adaptation to surrounding tissues. 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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