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The Use of Volar Locked Plate in Management of Distal Radial Fractures

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ABSTRACT

Background: K-wire pinning, volar fixed angle locking plate, enhanced external fixators, and fragment specific fixations are all alternatives for treating comminuted distal radial fractures. Each strategy has pros and downsides, but there is no agreement on which way is the best. **Objective:** This study aimed to improve the functional outcome in patients with distal radial fractures, treated with a volar locked plate.

Patients and methods: This prospective study included 18 patients with distal radial fractures who were admitted and operated at Orthopedic Department, Zagazig University Hospitals. All patients were subjected to preoperative and postoperative evaluation. The follow up period of the cases ranged from 6 to 12 months.

Results: The final outcome in distal radius fracture management is dependent on many factors and can be influenced by accurate restoration of the anatomy, minimal disruption of the surrounding tissues, and early active wrist rehabilitation. Fragment specific fixation can give better results in certain types of distal radius fractures.

Conclusion: Volar fixed-angle locked plating is better than external fixation and percutaneous wiring in treating intra-articular distal radial fractures because it affords more stable fixation with anatomical reduction, lower rate of complication and early motion, which results in better functional results.

Keywords: Distal Radial Fractures, Volar Locked Plate, Functional Outcome.

INTRODUCTION

One sixth of all fractures seen and treated in emergency departments are distal radial fractures, one of the most frequent types of fractures. The demographics that are most at risk for this injury include children and the elderly. In senior people with osteoporotic bones, it can be brought on by a simple fall, whereas in young adults, it can be brought on by high-energy trauma [(1)]. A functional result depends on precise anatomical reduction of the articular surface and extra-articular alignment because the distal radius affects the kinematics of the radiocarpal and radioulnar joints. Reconstruction of articular congruity and secure fixation lowers the incidence of post-traumatic osteoarthritis and enables early functional rehabilitation since the distal radius is the basis of the wrist joint and a crucial component of ligamentous support [(2)].

For displaced or unstable intra or extra articular fractures, open reduction and internal fixation is a possibility, and some studies have indicated that volar plating can offer stable internal fixation. This resulted in an early start to activity and a prompt return to regular activities. Also, compared to alternative treatment choices, a low complication rate has been found [(3)].

A locked plate and its screws function as a single unit, sustaining a fracture reduction even in the presence of poor bone quality, in contrast to conventional plate and screw designs that need compression between the plate and bone to generate stability [(4)].

In comparison to non-locked plates, these plate systems offer better fixing strength, higher stiffness, and axial loading strength. In older individuals with osteoporotic bone, this is very helpful in preventing subsequent displacement of the unstable fracture [(5)].

To manage dorsally displaced fractures, locked plates can be positioned along the volar cortex of the distal radius. By doing so, the irritation of the extensor tendon brought on by dorsal plate fixations is prevented. Yet, it's important to take into account the possibility of flexor tendon irritability as well as other issues [(6)].

Therefore, this study aimed to evaluate the functional and radiological results of treating distal radius fracture fixed with a volar locked plate.

PATIENTS AND METHODS

This prospective study was conducted during the period (2020-2022). Eighteen (18) patients of distal radial fractures were admitted and operated in the Casualty Unit of the Orthopedic Department of Zagazig University Hospitals. The follow up period of the cases was ranged from 6 months to 12 months with average time 9 months.

Inclusion criteria: Patients with distal radial fracture. Age >18 and <70 years, sex: male and female, less than 1 month old injury.

Exclusion criteria: Patients with open injury Gustilo grade II and III. Age <18 and >70. More than 1 month injury. Associated fractures of carpal bone and highly comminuted fractures were excluded.

I. Preoperative evaluation:

In order to reduce patient fear and secure their full participation, patient counselling was crucial. All patients had thorough histories taken, with particular attention paid to the mechanism of trauma, timing of trauma, hand dominance, occupation, any prior surgeries, particularly those affecting the wrist, and history of chronic medical conditions. The afflicted wrist had a thorough examination to look for any accompanying wounds, abrasions, or deformities. Peripheral arterial pulse at the affected extremity was also assessed to look for any potential radial artery insults. A thorough neurological examination was done

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whenever the patient's condition allowed it to determine whether there had been any nerve damage.

Each patient had a wrist trauma series for radiological examination, which comprised antero-posterior (AP) and lateral radiographs. It was advised to use computed tomography (CT).

The typical preoperative lab tests included liver and kidney function checks, full blood counts, random blood glucose levels, bleeding profiles, and more.

II. Operative management:

1. Anesthesia: General anesthetic was used to manage all research participants, with the exception of one patient who received supraclavicular regional anesthetic. Before the induction of anesthesia, a preventative wide spectrum antibiotic was taken—by approximately a half an hour.

2. Surgical preparations: The injured limb was elevated for a period while the patient was supine on the operating table, and then a hand cuff was applied to the arm with pressure raised to 250 degrees. The volar surface of the injured limb was made visible by placing it over a side table. The whole body, with the exception of the area that had been cleaned, was covered with sterilised coverings after the forearm and wrist were scrubbed with betadine from the middle of the forearm to the middle of the palmar surface of the hand.

3. Surgical technique: Directly on the flexor carpi radialis tendon, an 8-cm incision was created. The sheath of the flexor carpi radialis tendon was entered through the incision. The forearm fascia on the radial border of the flexor carpi radialis was incised, and the tendon sheath was opened. After the use of retractors, the flexor pollicis longus' connection to the radius was partially cut away to allow a clear view of the pronator quadratus. To prevent the pronator quadratus from fully elevating from the radius, an L-shaped incision was made over its radial border [7]. Depending on the kind and severity of the fracture, several types of plates were employed in these surgeries.

Postoperative management protocol including the following:

- Postoperative care.
- Rehabilitation program.
- Follow up examination:
- The duration average of follow up was 9 months postoperatively.
- Radiological and clinical follow up.
- X-ray done immediately postoperatively then at 2, 4, 6 and 8 weeks.
- Patients were assessed using Mayo wrist score at end of follow up period.

Every patient was evaluated at the end of the follow up period according to the Mayo wrist score, which is a 100-point score system. This scoring system consists of four variables that are used to assess the function of the wrist.

Ethical Consideration: The Academic and Ethical Committee of Zagazig University approved the project. All of the subjects' written informed permission was acquired. The Declaration of Helsinki, the International Medical Association's code of ethics for studies involving humans, guided the conduct of this work.

Statistical analysis

With Microsoft Excel, data were evaluated. The Statistical Package for the Social Sciences (SPSS) version 20.0 software was then used to import the data for analysis. Quantitative data were presented as mean, standard deviation (SD), median and range and were compared by the Student t-test. Qualitative data were presented as frequency and percentage and were compared by Chi^2 test. P-value equal to or less than 0.05 was considered significant.

RESULTS

The man age of the patients was 39.44±7.67. 61.1% of the patients were males. The dominant hand was involved in twelve (60%) patients, 12 patients right side and 8 left side but all right handed. 77.8% had no co-morbidity and 16.7% had DM and 5.6% had HTN, and 44.4% were smoker **(Table 1).**

Table (1): Demographic data distribution among studied group (N=18)

		Age	
Mean± SD		**39.44±7.67**	
Median (Range)		**41.50 (27-50)**	
		N	**%**
Sex	**Male**	**11**	**61.1**
	Female	**7**	**38.9**
Dominant	**Left**	**8**	**40**
	Right	**12**	**60**
Co morbidity	**No**	**14**	**77.8**
	DM	**3**	**16.7**
	Hypertension	**1**	**5.6**
Smoking	**No**	**10**	**55.6**
	Smoker	**8**	**44.4**
	Total	**18**	**100.0**

Fall from height and slipped on floor were the major causes of injury. According to the AO classification of distal radius fractures, nine (9) patients had Type A fractures **(Table 2)**.

Table (2): Mode of trauma and classification distribution among studied group

		N	%
Mode of trauma	**Fall from height**	**8**	**44.4**
	Motor bike accident	**2**	**11.1**
	Slipped on floor	**8**	**44.4**
AO classification	**A**	**9**	**50.0**
	B1	**6**	**33.3**
	B2	**3**	**16.7**
	Total	**18**	**100.0**

Mean Mayo score was 85.0±5.78 with minimum 73 and maximum 93, and regarding grade; majority were good with 61.1%, then excellent 22.2%, and then satisfactory 16.7% **(Figure 1)**.

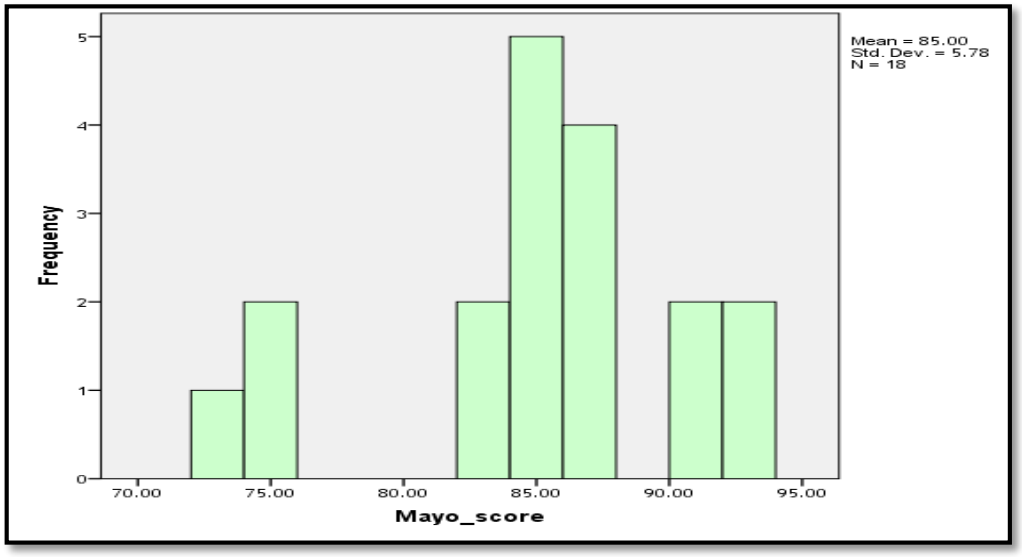

Figure (1): Frequency of Mayo score distribution among studied group.

Degrees of flexion and extension and pronation and supination are shown in tables 3 and 4.

Table (3): Flexion and extension in degrees among studied group

	Flexion in degrees	Extension in degrees
Mean± SD	**69.44±11.86**	**66.66±7.66**
Median (Range)	**75.0 (50-80)**	**70.0 (50-70)**

Table (4): Pronation and supination in degrees among studied group

	Pronation in degrees	Supination in degrees
Mean± SD	81.11±10.22	83.61±8.87
Median (Range)	90.0 (70-90)	85.0 (65-90)

VAS score for pain decreased from 6 weeks to 6 months **(Table 5)**. Values of radial height, radial inclination and volar tilt are shown in **(Table 6)**.

Table (5): VAS score for pain among studied group

	6 weeks	3 months	6 months
Mean± SD	3.23±1.12	1.5±0.45	0.5±0.25
Median (Range)	3 (1-5)	1 (0-3)	0 (0-1)

Table (6): Grip strength parameters among studied group

	Radial height in/ mm	Radial inclination in degrees	Volar tilt in degrees
Mean± SD	**10.66±1.18**	**20.38±2.27**	**12.50±1.61**
Median (Range)	**11.0 (8-12)**	**21.0 (16-23)**	**12.0 (9-14)**

The current study showed that 33.3% of studied group had complications.

Incomplete correction happened in 4 cases (22.2%), wound infection happened in 2 cases (11.1%), wound scar happened in 2 cases (11.1%), and stiffness happened in 6 cases (33.3%). No Sudek's atrophy, nerve or tendon injury happened **(Figure 2)**.

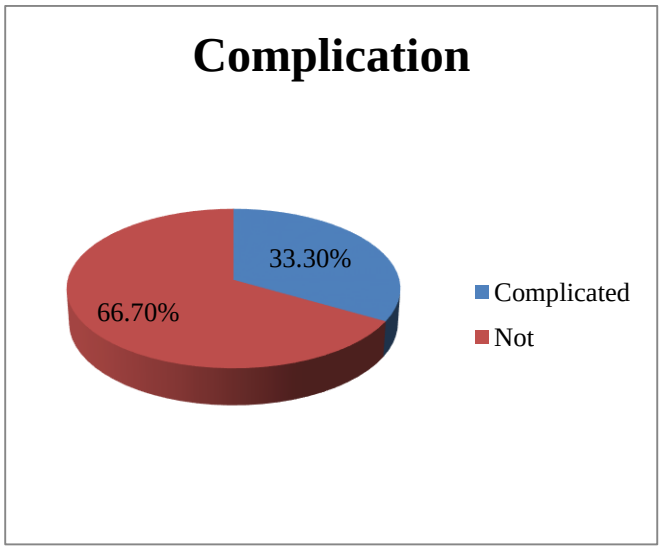

Figure (2): Mean of Complication distribution among studied group.

Compared to excellent and good group, satisfactory outcome group was significantly older in age, significantly lower in Mayo score, and also significantly lower regarding flexion, extension, supination, pronation and grip strength. Radial height was also significantly associated with incomplete correction, wound infection, stiffness and wound scar **(Table 7)**.

Table (7): Relation with outcome among the studied Patients

			Excellent and good N=15	Satisfactory N=3	P
Age			**38.06±7.66**	**46.33±2.08**	**0.019***
Mayo score			**87.13±3.33**	**74.33±1.15**	**0.00****
Flexion in /degrees			**71.33±12.16**	**60.0±0.0**	**0.045***
Extension in/ degrees			**70.0±0.0**	**50.0±0.0**	**0.035***
Pronation in/degrees			**83.33±9.75**	**70.0±0.0**	**0.00****
Supination in/degrees			**87.33±2.58**	**65.0±0.0**	**0.029***
Grip strength			**27.95±9.40**	**14.63±0.37**	**0.004***
Radial height in/mm			**11.0±0.92**	**9.0±1.0**	**0.00****
Radial inclination in/degrees			**21.20±1.42**	**16.33±0.57**	**0.077**
Volar tilt in/degrees			**12.20±1.61**	**14.0±0.0**	**0.089**
Sex	**Female**	**N**		**2**	
		%		**66.7%**	
	Male	**N**	**0.28**	**1**	**0.28**
		%	**66.7%**	**33.3%**	
Mode of trauma	**Fall from height**	**N**	**5**	**3**	
		%	**33.3%**	**100.0%**	
	Motor bike accident	**N**	**2**	**0**	
		%	**13.3%**	**0.0%**	**0.105**
	Slipped on floor	**N**	**8**	**0**	
		%	**53.3%**	**0.0%**	
Incomplete correction	**No**	**N**	**13**	**1**	
		%	**86.7%**	**33.3%**	
	Yes	**N**	**2**	**2**	**0.043***
		%	**13.3%**	**66.7%**	
Wound infection	**No**	**N**	**15**	**1**	
		%	**100.0%**	**33.3%**	
	Yes	**N**	**0**	**2**	**0.001****
		%	**0.0%**	**66.7%**	
Wound scar	**No**	**N**	**15**	**1**	
		%	**100.0%**	**33.3%**	
	Yes	**N**	**0**	**2**	**0.001****
		%	**0.0%**	**66.7%**	
Stiffness	**No**	**N**	**11**	**1**	
		%	**73.3%**	**33.3%**	
	Yes	**N**	**4**	**2**	**0.17**
		%	**26.7%**	**66.7%**	
Overall Complication	**Not**	**N**	**11**	**1**	
		%	**73.3%**	**33.3%**	
	Complicated	**N**	**4**	**2**	
		%	**26.7%**	**66.7%**	**0.17**
Total		**N**	**15**	**3**	
		%	**100.0%**	**100.0%**	

Data are presented as mean± SD or as frequency and percentage

DISCUSSION

In elderly people with weak bones, a simple fall may result in a distal radial fracture; in young individuals, it can be brought on by high-energy trauma. For management and prognosis prediction, a number of categorization systems are employed, including the AO Classification System. All fracture treatments should aim to relieve as much pain as possible while restoring wrist function [(8)].

There are numerous ways to treat comminuted distal radial fractures in order to achieve this aim as quickly as possible, including K-wire pinning, volar fixed angle locking plates, enhanced external fixators, and fragment specific fixations. Because each strategy has pros and downsides, no one can agree on which is the most effective [(5)].

The treatment of several forms of distal radius fractures by numerous surgeons has altered thanks to open reduction and internal fixation (ORIF) with locked volar plating. Distal radius fractures are commonplace and are become increasingly frequent in older or disabled people [(4)]. These patients require speedy rehabilitation, simple anesthetic due to poor general health, and stable fixation for low bone quality.

For this patient population, volar fixed-angle fixation offers an appropriate therapeutic option because it makes use of the subchondral plate, the only major bone that still exists in severe osteoporosis. The volar technique can be carried out while receiving regional anesthetic and is well tolerated [(9)].

In contrast to conventional screw-plate fixation, angular stable fixation allows for mechanical bone bridging and load-bearing through the locked screw-plate construct; locking-head screws do not rely on the bone thread for traction. These are the key features of angular stable fixation. Early failure of fixation with an angular stable implant will only occur if the entire screw-plate construct pulls out from the bone or if the implant experiences material failure because screws that lock into the plate prevent loosening within the implant [(10)].

Theoretical advantages of volar plate fixation include ease of anatomic reduction because the volar cortex is frequently less comminuted than the dorsal side of the injury, early restoration of hand and upper-limb function, decreased frequency and duration of formal occupational therapy, potential reduction in overall pain, a decreased risk of displacement, and potential cost savings because of a reduced need for radiographs [(11,12)]. Several of these advantages would result from the fixed-angle plate-screw construct's inherent stability.

Rampoldi *et al.* [(13)] evaluated the outcome of fractures of the distal radius with metaphyseal and diaphyseal involvement treated with fixed angle volar plates. The study included 6 female and 15 male patients. The average age of the patients was 41. Mean age was 39.44±7.67 with minimum 27 and maximum 50 years. Regarding sex distribution males were majority with 61.1%, worker and housewives were majority with 33.3% each. Most of the fractures were due to car or motor vehicle accidents (12 cases); domestic accidents were responsible in 5 cases, work injuries in 3, winter sports in 1. According to the AO comprehensive classification, fractures have been classified as A3.3 (12 cases) and C2–C3.3 (9 cases).

Martinez-Mendez *et al.* [(14)] assessed the ability of the volar locking plate to maintain the radiographic parameters over the time in elderly patients with complex intra-articular distal radius fractures. The study consisted in 66 patients, 49 females, and 17 males with mean age of 68.1 (range, 60–81) years. Dominant hand was affected in 54 patients (81.8%). Fractures were AO type C1 in 32 patients, C2 in 28, and C3 in 6.

Also, **Fok *et al.*** [(15)] investigated the efficacy of a fixed-angle locking plate applied through a single volar approach in maintaining the radiographic alignment of unstable intra-articular fractures, 97 patients with 101 intra-articular distal radius fractures, including 13 volarly displaced and 88 dorsally angulated fractures were analyzed. There were 41 female and 56 male patients. The average age was 50.3 years old (range, 18–76 years old). More than 50% of the patients (n = 50) sustained their injury after a simple fall on an outstretched hand. The remaining were work-related accidents, motor vehicle accidents, and sports injuries. Over 80% were C2/C3 fractures, based on the AO classification. 16 open fractures were noted.

In our study, majority of fracture were caused by fall from height (44.4%) and slipping on floor (44.4%).

Rampoldi *et al.* [(13)] reported that all patients had preoperative standard radiographs; CT scan was executed in 6 cases with major articular involvement. Patients were operated on under locoregional anesthesia using a tourniquet. The fracture was exposed via a standard Henry's access extended proximally to the diaphysis. Three different fixed angle long volar plates were used: DVR (Hand Innovation LLC, Miami, FL, USA) plates in 11 cases, Acu Lock (Acumed) in 4, and LCP Synthes plates (Synthes Ltd., USA) in the remaining 6 cases. Patients were evaluated monthly with standard X-rays and clinical examinations according to the Mayo wrist score system; DASH scores were assessed at 3, 6 and 12 months from the operation.

Martinez-Mendez *et al.* [(14)] revealed that all patients were treated with open reduction and internal fixation using a single type of volar locking plate (Acu-Loc, Acumed, Hillsboro, USA), through a standard Henry approach.

Anteroposterior and true lateral radiographic views of both wrists were taken preoperatively and only of the affected wrist at immediate postoperatively, after three, four, six, and 12 months. Radiographic parameters were volar tilt, radial inclination, radial height, ulnar variance, and articular step-off. These parameters were compared with the unaffected wrist.

The Patient-Rated Wrist Evaluation (PRWE) scores were used for clinical evaluation every year for a minimum of two years. The Disabilities of the Arm, Shoulder, and Hand (DASH) score, range of motion with a clinical goniometer, and grip strength with a Jamar dynamometer were also used to evaluate quality of life in comparison to the non-affected hand [16,17].

In a study of **Fok *et al.*** [15], the preoperative radiographic evaluation showed an average dorsal tilt of 22° (range, 35° volar tilt to 60° dorsal tilt), an average radial inclination of 9.7° (range, – 10° to 35°), and an average radial shortening of 4.3 mm (range, 0 to 12 mm). Articular incongruity (step-off or gap of the articular surface) averaged 4.0 mm (range, 1 to 10 mm). All fractures were treated by using a fixed-angle locking plate and a single volar incision overlying the FCR tendon. The plate was applied to the proximal fragment first and then used as a template to reduce the distal fragments and restore the contour of the volar surface and volar tilt.

In our study, the preoperative radiographic evaluation was done. Each patient underwent wrist trauma series which included antero-posterior (AP), and lateral radiographs. The patient was placed on the operating table in supine position, incision was made directly on the radial the flexor carpi radialis tendon. Variable types of plates were used in these operations according to the type and extent of the fracture (Polyaxial distal radius plate and volar locking T plate). Patients were evaluated monthly with standard X-rays and clinical examinations according to the Mayo wrist score system.

In a study by **Rampoldi *et al.*** [13], radiographs showed recovery of normal radial anatomy; radial inclination 20, volar tilt 10, radial length 10 mm, neutral ulnar variance, no articular step-off in 10 of 12 A3 fractures. At the final follow-up, flexion and extension averaged 62.85 [range 40–80, 95% confidence interval (CI) ±3.92, standard deviation (SD) 8.5982] and 73.85 (range 45–90, CI ±4.07, SD 8.931); pronation and supination 85.24 (range 70–90, CI ±2.64, SD 5.80) and 80.23 (range 65–90, CI ±3.49, SD 7.661), According to the Mayo wrist rating system, 4 patients had excellent results (90–100), 10 had good results (80–90) and 7 had satisfactory results (60–80).

Finally, this study seems to demonstrate the effectiveness of volar long plating for treating distal radius fractures that extend proximally to the radial diaphysis.

In the study of **Martinez-Mendez *et al.*** [14], the mean postoperative follow-up was 31 (range, 24–47) months. Compared to noninvolved wrist, the radiographic parameters at immediate postoperative were significantly decrease in volar tilt ($p = 0.036$) and radial height ($p = 0.001$), and without significant differences in radial inclination ($p = 0.116$) and ulnar variance ($p = 0.548$). At the final evaluation, 35 (50.1%) patients had all radiographic parameters restored in comparison with the noninvolved wrists. However, 55 (83.38%) patients had all radiographic parameters within the functional range ($p = 0.001$). Regarding to functional outcomes, all patients but three had a success PRWE (lower than 50) at the final follow-up. No significant relationship between radiographic and functional outcomes was found ($p = 0.474$). This study discovered that volar locking plate fixation was a successful treatment to provide successful functional results for displaced intra-articular distal radius fractures in older individuals. The majority of these older patients' volar plates were able to maintain fracture stabilisation with radiographic parameters within functional range over time, despite the fact that decrease loss in volar tilt and radial height occurred within the first four months [14].

According to **Fok *et al.*** [15], the wrist's range of motion was quite good, and the mean grip strength was 81% of the wrist opposite. They also reported an average follow-up of 28 months (with a range of 24-70 months). The DASH score (Disabilities of the Arm, Shoulder, and Hand) was 8. The problems rate was less than 5%, and two individuals lost their ability to reduce. Within three months after the injury, all fractures were healed.

The vast majority of intra-articular fractures of the distal radius may be treated with a fixed angle volar plate using a single volar approach, regardless of the direction and magnitude of the original displacement [18].

There were some limitations that faced this study. Firstly, the small number of patients included especially those with intra-articular distal radius fractures; type B1 and B2 according to AO classification. Secondly some patients were not cooperative and didn't understand the importance of method of fixation, follow up and physiotherapy; the thing that decreased number of cases included.

Further study should be carried out with larger groups of patients and with longer duration of postoperative follow up to validate the results of this study.

CONCLUSION

Volar fixed-angle locked plating is a valuable technique for distal radius fractures in well planned and selected patients; as it achieves a high rate of union and good functional outcome on follow up and it allows excellent grip strength and range of motion of wrist joint.

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