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Functional and radiological outcome measures of surgically treated unstable distal radius fractures using a variable angle volar locking compression plate

Dr Ajith K

MBBS, D Ortho, MS Ortho, Assistant professor, Dr Moopens Medical College, Wayanad

Dr Mathew Panackathottam*

MBBS, MS Ortho, Assistant Professor, Dr Moopens Medical College, Wayanad
*Corresponding author

Dr Ganesh P Subbaiah

MS Ortho, Associate Professor, DMWIMS, Meppadi. Wayanad. Kerala

Dr. Jishnu. V.N.

MBBS, MS Ortho, Senior Resident, Dr Moopens Medical College, Wayanad

Abstract--Background: Various treatment modalities have been described to manage unstable distal end radius fractures. The use of variable angle volar locking compression plates is promoted for the management of these difficult fractures. Objectives: Objective was to evaluate the clinical and radiological outcomes in surgically treated unstable distal radius fractures with variable angle volar locking compression plates. Patients and Methods: We reviewed 23 out of 36 unstable distal end radius fractures that were surgically treated with variable angle volar locking compression plates at our institute. The mean age of these patients were 32.82 ± 11.81 years (range 19 to 62) and the mean follow-up duration was 11.04 ± 2.47 months (range 6 to 15). All of them underwent open reduction and internal fixation with a variable angle volar locking compression plate. Radiological parameters measured were radial inclination, length, tilt, and ulnar variance. These were measured at six weeks and at the final follow up. The functional evaluation was by measuring the range of motion at the wrist and the grip strength. To assess the final outcome Gartland and Werley's demerit scoring system was used. Results: There was significant improvement in the functional outcome indices from six weeks to the final follow-up, while the radiological parameters were

maintained. According to Gartland and Werley, excellent results were reported in 65.2% cases, while good results were present in 35% cases. There were two cases of pin tract infection that responded to oral antibiotics. Hyper sensitive scar was seen in one patient, while another had carpal tunnel syndrome that was conservatively managed. Conclusions: The use of variable angle volar locking compression plates in treating unstable distal end radius fractures is associated with excellent to good functional outcomes with minimal complications.

Keywords---Locking Plates, Radius fracture, Volar Plate, Fracture Internal Fixation.

Introduction

10% of all skeletal fractures in humans constitute distal radius fractures¹. Mainly affect the elderly population and always secondary to low energy trauma². However, in young adults road traffic accidents accounts for a substantial number of cases and majority of them are unstable. For good functional outcomes restoration of volar angulation, radial length, and radial inclination are essential. Restoration of articular congruity and stable fixation reduce the incidence of osteoarthritis and also help with earlier rehabilitation³. Plaster cast application, Kirschner wire fixation, dorsal and volar plates, and external fixation are the various treatment modalities described for the treatment of these fractures^{4,5}.

Locking plates are favored in the treatment of these complex fractures especially in elderly osteoporotic fractures⁶. Because of its ability to mechanically bridge the bone and bear the load through the locking construct there is lower incidence of failure. The subchondral placement of distal screws as pegs prevents loss of correction and achieves good functional results⁵. This is because these plates allow the screws to be inserted in a predefined direction, and do not take into account the personality of the fracture and any variability in the positioning of the plate. These type of fractures can be better managed with the use of a variable angle locking plate (VALP) as it allows greater flexibility in terms of screw angle insertion and the engagement of periarticular fragments⁷. Additional fixation methods such as kirschner wire and dorsal plate may be required in comminuted distal end radius fractures. The literature on the functional and radiological outcomes of those treated with variable angle locking plates is scarce even though we do have a number of studies on the operative management of distal end radius fractures treated with fixed angle volar locking plates.

Objectives

A selected cohort of patients with unstable distal end of radius fractures was retrospectively analyzed in order to determine the functional and radiological outcomes of treatment with VALP.

Patients and Methods

A retrospective review of patients with distal end of radius fractures who were treated surgically between June 2018 and March 2019 was done and then followed up for at least six months. The inclusion criteria for the study were:

Patients aged between 18 to 70 years with isolated closed intra-articular distal end of radius fractures with displacement more than 2 mm from the anatomical position, a dorsal inclination of the distal fragment of more than 20°, a radial shortening of 10 mm or more, and dorsal comminution⁸⁻¹⁰. The exclusion criteria for the study were:

1. Pathological fractures.
2. Patients with delayed presentation (> two weeks).
3. Bilateral wrist fractures.
4. Pregnant females.

By reviewing the charts from the medical records section of the institution all preoperative (Figure 1) and postoperative data were obtained. The patients were contacted by telephone to arrange an additional visit. All of the patients gave informed consent to participate in the study. The study was approved by the institutional review board.

A total of 36 patients were contacted, out of these 23 were willing to participate in this study. The mean age of these patients were 32.82_11.81 years (range 19 to 62). There were 18 males and five females. There were 17 dominant and six non-dominant hands. The mode of injury was motor vehicle accident in 18 patients, fall while walking in five patients. The fractures were classified on the basis of the Arbeitsgemeinschaft fur osteosynthesefragen (AO) classification. There were four AO type A3, nine type C2, and ten type C3.

The patients were given general/regional anesthesia as per the anesthesiologist discretion. The fracture was approached as popularized by Henry et al under tourniquet control¹¹. All of the patients underwent open reduction and internal fixation with a 2.4mm variable angle locking plate. The use of bone grafting or bone graft substitutes was left to the discretion of the operating surgeon. Active finger movements were advised in the immediate post-operative period for all patients. The wrist was immobilized in a splint for two weeks which was removed at the time of suture removal and all the patients were taught the standard range of motion exercises for the wrist and fingers by a physiotherapist.

The follow up serial radiographs were used for radiographic assessment. These included anteroposterior and lateral views taken in the immediate post-operative period, at three weeks, at six weeks, and thereafter to assess fracture union and any fracture or hardware related complications (Figure 2). Standard goniometer was used to measure the quality of reduction and then classified as satisfactory in cases with a dorsal tilt < 10°, < 2mm of radial shortening, and < 2mm of joint surface step-off^{12,13}. The range of motion at the wrist joint was measured with the help of a goniometer. The grip strength was calculated using a digital hand dynamometer (Takei scientific instruments Co. Ltd., Japan). The patient was made to stand with his/her elbow at full extension and with the shoulder

adducted and neutrally rotated. The grip strength was measured in kilograms and as a percentage of the normal strength of the other wrist. All of the functional parameters were recorded at six weeks and at the final follow-up. The functional outcome was evaluated using the objective and subjective criteria described by Gartland and Werley¹⁴.

Statistical Analysis

To compare the results Student's t-test was used between patient groups, with statistical difference defined as 5% (P<0.05).

Results

In the present retrospective cohort study based on our inclusion criteria, 23 patients were available for analysis (Table 1). The mean follow-up duration was 11.04 ± 2.47 months (range 6 to 15). Five patients developed complications among the 23 patients enrolled in the present study. One patient developed a scar tenderness that resolved conservatively, while two patients developed pin tract infection that again resolved with regular dressings and oral antibiotic administration for two weeks (Cefuroxime 500mg twice daily). There was screw misplacement in one patient, which remained symptomatic at follow-up (Figure 3). Another patient developed features of carpal tunnel syndrome, which was managed with a cock up splint and the symptoms resolved in three months. None of the patients had tendon rupture, malunion, or nonunion.

Immediate post-operative radiological parameters were compared with those at the time of final follow-up, as outlined in Table 2. The average radial inclination loss was 0.68 mm, radial length was 0.1 mm, volar angle was 0.26°, and ulnar variance was 0.16 mm, although the change in indices was not statistically significant.

Clinical parameters (flexion, extension, supination, and pronation) as measured at eight weeks and at final follow-up revealed significant improvement (Table 3). According to Gartland and Werley's scoring system, 15 patients had excellent results and eight patients had good results. None of the patients had fair or poor results.

Table 1: Clinical profile of patients^a

Clinical Profile	Data
Gender	
Male	18
Female	5
Age, y	32.82 ± 11.81
Mode of injury	
RTA	18
Fall	5
Type of fracture (AO Classification)	
A3	4
C2	9
C3	10

Abbreviation: RTA: Road traffic accident.

a Values are expressed as mean standard deviation or No.

Table 2: Radiological parameters^{a,b}

Parameter	Immediate Postoperative Period	At Final Follow-Up	P Value
Radial length,mm	12.04_1.91	11.84_2.04	0.1309
Radial inclination,°	23.08_2.46	22.89_2.64	0.0951
Ulnar variance,mm	-0.33_0.68	-0.29_0.58	0.1337
Volar angulation, °	5.56_5.54	5.21_5.72	0.1334

A Values are expressed as mean standard deviation.

B There was no significant difference in the radiological parameters between different follow ups.

Table 3: Clinical Outcome Measures ^a

Parameter	At SixWeeks	Final Follow-Up
Flexion,°	46.73_7.24	71.91_8.08
Extension, °	49.08_6.28	76.95_5.70
Supination, °	75.47_6.02	81.86_6.28
Pronation, °	72.04_5.09	77.65_6.01
Percentage grip power, %	41_6.23	94.52_5.02

A Values are expressed as mean _standard deviation.

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Pre op lateral



Pre op ap view



Post op lateral view



Post op ap view



Discussion

Closed reduction and casting is done in minimally displaced fractures but open reduction and internal fixation is opted for more complex fractures of distal end radius fractures. Restoration of the wrist's anatomy by doing an open reduction and internal fixation helps in faster rehabilitation and good clinical outcomes¹⁵.

Currently favored treatment for comminuted distal end radius fracture patterns and osteoporotic bones is volar plating¹⁶. The dorsal cortex of the distal end radius is more often comminuted than the volar cortex and anatomical reduction of the palmar cortex is easier and this restores the radial shortening. Moreover, the palmar cortex compared to dorsal is better contoured for plate application.

Locking volar plates provide secure and reliable fixation than nonlocking volar plates because of their better angular stability properties especially in complex and osteoporotic fractures^{17,18}. At final follow up Kanabar et al¹⁷ did not notice any decrease in the radiological parameters after early mobilization in fractures treated with volar fixed locking plates¹⁶. However, Gruber et al. noticed statically significant loss of parameters like radial inclination and volar tilt with the use of volar fixed-angle plates¹⁹. Similar results are seen in few other studies too^{20,21}. This is more in comminuted distal end of radius fractures (AO types C2 and C3) and variable angle plates addresses this problem better. In Stanbury et al. study volar fixed and variable angle locking plates showed similar mean load to failure on cyclical loading and thus the biomechanical rigidity²². VALPs can tolerate better the physiological compressive loads too during movement of the wrist.

Due to the flexible plate positioning and subchondral purchase in the articular fragments VALP allow and maintains the reduction. Figl et al. in their case series on VALP found no significant loss of radiological parameters in the follow-up period²³. Similarly, our case series too there wasn't any significant loss of radial length, radial inclination, volar angle or in ulnar variance at final follow-up when compared to immediate post-operative period.

Late flexor tendon rupture is one of the commonest complication seen in these comminuted intra-articular radius fractures treated with plates placed distal near to the watershed line in order to capture the articular fragments²⁴. This can be to some extent avoided by VALP by placing the plate proximal to the watershed line and still be able to engage those fragments. Another advantage is the bicortical purchase and the flexibility offered by the variable angle system to capture the various fracture fragments (proximal/distal and medial/lateral) in the management of these complex fractures²⁵.

In comminuted fracture patterns (AO type C3) additional methods like Kirschner wire and/or dorsal plating have been advocated by various other authors^{26,27}. After VALP these additional methods of fixation is on the decline. Again it's adaptation of screw direction avoids intraarticular positioning and able to capture specific fracture fragments. Superiority of variable angle volar locking plates over fixed-angle locking plates in capturing the distal radial styloid is been reported by Stanbury et al²². In our case series, however additional Kirschner wires were used in three cases to stabilize the unstable distal end radius fracture.

In all the cases, Kirschner wires were used to engage the small radial styloid fragments that could not be engaged with the plate screws (Figure 4).

Complications are similar to those found with other volar plates such as hardware prominence, tendon rupture and loss of reduction. Poor results are primarily to not understand the articular anatomy and poor reduction. This is the same with this newer implant too (VALP). In our study the overall complication rate was 21.7%, which is comparable to that of Jagodzinski et al. study²⁸. They reported a complication rate of 19.6%, and majority were screw misplacement. While Kawasaki et al. reported only few cases of screw misplacement²⁹. In our study, there was only one case of screw misplacement because extra time and care were taken to prevent this complication. However, no effort was made to calculate the resultant extra fluoroscopy exposure. The smaller sample size in our study could also be the reason for only a single case of such a complication.

According to Gartland and Werley's demerit scoring system, our results revealed that 65.22% patients had excellent results and 34.78% good results (Figure 5). As per Figl et al. study excellent results were seen in 37.5% of patients, good results in 67%, and fair results in 1%²². Mean DASH (disabilities of the arm, shoulder, and hand) score reported in Jagodzinski et al. study was 18.2 in patients treated with VALP²⁸. The results are, however, not truly comparable with those of our study as a different scoring system was used in the evaluation of the results.

Patients with distal end radius fractures achieve the majority of their grip strength and movement in six months as per MacDermid et al³⁰. We took as the benchmark and our minimum duration of follow-up was six months. Kanabar et al. in their large series of 170 patients with distal end radius fractures, noticed that parameters such as range of motion and grip strength were regained by up to 94% in the three months after volar plating¹⁷.

Limitation of the present study is that this is a retrospective cohort treated surgically by experts with more than 10 years of experience. It is difficult to say whether the findings of this study can be generalized to patients managed at other centers. There was also a wide range of patient ages. A number of patients did not consent to participate in our study or else could not be traced due to an incomplete contact address or contact number. Further, some of the patients could be osteopenic, although this was not assessed with dualenergy X-ray absorptiometry (DEXA) or a computerized tomography scan. It is difficult to compare other modalities of treatment to the outcomes of this study as we did not compare treatment methodologies. However, we believe that the data from the present study can be used for comparison going forward.

In conclusion, variable volar locking plates (VALP) are a treatment method with a low complication rate. Early rehabilitation can be initiated without the fear of a decrease in radiographic indices and hence functional results with these plates especially in unstable distal end radial fractures. The present study despite its small sample size should provide the basis for a prospective study involving variable volar locking plates in future.

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