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Original Research Article

An Evaluation of Variable-Angle Volar Locking Plate for Distal Radius Fractures

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Abstract

Introduction: This study is regarding the fracture of distal end of radius and its management. There are several treatment modalities available for fracture distal end radius. Complication rate with majority of modalities is very high. The prevalence of radius fracture at distal end was reported to be about 37 for every 10,000 person-years among female population while in male population it is about 9 for every 10,000 person-years over the age of 35 years. It was proposed that volar locking plate is better to improve patient's outcome in terms of radiological parameters and also to increase the range of motion. Several volar and dorsal plates are available for managing the distal radius fractures in the India. This can be classified as fixed-angle locking plates, non-locking and recently available variable angle locking plates.

Aims and Objectives: To evaluate the outcome of applying variable angle locking plates in comparison to existing treatment modalities in terms of improvement in radiological parameters and functional outcome.

Materials and Methods: In this retrospective study, patients with distal radius fractures treated with variable angle locking plate were considered. The outcome parameters for analysis were determined at different follow up time i.e. immediate post op, at 8th week and 6 months after operation.

Results: The study found that the improvement in radiological picture and functional movements were significantly better (p>0.05) and suggest to use volar variable angle locking plate as better alternative than ORIF and fixing with fixed angle locking plate. Gartland and Werley's scores also came to be excellent with 73.52% of patients.

Conclusion: The study has concluded that variable angle volar locking plate can be used with lower complication rate and should be considered in the guidelines to be used as better treatment modality to the existing treatment modalities.

Keywords: Locking Plate, Radius Fracture, ORIF, Distal Radius Fracture, Volar Locking Plate

Introduction

Distal radius fractures comprise 10% among all other skeletal fractures in humans [1]. These make up between 10% and 25% of all extremities fractures and are one of the most commonly occurring fractures seen in treatment centers[2,3]. Within ten years, it is anticipated that perhaps the occurrence of such fractures will keep rising as life expectancy increases and the incidence of osteopenia

rises [3]. These fractures, includes low-energy trauma [4], and high-intensity traumas like the one brought on by automobile crashes, commonly seen in younger generations. For the better functioning of the wrist joint, the recovery of volar angulation, inclination, and radial length are all crucial. Osteoarthritis occurrence is decreased along with early treatment with maintaining articular congruity and stable fixation [5]. A distal radius fracture will occur in more than 10% of women throughout their entire lifespan [6]. Distal radial fracture prevalence was reported in multicenter epidemiological research as about 36.8 per 10,000 person-years in females and 9.0 per 10,000 person-years in males over the age of 35. A cohort of 1.4 million people had 15,000 distal forearm fractures, according to the analysis of 5 percent samples of Medicare claims records from about 1986-1990. The frequency of distal radial fractures is predicted to rise as people live longer. By 2030, it's anticipated that the absolute amount of such fractures will increased by more than 50%. [7]. With 640,000 distal radius fractures happening each year in the India simply, the impact of these fractures is significant [8]. Most of these fractures can be successfully healed without surgery but will be malunited. Yet, it is thought that 40 to 49 percent of patients have unstable fracture and could be benefited from surgery [6]. In order to prevent radiocarpal arthritis, impingement, and instability, creating insufficient strength and flexibility, aim of treatment should be maintaining volar tilt, articular congruency, radial inclination, and height must for better recovery during the course of repairing distal radius fractures. Effective therapy of these fractures depends critically on knowledge of distal radius anatomy. The aim of treatment should be to maintain standard radial height and inclination, volar tilt of the distal radius [7]. Locking plates are used in the management of such difficult fractures to combat osteoporosis and high demands in young population [9].

Open reduction and internal fixation (ORIF), percutaneous pinning, closed reduction and casting, external fixators and other procedures are available for treating distal radius fracture [10,11]. A fact as closed reduction and casting are still effective long-term solutions for some fractures [12,13] but ORIF can better restore wrist architecture and mobility and produce satisfactory results [14,15].

Several volar plates are available for managing the distal radius fractures in the India. This can be classified as non-locking, fixed-angle locking and recently available variable angle locking plates [16]. Being popular is somewhat the outcome of biomechanical benefits of volar plate fixation in comparison to other techniques [17,18]. Volar and dorsal plates, intramedullary locking nailing and radial fragment-specific fixation are among the ORIF alternatives [19]. The goal of treatment is to offer stable fixation of the periarticular fracture even with comminution or osteopenia, & the capability of early mobility and recovery, volar locked plating has attracted attention recently [20]. A reduced prevalence of nonunion is achieved by mechanically bridging the bone with locking volar plate and bearing the load through a locking structure. Distal screws must be placed subchondral to avoid loss of reduction and to produce positive functional outcomes. It was shown that volar locking plate fixation enables the early rehabilitation [21]. Most fracture subtypes, along with some dorsally unstable distal radius fractures can now be successfully fixed because of the different volar locking plate designs that have been accessible in recent times. When compared to a dorsal approach, these have the benefit of improved soft tissue coverage and lesser extensor tendon impairment. Particularly in fractures that seem to be distal towards the watershed line, the fracture strength after plates must

be evaluated intraoperatively and if needed treated with a different strategy. Such far-distal fracture might need extra fixation distal to the plate with suture wires to stabilize the marginal lip fracture if a typical volar plate intended for implantation proximal to the watershed line is employed. Volar fixed-angle locking plates don't consider fracture's personality or any variations in the plate's placement, instead they enable the screws to be put in a given direction. A variable-angle plate can help facilitate this kind of fracture better because it offers more flexibility for screw insertion and periarticular fragment engagement [22].

Variable-angle locking screws ranging to 30-40 degree angular variations for both plate and locking screw have been formed on the basis of newer locking technology [23]. The likelihood of screw penetration of the joint while attempting to capture dorsal fragments by distally directing variable-angle screws via the plate is reduced. Volar plates with variable-angle locking screws have lately been made accessible, giving treatments for distal radial fracture more flexibility by plate and screw fixation. Numerous researches are conducted on the surgical care of distal radius fracture for treatment with fixed-angle volar locking plates but there is little information available for radiology and functional results of patients taking treatment with variable-angle locking plates [24].

Materials and Methods

This current study is of retrospective design. The patients who came to our hospital between December, 2021 and May, 2022, are only considered. The patients with radial fracture (distal end fracture), were treated firstly and then, they were asked to come for follow-up study after 8 weeks and 6 months. The included patients were from 18 years to 65 years old, patients with intra-articular fracture at distal end of radius, patients with no underlying chronic condition or osteoarthritis and the patients who cooperated with the whole treatment protocol of the hospital including visiting the follow-up study. The exclusion criteria were patients with pathological fracture, patients having delayed presentation, bilateral wrist fracture, pregnant females and those patients who did not cooperate or follow the whole treatment protocol till the end, were all excluded.

After applying inclusion and exclusion criteria, 34 patients were considered for this study. The classification of fracture was done according to Arbeitgemeinschaft fur Osteosynthesefragen classification. The patients were given regional anesthesia and the fracture was accessed through the volar incision lateral to radial artery. Then Open Reduction and Internal Fixation (ORIF) done by utilizing variable locking plate of 2.4 mm. The patients were asked to move their fingers actively post-operatively. The upper limb of each patient was kept immobilized by using splint for 7 days, after which, the splint was removed and each patient was given exercises to increase range of motion.

The follow-up study was done by radiographic images which were taken post-operatively, at 8th week and then after 6 months, images were taken for assessment of union of the fracture and appearance of any fracture related complication. Goniometer was used for determining the outcome of ORIF. The study considered recording the outcome parameters for analysis at intervals. The subjective criteria of the outcomes were evaluated by Gartland and Werley.

Statistical analysis

The study used SPSS 25 and excel software for effective analysis. The study conducted t-test for efficient analysis to evaluate the outcome of volar locking plates. The level of significance was considered to be 0.05

Results

The study has shown that the mean age of the patients was 32.55±9.5 years old. There were 23 males (67.64%) and 11 females (32.34%), in this study. The mode of injury was mostly found to be Road Traffic Injury followed by domestic fall and violence. The study also noted that there were 18 cases (52.94%) of C3 type of fractures, followed by C2 type (12, 35.29%) and A3 type (4, 11.76%).

Table 1: Basic and clinical characteristics of the study sample

Characteristic	Value
Age (mean ± standard deviation)	32.55±9.5
Gender	
Male	23 (67.64%)
Female	11 (32.34%)
Mode of Injury	
Road Traffic Injury	20
Domestic Fall	8
Violence	6
Fracture type	
C3 type	18
C2 type	12
A3 type	4

The study has recorded the radiological parameters, immediately after the operation which was compared with the final follow-up. Table 2 shows the findings of radiological parameters measured during these two times and significance between the two follow up measurements.

Table 2: Measurements of radiological parameters determined during two follow up studies and the *p*-value between them

Parameter	Study Immediately after operation	Follow-up study	*p*-value*
Length of radius (in mm)	12.21±1.85	11.20±2.09	0.1505
Radial inclination	22.35±2.32	20.23±2.10	0.0869
Volar angulation	5.25±5.31	4.85±4.51	0.1329
Ulnar variance (in mm)	-0.30±0.52	-0.28±0.22	0.1339

* $\alpha = 0.05$

The outcome or clinical parameters were determined at 8th week and during the final follow up after 6 months. The study found that there is strong significance in improvement between the follow up studies. Table 3 shows the improvement in various anatomical movements of the fractured region at 8th week and final follow up.

Table 3: The determination of anatomical movements measured in degrees during different follow up studies

Parameter	At 8th week follow up	Final Follow-up	*p*-value*
Extension movement (in °)	45.25±6.35	72.55±8.02	0.067
Flexion movement (in °)	48.55±6.36	77.36±6.36	0.072
Pronation movement (in °)	71.12±6.01	78.12±6.15	0.0895
Supination movement (in °)	74.22±5.26	82.66±6.36	0.0691
Percentage of gripping (%)	40.25±6.33	95.62±5.08	0.0632

The study also evaluated the patients' outcome with Gartland and Werley's scores and found that 25 patients (73.52%) had shown to have excellent score and 9 (26.47%) patients had good score.

Discussion

Now a days plating is used for treating distal radius fracture having the goal of early functional recovery and stable construct. To achieve this objective, a variety of strategies, plates, and reduction techniques might be employed. The volar plate is one of the plate design innovations that has produced great functional results with reduced risk of complications. Aimed at surgical treatment of distal radius fracture, volar plate fixation with fixed-angle locking screws has resulted in satisfactory results in terms including both functioning and radiological criteria. Using fixed-angle volar plates, some investigations have observed a lack of reductions at short-term follow-up [25-28]. One study revealed that approximately 40 percent of individuals lost about more than 5 degrees of volar tilt [25]. It's been suggested that with the introduction of variable-angle locking plate will enable better plate placement flexibility and subchondral screw positioning, perhaps enhancing fracture purchase and reductions management. Volar plating is presently preferred for osteoporotic bones and comminuted distal radius fractured structures [29]. Anatomically reducing the palmar cortex restores radial shortening because of volar cortex at the distal end of the radius is frequently lesser comminuted compared to the dorsal cortex. Furthermore, in terms of plate application, palmar cortex is better sculpted than the dorsal cortex. The usage of locking volar plates has replaced the use of non-locking volar plates [30,31]. Early mobilizing in fractures managed by volar variable angle locking plates, according to Kanabar et al., did not result in a reduction in the radiographic alignment at terminal follow-up [16]. Furthermore, Gruber et al. found, using volar variable angle plates resulted in a statistically significant loss in parameters such as radial inclination and volar tilt in a case series with comminuted distal end radius fracture [32].

Additional investigations by usage of volar fixed-angle plates have similarly documented a decrease in radiology-related parameters along the course of the follow-up term. [33, 34].The comminuted distal end radius fractures showed the greatest change in values (AO types C2 & C3). In many of these situations, the inclusion of variable angle plates solved the issue. Concerns were raised about the biomechanical stiffness of locking plates with changeable angles versus fixed angles. Stanbury et al. demonstrated that average load to failing on cyclical load for the volar fixation and variable angle locking plates was comparable [35]. With variable angle locking plates, the physiological compressive pressures that occur during wrist action can be comfortably endured. Based on flexible plate location, it enables subchondral purchase in the articular fragments and may hence sustain the reductions. Figl et al. identified no instances of a substantial reduction of radiology measures in their case reports on variable angle locking plates during the follow-up term after fixing [36]. Similar to this, despite early and rigorous rehabilitation, in several cases mean reduction in radial length and inclination, and volar angle also changes in ulnar variance is never substantial at ultimate follow-up in compared to especially in the later term. To collect the articular fragment in comminuted intra-articular radius fracture, the volar plate distal might have placing close to watershed line; yet, might also cause a late flexor tendon rupture [37]. Close to the watershed line, a locking plate with a variable angle still can contact these fragments. Another crucial step in managing complex fracture patterns is bi-

cortical purchasing, which could be accomplished by flexible plating location in variable angle plates. Due to flexibility provided by the variable angle system allows for the accommodation of several line (proximal/distal and medial/lateral) [38]. In some comminuted fracture patterns, several writers documented the utilization of additional techniques like Kirschner wire or dorsal plating (AO type C3).

These extra techniques of fixation have been less common since the invention of variable angle locking plates. In order to avoid intra articular penetration and engage particular fracture pieces, the screw direction must be adjusted. To capture the distal radial styloid, Stanbury et al. found that variable angle volar locking plates outperformed fixed-angle locking plates [35]. Three patients, though, in a small number of case series, needed further treatment to stabilize the instability in distal end radius fractures. A cortical screw has been used in one particular instance, while Kirschner wire has been used in two situations engaging small radial styloid fragments that cannot be engaged with the plate and screw. Poor outcomes with the much more recent implant will be caused by failure to understand the articular anatomy of distal end radius and inadequate repair of fractures.

Similar issues with other volar plates include hardware prominence, tendon discomfort and loss of reduction is seen. In bi centric research over distal radius variable angle locking plates, Jagodzinski et al. studies show a complication rate of 21.7 percent, which is close to the report's total complication rate [39]. Whereas Kawasaki et al. showed no recorded instances of malposition of screws, they showed a complication rate of 19.6%, the bulk of which involved screw misplacement [40].Figl et al. documented that 37.5 percent of individuals had outstanding findings, 67 percent had great results, and 1 percent had fair results [36]. Patients receiving variable angle locking plates had an average DASH (disabilities of the arm, shoulder, and hand) score of 18.2 according to Jagodzinski et al [39]. However, because a separate scoring system was employed in the evaluation of the data, the findings are not really comparative. In our investigation, the minimum follow-up period was six months. Individuals having distal radius fracture show recovering of bulk grip strength and movement in 6 months, according to MacDermid et al [41]. Kanabar et al. observed that in a larger section of 170 individuals with distal end radius fracture, metrics that show ranging with motion and grip strength recovered up to 94 percent in 3 months following volar plating [30]. To maintain fracture fixation and reduce implant-related problems, surgeon must select the right implant and screws for the best results. To achieve an anatomic reduction of the fracture fragments, a number of procedures, including the targeted lengthening of the radial height and correction of the volar tilt utilizing plate leverage, may be helpful. For management of displaced unstable distal radius fracture, volar locking plates, particularly variable angle locking screw volar locking plates, seen of becoming more and more popular [42]. The variable-angle locking plate's attraction is based on the surgeon's improved flexibility in fracture repair. Early biomechanical and clinical investigations suggest that these new implants will continue to be successful despite the scarcity of research. Variable volar locking plates are a therapy option with minimal risk of complications, to sum up. Early rehabilitation is facilitated by the use of such plates without having to worry about functional outcomes and radiographic markers declining. As a result, it might be a helpful treatment option for unstable distal end radial fractures. The latest series should serve as the foundation for a related future investigation utilizing variable volar

locking plate, despite the limited sample size. [43]

Drawbacks such as the usage of a specific type of variable angle locking plates, within available results, might not even be transferable to certain other plates. A comparison with a fixed-angle volar locking plate architecture could be useful in future research. Given the danger of delayed flexor tendon rupture associated with conventional, more proximally positioned volar plates, a report evaluating long-term patient follow-up needs to be taken into consideration.

Conclusion

The study has concluded that variable volar locking plate can be used with lower complication and applying such locking plate in the treatment with early rehabilitation can results in improved radiological parameters significantly. However, this study has not facilitated the comparative evaluation of the outcomes of using fixed angle volar locking plate, the findings of this study can form the basis of future comparative analysis where the usage of variable volar locking plate can be compared with another treatment modality. There is obvious improvement in radiological parameters and anatomical movements by applying variable angle volar locking plate and can be considered as better alternative.

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