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Research Article

Functional Outcome In Distal Radius Fracture With Diaphyseal Involvement Fixed With Fixed Angle Volar Plate

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ABSTRACT

AIM AND OBJECTIVES: This study is to assess the functional outcome of patients with metaphyseal and diaphyseal fractures of distal radius treated with fixed angle volar plate.

MATERIALS AND METHODS: 30 patients with metaphyseal and diaphyseal distal radius fractures were managed with fixed angle volar plate. The standard Henrys approach was used. In 22 patients, long fixed angular plate and screws was used and in 8 patients, long fixed angular plate and k wire was used for co-existing ulnar fractures. Radiograph, physical examination, Wrist ROM (range of movements), Grip strength, Disability of arm shoulder and hand score (DASH score) and Mayo wrist score was assessed at 30 days, 60 days, 90 days and 120 days prospectively after surgery.

RESULT: Average time required to heal for all cases were 90 days. Bone grating was done in 1 case to achieve union. Radio ulnar synostosis was seen in 1 case. 23 of 30 cases showed optimum reduction, with neutral ulnar variance and normal radial length. Mean ROM at the end of 1 year was 68.17 (5.33) flexion, extension 80.33 (5.24), pronation 85.33 (4.54) and supination 85.33 (4.54). They were found to be significant ($P < 0.00001$). DASH score was averagely 4 at end of 30 days and 3 during follow up periods. MAYO wrist score showed excellent outcomes in 22 cases, good outcomes in 6 cases, fair outcomes in 1 case and poor outcomes in 1 case at the end of 4 months. DASH score and MAYO wrist score were found to be significant ($P < 0.00001$). Grip strength improved from 64.83 % to 85.20% at end of 4 months and was found to be significant ($P < 0.00001$)

CONCLUSION: In these challenging fractures, fixed angle volar plates are safe and efficient mode of treatment.

Keywords*: Diaphyseal involvement, Distal radius fractures, Fixed long angle volar plate, Internal fixation.*

INTRODUCTION

Metaphyseal and diaphyseal fractures of the distal radius are caused due to high velocity trauma and their management is a challenge to orthopaedic surgeons [1]. Comminuted fractures are common with distal radius fracture and are very difficult to reduce with normal radial length and radioulnar relation [2]. Dorsal approach with distraction plate fixation, external fixation, LCP plates with standard 3.5 mm, and fixed angle volar plates are some of the treatment options commonly used. Among all treatment options fixed angle volar plates has showed promising results and has least complications [3, 4]. Long fixed angle volar plates can stabilize the meta-diaphyseal junction, reduce the distal radius and provide firm fixation of the diaphysis and correct the congruity and relationship of the articular surface, and the length and alignment of the radius. Wrist immobilization is limited to 7 - 10 days only after the surgery while the conventional surgery requires 6 weeks of immobilisation [5]. This leads to reduced risk of contracture and stiffness. Michele Rampoldiet al (2011) has done a research study of fixed angle volar plate on 21 patients with metaphyseal and epiphyseal distal radius fracture and follow up was done for 1 year. DASH scored was 30 points at 3 months, 14 points at 6 months

and reduced to 6.7 at final follow up. ROM (range of movements) wrist was also assessed in his research and found to have significant improvement [1]. Much of the studies were not conducted related to fixed angle volar plate in distal radius fracture. Fixed angle volar plate is commonly available in the instrument set for managing distal radius fracture. Hence, we planned to study the functional outcomes of patients with distal radius fracture treated with fixed angle volar plate.

MATERIALS AND METHODS

The study was initiated after obtaining approval from institutional human ethics committee and was done in accordance with Indian GCP and Declaration of Helsinki. It is a prospective, open labeled study done in 30 patients for a period of 1 year attending orthopedics OPD.

Inclusion criteria

i. Non-treated, closed radial fracture with diaphysis extension to the proximal 3rd part reporting to OPD within 3 days of fracture
ii. AO classification – 2R3A3.3, 2R3C2.3 & 2R3C3.3
iii. Age between 18 – 60 years
iv. Willing to give informed consent

Exclusion criteria

i. Open fractures
ii. Pathological fracture
iii. Closed fracture reporting after 3 days
iv. Earlier treated with other modalities.

Sample size calculation

Sample size calculation was done using the formula

$$n = \left(\sigma \frac{z_{1-\alpha} + z_{1-\beta}}{\mu - \mu_0} \right)^2$$

Where n= sample size, Z1 = 1.76 (standard), $\alpha = 0.05$ (type 1 error), $\beta = 0.20$ (type 2 error), $\mu = 62.85$ (true mean), $\mu 0 = 66.5$ (null hypothesis) and $\sigma = 8.5$ (standard deviation).

Based on the sample size calculation, 30 patients are included in the study after getting informed consent. 20 cases had fractures due to motor vehicle accidents, 8 cases due to domestic injuries and 2 cases due to work related injury. 8 cases had distal ulnar fracture along with distal radius fracture. According to AO classification 8 cases were A3.2, 12 cases were A3.3, 1 case was C2.1, 3 cases were C2.3 and 6 cases were C3.3.

Study procedure

30 patients with metaphyseal and diaphyseal distal radius fractures were managed with long fixed angle volar plate. The standard Henry's approach was used. Procedure was performed within 1-5 days of the injury (mean 2.6 days) under RA with the use of tourniquet. Radial length and alignment were achieved with accurate reduction under C-arm guidance and fixation was then done. In 22 patients, long fixed angular plate and screws was used and in 8 patients, long fixed angular plate and k wire was used for co-existing ulnar fractures. No bone graft was used.

Postoperative care

22 patients were applied with rigid splint with wrist in minimal extension, keeping the elbow free to move, for about 3 weeks. Active wrist mobilization was started after 3 weeks. They were advised neither to lift weights nor to do any heavy physical activity. Fragmented fractures and unstable fractures (8 cases) were immobilized with a BE cast for 4 weeks that was then converted to a removable splint for 2 weeks. Rehabilitation remained the same for them.

Study assessments:

i. Radiograph, Physical examination, Wrist ROM, Grip strength, DASH score and Mayo wrist score was assessed at the end of 30 days, 60 days, 90 days and 120 days prospectively after surgery.
ii. Physical examination done with upper limb in a standardized position (shoulder in adducted and rotated neutrally, elbow flexed at 90°, forearm and wrist in neutral position
iii. A type (Extraarticular) fractures and C type (articular) fractures, the absence or presence of ulnar fracture, and the quality of reduction was used for comparing the outcome.
iv. volar tilt 10° (±5°), radial length 10 mm, radial inclination 20° (±5), no articular step-off and neutral ulnar variance were used as radiological parameters for good reduction. Cases showing deviation of these parameters were classed as imperfect.

v. Double-armed goniometer and Jamar dynamometer was used to measure wrist ROM and Grip strength respectively

Statistical analysis:

- Descriptive statistics of demographic data and end points were carried out within group.
- Mean and Standard Deviation (SD) were derived for the results of wrist ROM
- Median and intra interquartile range (IQR) for DASH score and Mayo wrist score
- Comparative statistics was done within the group by repeated series ANOVA and Freidman test.
- *p value < 0.05 was considered significant.

RESULTS

In this study the functional outcome of patients with metaphyseal and diaphyseal fractures of distal radius treated with fixed angle volar plate were assessed. 30 patients were included in this study. All the 30 patients completed the study without dropouts.

The parameters used to assess the functional outcomes of the patients with metaphyseal and diaphyseal fractures of distal radius treated with fixed angle volar plate were Radiograph, Physical examination, Wrist ROM, Grip strength, DASH score and Mayo wrist score was assessed at the end of 30 days, 60 days, 90 days and 120 days prospectively after surgery.

Baseline demographic data:

Baseline demographic data were collected at the initiation of study. Mean age of the patients was 30.7 (9.8). Among 30 patients, 24 were male patients and 6 are female patients. Based on the mode of injury 20 cases had fractures due to motor vehicle accidents, 8 cases due to domestic injuries and 2 cases due to work related injury. 8 cases had distal ulnar fracture along with distal radius fracture. According to AO classification 8 cases were A3.2, 12 cases were A3.3, 1 case was C2.1, 3 cases were C2.3 and 6 cases were C3.3.

Physical examination and analysis of wrist range of movements:

At the end of 1st month, the mean flexion was 61.7 (6.78), extension was 64.5 (5.62), pronation was 71.5 (4.18) and Supination was 71.5 (4.18). At the end of 2nd month, the mean flexion was 62.33 (6.78), extension was 69.5 (5.62), pronation was 75.67 (4.18) and Supination was 75.67 (4.18). At the end of 3rd month, the mean flexion was 66.00 (6.78), extension was 75.33 (5.62), pronation was 80.5 (4.18) and Supination was 80.5 (4.18). At the end of 4th month, the mean flexion was 68.17 (6.78), extension was 80.33 (5.62), pronation was 85.33 (4.18) and Supination was 85.33 (4.18). Statistical analysis was done by repeated measures ANOVA and were found to be statistically significant (P < 0.00001). The mean ROM are provided in table 1

Table 1: ROM (Mean / S.D)

	1st Month	2nd Month	3rd Month	4th Month	P-value
Flexion	61.17(6.78)	62.33(5.93)	66.00(5.78)	68.17(5.33)	<0.00001*
Extension	64.5 (5.62)	69.5 (5.62)	75.33(5.24)	80.33(5.24)	<0.00001*
Pronation	71.5 (4.18)	75.67(3.88)	80.5(2.74)	85.33(4.54)	<0.00001*
Supination	71.5 (4.18)	75.67(3.88)	80.5(2.74)	85.33(4.54)	<0.00001*

*Statistical analysis – Repeated measures ANOVA, P < 0.5 was considered significant

Analysis of MAYO score:

At the end of 1st month, median MAYO score was 80 (8.75). At the end of 2nd month, median MAYO score was 85 (8.75). At the end of 3rd month, median MAYO score was 80 (8.75). At the end of 4th month, median MAYO score was 90 (5). Statistical analysis was done by Friedman test for repeated measures and were found to be statistically significant (P < 0.00001) as shown in table 2

Table 2: MAYO SCORE

	1st Month	2nd Month	3rd Month	4th Month	P value
EXCELLENT	3	7	7	22	<0.00001*
GOOD	16	16	20	6	
FAIR	10	6	2	1	
POOR	1	1	1	1	

*Statistical analysis – chi-square statistics, P < 0.5 was considered significant

It was also found that, at the end of 1st month, 3 patients showed excellent results, 16 patients showed good results and 10 patients showed fair results. At the end of 2nd month, 7 patients showed excellent results, 16 patients showed good

results and 6 patients showed fair results. at the end of 3rd month, 7 patients showed excellent results, 20 patients showed good results and 2 patients showed fair results. at the end of 4th month, 22 patients showed excellent results, 6 patients showed good results and 1 patient showed fair results. 1 patient showed poor results in all 4 months. Statistical analysis was done by Chi-square and were found to be statistically significant (P < 0.00001).

Analysis of DASH score

At the end of 1st month, median DASH score was 4 (1). At the end of 2nd month, median DASH score was 3 (0.75). At the end of 3rd month, median DASH score was 3 (1). At the end of 4th month, median MAYO score was 3 (1). Statistical analysis was done by Friedman test for repeated measures and were found to be statistically significant (P < 0.00001) as shown in table 3.

Table 3: MAYO AND DASH SCORE (median / IQR)

	1st Month	2nd Month	3rd Month	4th Month	p-value
DASH score	4 (1)	3(0.75)	3(1)	3(1)	<0.00001*
MAYO score	80 (8.75)	85 (8.75)	85 (8.75)	90 (5)	<0.00001*
*Statistical analysis – FRIEDMAN TEST FOR REPEATED MEASURES, P < 0.5 was considered significant					

Grip strength

At the end of 1st month, mean grip strength was 64.83%. At the end of 2nd month, mean grip strength was 72.90%. At the end of 3rd month, mean grip strength was 77%. At the end of 4th month, mean grip strength was 85.20%. Statistical analysis was done by chi-square test and was found to be statistically significant (P < 0.00001) as shown in table 4

Table 4: GRIP STRENGTH (%)

	1st Month	2nd Month	3rd Month	4th Month	P-value
MEAN (S.D)	64.83 (2.70)	72.90 (1.60)	77.00 (1.20)	85.20 (5.38)	<0.00001*
*Statistical analysis – Repeated measures ANOVA, P < 0.5 was considered significant					

Radiographs

Fracture united in average of 90 days in 28 of 30 cases. Incompletely healing diaphyseal fracture was seen in 1 case at 4th month and was grafted with bone, and 2 months' later consolidation was achieved. 9 months later, 1 case reported radioulnar synostosis. But leaded to complete recovery of Rotation of forearm. Recovery of normal radial anatomy: volar tilt 10°, length 10 mm, inclination 20°, no articular step-off and nil ulnar variance in 18 of 20 cases of A3 type fractures was seen radiographically. There was a patient with ulnar head fracture, and was healed with minimal dorsal ulnar subluxation and incongruity of the articular surface, clinically was with an incomplete supination among the other 2 cases. And 1 case showed neutral volar tilt. 8 of 10 cases of C2-C3 class showed mild incongruity. All cases were restored with normal radial length and 0mm of ulnar variance. Delayed healing and a radio-ulnar synostosis were the major complications with 2 cases, they needed secondary surgery. Satisfactory result was achieved and complete recovery of the rotation of forearm was recorded.

Figure – 1 & 2: Type C3 fracture of a 73 years old male, Bone healing at 3 months

Figure 3: Bone healing at 6 months

DISCUSSION

Distal forearm fractures including radius or ulna resulting from high energy trauma causes diaphyseal and metaphyseal injury with soft tissue and major joint involvement. It results in nonunion, CRPS (complex regional pain syndrome), finger stiffness, delayed union due to excessive distraction of hardware [6, 7]. Recent study has reported that better radiological and functional outcomes of Open reduction with external fixation compared to RCT [8]. Inadequate fixation of epiphyseal and metaphyseal fractures is seen with the standard straight plate compared to volar plate which provides optimal for diaphysis fixation. Moreover, Straight plates are bulky and cause damage to flexor tendons when positioned from volar aspect. They need to be bent down to provide volar inclination. Ginn et al. [9], in his recent study has used a new technique, where in they used bridging the fracture with 3.5 mm standard plate applied dorsally and fixed with some distraction from the radius to the distally located at 3rd metacarpal shaft. This is used in ligamentotaxis and for external fixation of small, comminuted intraarticular fracture which are hard to fix with plate and other non-bridging methods. The use of K-wires, supplementary screws and bone grafts are included in the procedure as an alternative. After radiographic evidence of healing (mean: 124 days) the implant is removed and wrist mobilization is initiated as early as possible, which showed better clinical and radio-graphical results [10]. Main disadvantages of conventional surgery are prolonged immobilization of wrist, secondary surgery to remove implant which causes the potential damage to the extensor tendons, difficulty in reduction and stabilization of the volar fragments, and the risks of distraction of the radiocarpal joint (CPRS, finger functional impairment) [6,7]. It is observed in this study that both dorsal and volar comminution can adequately stabilize articular fragments both in normal as well as osteoporotic bone [11, 12]. It helps in restoration of radius bone length with radial and palmar tilt, adequate blood supply to fracture site was maintained with volar plate fixation with screws or pins which acts as a internal fixator which reduces the need for bone graft. In conventional method, Metaphyseal and diaphyseal fractures are fixed with long plate where they bypass the fracture site and are fixed with 3 screws in the healthy diaphysis. While in newer technique we use a single cortical screws and multiple wire loops for better stability and better reduction of the meta-diaphyseal part of fragmented and comminated fractures. Other advantages include, accurate fracture stability, correcting the radial length, correcting the radioulnar and radiocarpal relation, minimizing the soft tissues impingement, and allowing an early recovery. Depending upon the stability of the fracture, the associated ulnar fracture was treated with percutaneous pin fixation or Open Reduction and IF depending on the fracture stability [13, 14]. In this study, this technique leads to healing of all fractures except 1 case which needed bone graft. 1 case reported radio-ulnar synostosis. 23 of 30 cases showed optimum reduction, with neutral ulnar variance and normal radial length. Mean ROM at the end of 1 year was 68.17 (5.33) flexion, extension 80.33 (5.24), pronation 85.33 (4.54) and supination 85.33 (4.54). DASH score was averagely 4 at end of 30 days and 3 during follow up periods. MAYO wrist score showed excellent outcomes in 22 cases, good outcomes in 6 cases, fair outcomes in 1 case and poor outcomes in 1 case at the end of 4 months. Grip strength improved from 64.83 % to 85.20% at end of 4 months. It was also noted in our study that Extra-articular A3 type of fractures showed better outcome than the articular C2 and C3 types of fractures, but significant differences were not noted among these two groups ($p = 0.2$). Associated ulnar fractures also did not affect the outcome ($p=0.4$). In fractures with many small articular fragments of C3 type, fixation with periarticular plates can be difficult where, some authors suggest the use of external fixators to avoid collapse of the articular surface [15,16]; but in this study external fixator was not used.

CONCLUSION

Our study seems to report the competence of long volar plating for managing distal radius fractures that extend proximally to the diaphysis. In these challenging fractures, fixed angle volar plates are safe and efficient mode of treatment.

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