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Original Article

Functional and Radiological Outcomes in Intra-Articular Fractures of Distal Radius with Volar Variable Angle Locking Plates

Sahil Arora[1], Vasudha Govil [2*], Avik Kr Neogi [1], Sanju Bishnoi [1], Shagnik Paul [1], R K Gupta [1]

[1] Department of Orthopaedics, PT. BD Sharma PGIMS Rohtak

2 Department of Anaesthesia, PT. BD Sharma PGIMS Rohtak

*Corresponding Author: Vasudha Govil, Department of Anaesthesia, PT. BD Sharma PGIMS Rohtak, Tel: 0919446236862, E-mail: vasudha_govil@yahoo.com.

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Abstract

Introduction: Intra-articular fractures of the distal radius pose a surgical challenge as there is no consensus in the literature on the treatment for these fractures. Many treatment modalities have been described; however, the use of volar variable angle locking plates is currently being advocated for these fractures.

Methods: Overall, 28 patients with intra-articular fractures of the distal radius managed with a volar variable angle locking plate were included in this study. The mean age of the patients in our study was 33.24 ± 11.74 years (range 22-64), and the average follow-up period was 12.18 ±2.64 months (range 6-20). Radiological assessment was done by analyzing volar tilt, radial inclination, radial length, and ulnar variance from the radiographs taken at six weeks and six months' post-surgery. Functional assessment was done at two weeks, six weeks, three months, and six months. The final functional outcome was calculated at six months using the Gartland and Werley scoring system.

Results: There was a constant gain in functional parameters, and significant improvements occurred within 12 weeks. Radiological indices were also maintained after six months of final follow-up showed no significant change. According to the Gartland and Werley scoring system, results were 75% excellent, 14.28% good, 7.14% fair, and 3.57% poor. One patient developed a superficial infection which was managed with oral antibiotics, one patient had screw impingement for which screw removal was done at eight months, and another developed complex regional pain syndrome that was managed conservatively but ultimately had a poor outcome.

Conclusion: The use of Volar VALCP in intraarticular distal radius fractures is associated with early rehabilitation and good functional and radiological outcomes.

Keywords: Distal Radiu, Intra-Articular, Volar Locking Plate, Variable Angle.

Introduction

Distal radius fractures are the most common fractures of the human skeleton and constitute around 16 percent of the total fractures presented to the emergency department.[1] These fractures have a bimodal age distribution that occurs in the elderly due to underlying osteoporosis and in the adult age group due to high energy trauma, mostly.[2-5] Intra-articular extension of these fractures should be noticed as restoration of articular congruity reduces the incidence of osteoarthritis, also restoration of radial length, radial inclination, volar tilt, and ulnar variance is essential for good clinical outcomes and earlier rehabilitation. [6] Colles et al. in 1814 described controversies, however, they still exist regarding the management of these fractures, and there is no consensus in the literature regarding the guidelines for the management of these fractures.[2,7] Various methods have been described in the literature for the management of these fractures that include closed reduction and cast application, Kirschner wire(K-wire) fixation, external fixators with or without K-wires, and locking compression plates(LCP), with each modality having its own set of advantages and disadvantages.[8,9] Recent advances have shown that volar variable angle LCP(VALCP) provides a bio-mechanically stable construct in these fractures and provides the placement of screws in different directions according to the character of fracture, which gives an advantage over volar fixed-angle LCP(FALCP).[9,10] Few

studies in the literature assess long-term functional and radiological outcomes in patients managed with volar VALCP's. Therefore, this cross-sectional study was done to evaluate the radiological and functional consequences in patients of distal radius fractures managed with volar VALCP.

Methods

The cross-sectional study was conducted at a tertiary care hospital and trauma center in north India. The study was approved by the hospital ethics committee. A total number of 28 patients of age more than 18 years, operated by a single surgeon between June 2017 to December 2019 and with a minimum follow up of 6 months postoperatively with complete records available, were included in the study. Patient records were retrieved from the medical records department of the hospital. Then, the clinical and radiological data were reviewed. Patients with extra-articular fractures of the distal radius and previous surgeries in the same limb, bilateral fractures, or additional injuries while sustaining distal radius fractures were excluded from the study. All patients were contacted telephonically for another visit to the hospital for examination and perusal of the operative records. Informed and written consent was taken from all the patients who participated in the study. All patients underwent open reduction and internal fixation with a 2.4 mm variable-angle locking plate (Synthes, Switzerland, marketed in India by Synthes India Pvt. Ltd.). The patient's demographic details were noted, and fractures were classified according to the Arbeitsgemeinschaft für Osteosynthesefragen (AO) classification system for distal radius fractures. All patients were operated under general or regional anesthesia using tourniquet control. Surgery was done by modifying Hbenry's approach using an image intensifier to confirm the reduction and placement of plates and screws intra-operatively [11]. Postoperatively patients were given Plaster of Paris (POP) below dorsal splints for two weeks, and patients were encouraged for active wrist and finger movements. Suture removal was done for two weeks, and active physiotherapy was performed. The patient's radiographs were done immediately post-surgery and at four weeks' intervals thereafter, and radiographs done at immediate postoperatively and six months postoperatively were analyzed to measure radial length, radial inclination, volar tilt, and ulnar variance to assess the radiological outcomes (Fig. 1-3). A standard goniometer was applied to assess the range of motion, and the values were recorded at two weeks, six weeks, three months, and six months' periods (Fig. 4). The grip strength was calculated using a digital hand dynamometer (Takei scientific instruments Co. Ltd., Japan), and a comparison was made with respect to the percentage of the opposite normal wrist strength. Modified Gartland and Werley scoring system was used to assess the functional outcome at six months of final follow up.12 Statistical Package for the Social Sciences (SPSS) version 20 (IBM Corp., Armonk, NY) was utilized to analyze the data.

Results

Out of the total of 28 patients included in the study, 22 were males and 6 were females with a mean age of 33.24±11.74 years (range 22-64). The mode of injury in the majority of the patients was road traffic accidents (RTA) (n=20), while in the rest, it fell on an outstretched hand (n=8). As per the AO classification, eight patients had AO type B, and 20 had AO type C fractures as shown in Table 1.

Table 1: showing distribution of fractures according to AO classification

Fracture classification (AO)	No. of fractures
B2	3
B3	5
C1	4
C2	6
C3	10

The average interval between fracture and surgery was 48.67±8.42 hours ranging from 24 to 96 hours' post-trauma. Patients were followed up for a minimum of 6 months' post-surgery with a mean duration of 12.18±2.64 months, ranging from 6 to 20 months. None of the patients required bone grafting and the average time to bony union was

10.6±1.76 weeks ranging from 8 to 16 weeks. Patients were assessed clinically at two weeks, six weeks, three months, and at six months of final follow-up time, and the observations are presented in Table 2. Radiological parameters were calculated from the x-rays postoperatively and after six months of the last follow-up as outlined in Table 3. Functional assessment was done using the modified Gartland and Werley scoring system at final follow-up and presented in table 4. Out of the 28 patients, 21 of them had excellent outcomes, four good, two fair, and one poor, according to the Gartland and Werley scoring system. Three patients reported complications, one of them had screwed impingement which removal of the screw was done eight months after surgery. One patient developed a superficial wound infection which was managed by oral antibiotics (cefuroxime 500 mg) for one week as regular dressings, and another one developed chronic regional pain syndrome (CRPS) that was managed conservatively; however, the patient developed severe restriction of movement in hand and wrist and ultimately had a poor outcome. None of the patients developed union, malunion, implant failure, or tendon rupture in our study.

Figure 1: Showing pre-operative anterior-posterior and lateral radiographs of wrist.

Figure 2: Showing immediately post-operatively anterior-posterior and lateral radiographs

Figure 3: Showing anterior-posterior and lateral radiographs at six months post-surgery.

Figure 4: A-F showing clinical photographs of patient at six month whose radiographs are shown in figure 1-3.

Table 2 showing ROM values Values are expressed as mean & standard deviation

Clinical Parameter	2 weeks	6 weeks	3 months	6 months
Flexion (degrees)	34.26 ± 6.82	48.18 ± 7.20	66.64 ± 7.64	70.82 ± 7.98
Extension(degrees)	40.28 ± 5.66	54.36 ± 5.94	70.42 ± 6.42	76.16 ± 6.68
Pronation (degrees)	70.64 ± 4.83	78.48 ± 4.98	80.44 ± 6.02	82.64 ± 6.13
Supination(degrees)	74.86 ± 5.87	82.58 ± 6.21	87.38 ± 6.54	87.38 ± 6.76
Ulnar deviation (degrees)	12.38 ± 3.97	16.74 ± 4.21	18.82 ± 4.43	18.82 ± 4.43
Radial deviation(degrees)	22.62 ± 4.27	26.84 ± 4.83	30.18 ± 5.08	30.18 ± 5.08
Percentage Grip Strength	44.82 ± 6.75	78.64 ± 5.98	88.34 ± 5.56	93.46 ± 5.32

Table 3. Radiological parameters Values are expressed as mean ±standard deviation

Radiological Parameter	Immediate Post op	Final follow up at 6 months	P value
Volar Tilt (degrees)	5.94 ± 5.26	5.62 ± 5.60	0.094
Radial Inclination (degrees)	23.22 ± 2.20	22.64 ± 2.58	0.067
Ulnar Variance (mm)	-0.38 ± 0.62	-0.34 ± 0.56	0.066
Radial Length (mm)	11.86 ± 1.82	11.54±1.98	0.142

Table 4. Gartland and Werley Score

Functional outcome	No. of patients
Excellent	21
Good	4
Fair	2
poor	1

Discussion

Though one of the most prevalent injuries of the human skeleton, the management of fractures of the distal radius is still a matter of debate. Different modalities of treatment have been described in literature ranging from conservative to various surgical options containing the recently developed volar VALCP, with each modality having its pros and cons. At the heart of all these management options, however, the fact is that restoring the natural anatomy of the distal radius and wrist joint contributes to early rehabilitation and good functional outcomes.[13]

Plating on the volar surface of the distal radius offers an anatomical advantage over the dorsal surface as there is more space available for the application of plate, and also the incidence of soft tissue complications is less as compared to plating on the dorsal side.[14] Also, locked plates are preferred over the conventional plates as they provide angular stability and a stable construct helping in early rehabilitation.[15,16] Gruber et al. have reported that fixation with volar fixed-angle locking plates(FALCP) result in statistically significant loss of radiological parameters like volar tilt and radial inclination over time as compared to volar VALCP with relatively better functional outcomes.[17.] The use of volar FALCP also has limitations in a subset of patients with distal radius fractures in which the fracture line extends the distal to the watershed line involving the volar rim as placement of volar FALCP distal to watershed line leads to prominence of the plate that may cause flexor tendons irritation, and also increased the chances of

placement of locking screws in the wrist joint.[18] This disadvantage is addressed with the use of volar VALCP as the screws can engage the distal fragments without placing the plate too distal from the watershed line. In addition, Lenz et al in their study demonstrated that variable locked screws offer the stable locking construct under cyclical loading compared to volar FALCP, thus adding to the stability of volar VALCP.[19] n various FALCP-Volar studies, they have used K-wires as additional hardware to hold components that are not engaged by the screws due to the fixed direction of the screws. However, VALCP volar offers an advantage because the screws can be placed in different directions based on the failure components, thus reducing the dependence on additional stabilization methods. Chen et al. had used k-wires to augment fixation in patients managed with volar FALCP while none was required in patients managed with VALCP.[20] Also, Stanbury et al, reported the advantage of VALCP in engaging the radial styloid fragment. [21] Similar to this study, no additional hardware was required except the plate and screws to stabilize the fracture or hold fragments.

Chen et al. had reported no significant change in the radiological parameters immediately post-surgery and at the final follow-up, especially volar tilt in patients managed with volar VALCP compared to patients managed with volar FALCP.[20]

In the same way, in our study, there was no significant change in radial inclination, radial tilt, ulnar variance and radial length at final follow-up compared to immediate post-surgery radiographs. There was a constant improvement in range of motion(ROM) values post-surgery, and significant improvements occurred by 12 weeks' post-surgery in our study. Grip strength was restored to 93% of the standard opposite non-injured side at the final follow-up in our study. Kanabar et al. reported that grip strength was regained by up to 94% in the three months after volar plating.[15] Similarly, Chen et al. described grip strength of 91.3% at the final follow-up of 12 months in their study.[20] Functional outcomes in our study with the Gartland and Werley scoring system was excellent in 75% of the patients, 14.28% had good, 7.14% had fair, and 3.57% had poor outcomes. Figl et al. had shown excellent results in 37.5% of patients, good results in 67%, and fair results in 1% of patients managed with volar VALCP.[21] Similarly, Kilic et al. reported excellent to good results in 89.9% of patients and moderate to poor in 11.1% patients according to Gartland and Werley system.[22] Therefore, the results of our study are comparable to those reported in the literature. There are a set of complications in every surgery; therefore, in this study, a complication rate of 10.71 % was reported, which included superficial wound infection in one patient, CRPS in one patient, and screw impingement in another for which removal was done later on. Chen et al. reported a complication rate of 10.5 % in the volar VALCP group that included flexor tendon irritation in two patients and was managed conservatively. They also described a complication rate of 21.4% in patients managed with volar FALCP.[20] Kawasaki et al. stated an overall complication rate of 4.1%.[23] Therefore, complication rates in our study are similar to the literature. The limitation of our study is that it is not a prospective study and the sample size is also limited. Also, since the operative method was not compared to other available treatment options, it will not be wise to generalize the findings of our study for the management of distal radius fractures. However, the observations of this study can be used to compare data from studies done on other treatment modalities in the past or the future and draw inferences that may help guide the treatment of distal radius fractures.

Conclusion

The observations of our study indicate that volar VALCP provides a good option in the management of distal radius fractures. These plates have better radiological and functional outcomes and aid in early rehabilitation. Also, these plates reduce the dependence on the use of additional fixation techniques along with locking plates for fixation of distal radius fractures.

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Conflict of Interest Disclosures

None

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Authors' Contributions

All authors pass the four criteria for authorship contribution based on the international committee of medical journal editors (ICMJE) recommendations.

Ethical Statement

The study was approved by the hospital ethical committee.

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