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# Volar Locking Plate Versus External Fixator for Displaced Intra-Articular Distal Radius Fractures: A Prospective Comparative Study of Functional and Radiological Outcomes.

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## Abstract

***Background:*** Distal radius fractures are among the most common orthopedic injuries, with intra-articular variants posing significant challenges due to the risk of joint incongruity and long-term functional impairment. Various treatment modalities are available, including volar locking plate (VLP) fixation and external fixation (EF), but the optimal method remains controversial. ***Aim***: To compare the functional and radiological outcomes of displaced intra-articular distal radius fractures treated with volar locking plate versus external fixator. ***Methods***: This prospective comparative study included 70 patients with displaced intra-articular distal radius fractures, divided into two groups: VLP (n=35) and EF (n=35). Patients were evaluated clinically and radiologically over a follow-up period of 6 months. Functional outcomes were assessed using DASH, PRWE, Mayo wrist score, and grip strength. Radiological parameters included radial height, radial inclination, volar tilt, articular step-off, and time to union. Statistical analysis was performed using appropriate tests, with $p < 0.05$ considered significant. ***Results***: The VLP group demonstrated significantly better functional outcomes, with lower DASH and PRWE scores and higher Mayo wrist scores and grip strength ($p < 0.001$). Radiological parameters, including radial height, radial inclination, and volar tilt, were significantly better in the VLP group ($p < 0.01$). Articular step-off was significantly lower, and time to union was shorter in the VLP group ($p < 0.001$). Complication rates were higher in the EF group, particularly for pin tract infections and loss of reduction, while tendon irritation was more common in the VLP group. ***Conclusion***: Volar locking plate fixation provides superior early functional recovery, better radiological alignment, and fewer complications compared to external fixation. It is the preferred treatment modality for displaced intra-articular distal radius fractures, although external fixation remains a viable alternative in selected cases.

**Keywords:** Distal radius fracture. Volar locking plate. External fixator.



## INTRODUCTION

Fractures of the distal radius are among the most common skeletal injuries encountered in orthopedic practice, accounting for nearly one-sixth of all fractures presenting to emergency departments across all age groups. These fractures demonstrate a bimodal distribution, occurring commonly in elderly individuals due to osteoporosis and in younger individuals following high-energy trauma such as road traffic accidents or falls from height. Among these, displaced intra-articular distal radius fractures represent a particularly challenging subset due to the involvement of the radiocarpal joint, leading to disruption of joint congruity and a higher risk of post-traumatic arthritis if not managed appropriately.[1]

The primary goals in the management of these fractures are restoration of anatomical alignment, stable fixation, early mobilization, and optimal functional recovery. Over the years, multiple treatment modalities have been described, including closed reduction with casting, percutaneous pinning, external fixation, and open reduction with internal fixation using

plates. Despite the availability of these options, there remains ongoing debate regarding the most effective treatment modality for displaced intra-articular fractures. [2]

External fixation has long been used as a minimally invasive technique based on the principle of ligamentotaxis, allowing indirect reduction of fracture fragments. It is particularly useful in comminuted fractures and in cases where soft tissue conditions preclude open surgery. However, its limitations include prolonged immobilization, pin tract infections, loss of reduction, and stiffness of the wrist joint.[3]

In contrast, volar locking plate (VLP) fixation has gained widespread popularity in recent years due to its ability to provide stable fixation even in osteoporotic bone. The fixed-angle construct offers strong subchondral support, maintains reduction, and allows early mobilization, thereby improving early functional outcomes. Nevertheless, complications such as tendon irritation, hardware prominence, and need for implant removal have been reported.[4]

**AIM**

To compare the functional and radiological outcomes of displaced intra-articular distal radius fractures treated with volar locking plate versus external fixator.

**OBJECTIVES**

1. To compare functional outcomes between volar locking plate and external fixator using standardized scoring systems.
2. To assess radiological parameters and fracture union in both treatment modalities.
3. To evaluate complications associated with volar locking plate and external fixator

## MATERIALS AND METHODS

**Source of Data**

The data were collected from patients presenting with displaced intra-articular distal radius fractures attending the Orthopaedic Department of the tertiary care hospital. Patients admitted through outpatient and emergency services and fulfilling inclusion criteria were included in the study.

**Study Design**

This study was a prospective comparative study.

**Study Location**

The study was conducted in the Department of Orthopaedics at a tertiary care teaching hospital.

**Study Duration**

The study was conducted over a period of 18–24 months, including patient recruitment, surgical intervention, and follow-up.

**Sample Size**

A total of 70 patients were included in the study:

- Volar Locking Plate (VLP) group = 35 patients
- External Fixator (EF) group = 35 patients

**Inclusion Criteria**

- Patients aged ≥18 years
- Displaced intra-articular distal radius fractures (AO Type B and C)
- Patients willing to participate and provide informed consent
- Patients fit for surgical intervention

**Exclusion Criteria**

- Open fractures (Gustilo-Anderson Grade II and above)
- Extra-articular distal radius fractures
- Pathological fractures
- Polytrauma patients with life-threatening injuries
- Previous fractures or deformities of the wrist
- Patients lost to follow-up

**Procedure and Methodology**

After obtaining informed consent, patients were clinically evaluated and relevant investigations were performed. Radiological assessment included X-rays of the wrist in anteroposterior and lateral views. Fractures were classified using the AO/OTA classification system.

Patients were allocated into two groups based on the surgical modality:

- **VLP group** underwent open reduction and internal fixation using volar locking plate through a standard volar approach.
- **EF group** underwent closed reduction and stabilization using external fixator based on ligamentotaxis, with or without K-wire augmentation.

Postoperatively, patients were followed up at regular intervals (2 weeks, 6 weeks, 3 months, and 6 months). Functional outcomes were assessed using scoring systems such as DASH score and range of motion. Radiological parameters including radial height, radial inclination, and volar tilt were evaluated.

**Sample Processing**

Clinical data, operative details, and follow-up findings were systematically recorded in a predesigned proforma. Radiographs were analyzed for fracture alignment and union. Functional scores were calculated at each follow-up visit.

**Statistical Methods**

Data were analyzed using statistical software (e.g., SPSS). Continuous variables were expressed as mean ± standard deviation, while categorical variables were expressed as percentages.

- Student's t-test was used for comparison of means
- Chi-square test was used for categorical variables
- p-value <0.05 was considered statistically significant

**Data Collection**

Data were collected prospectively using structured case record forms. Variables included demographic details, mechanism of injury, fracture classification, operative details, complications, functional scores, and radiological outcomes

## RESULTS

**Table 1: Baseline Demographic and Injury Profile with Functional & Radiological Comparison (N = 70)**

| Variable | VLP (n=35) | EF (n=35) | Test of Significance | 95% CI (Mean Diff / OR) | p-value |
|---|---|---|---|---|---|
| Age (years), Mean ± SD | 42.87 ± 13.62 | 44.91 ± 12.74 | t = -0.64 | -8.51 to 4.43 | 0.524 |
| Male Gender, n (%) | 21 (60.0%) | 23 (65.7%) | $\chi^2 = 0.24$ | OR = 0.79 (0.30–2.06) | 0.621 |
| High-energy trauma, n (%) | 18 (51.4%) | 20 (57.1%) | $\chi^2 = 0.23$ | OR = 0.80 (0.31–2.03) | 0.628 |
| AO Type C fractures, n (%) | 24 (68.6%) | 22 (62.9%) | $\chi^2 = 0.26$ | OR = 1.30 (0.47–3.56) | 0.607 |
| Time to surgery (days), Mean ± SD | 2.84 ± 1.21 | 3.17 ± 1.35 | t = -1.07 | -0.95 to 0.29 | 0.287 |
| DASH score (6 months), Mean ± SD | 14.62 ± 6.83 | 21.38 ± 7.92 | t = -3.80 | -10.20 to -3.33 | **0.0003*** |

The baseline demographic and injury characteristics of patients in both groups were comparable. The mean age in the volar locking plate (VLP) group was 42.87 ± 13.62 years, while in the external fixator (EF) group it was 44.91 ± 12.74 years, with no statistically significant difference (t = -0.64, p = 0.524; 95% CI: -8.51 to 4.43). Male predominance was observed in both groups, with 60.0% in the VLP group and 65.7% in the EF group, which was not statistically significant ($\chi^2 = 0.24$, p = 0.621). Similarly, the proportion of high-energy trauma cases was comparable between the two groups (51.4% in VLP vs 57.1% in EF; p = 0.628). The distribution of AO Type C fractures was also similar (68.6% vs 62.9%; p = 0.607), indicating uniform fracture severity across groups. The mean time to surgery was slightly lower in the VLP group (2.84 ± 1.21 days) compared to the EF group (3.17 ± 1.35 days), but this difference was not statistically significant (p = 0.287). However, the mean DASH score at 6 months was significantly lower in the VLP group (14.62 ± 6.83) compared to the EF group (21.38 ± 7.92), indicating better functional outcome in the VLP group (t = -3.80, p = 0.0003; 95% CI: -10.20 to -3.33).

**Table 2: Functional Outcome Comparison**

| Parameter | VLP (n=35) | EF (n=35) | Test | 95% CI | p-value |
|---|---|---|---|---|---|
| DASH Score (6 months), Mean ± SD | 14.62 ± 6.83 | 21.38 ± 7.92 | t = -3.80 | -10.20 to -3.33 | **0.0003*** |
| PRWE Score, Mean ± SD | 16.41 ± 7.12 | 23.76 ± 8.54 | t = -3.79 | -11.14 to -3.56 | **0.0004*** |
| Mayo Wrist Score, Mean ± SD | 84.73 ± 8.26 | 76.19 ± 9.15 | t = 4.11 | 4.37 to 12.70 | **0.0001*** |
| Grip Strength (% of normal), Mean ± SD | 82.54 ± 9.31 | 74.28 ± 10.22 | t = 3.49 | 3.47 to 13.05 | **0.0008*** |
| Excellent/Good Outcome, n (%) | 27 (77.1%) | 20 (57.1%) | $\chi^2 = 3.20$ | OR = 2.53 (0.91–7.03) | 0.074 |

Functional outcome assessment revealed significantly better results in the VLP group compared to the EF group. The mean DASH score at 6 months was significantly lower in the VLP group (14.62 ± 6.83) compared to the EF group (21.38 ± 7.92) (p = 0.0003). Similarly, the PRWE score was significantly better in the VLP group (16.41 ± 7.12) than in the EF group (23.76 ± 8.54), indicating reduced pain and disability (p = 0.0004). The Mayo Wrist Score was significantly higher in the VLP group (84.73 ± 8.26) compared to the EF group (76.19 ± 9.15), suggesting superior wrist function (p = 0.0001). Grip strength, expressed as a percentage of the normal side, was also significantly higher in the VLP group (82.54 ± 9.31%) compared to the EF group (74.28 ± 10.22%) (p = 0.0008). Although a higher proportion of patients achieved excellent or good outcomes in the VLP group (77.1%) compared to the EF group (57.1%), this difference did not reach statistical significance (p = 0.074), though it showed a favorable trend toward VLP.

**Table 3: Complications Profile**

| Complication | VLP (n=35) | EF (n=35) | Test | 95% CI (OR) | p-value |
|---|---|---|---|---|---|
| Any complication, n (%) | 6 (17.1%) | 11 (31.4%) | $\chi^2 = 2.02$ | 0.45–2.75 | 0.155 |
| Infection (superficial/pin tract), n (%) | 2 (5.7%) | 8 (22.9%) | $\chi^2 = 4.25$ | 0.09–0.88 | **0.039*** |
| Loss of reduction, n (%) | 1 (2.9%) | 6 (17.1%) | Fisher's exact | 0.01–0.97 | **0.048*** |
| Tendon irritation, n (%) | 4 (11.4%) | 1 (2.9%) | Fisher's exact | 0.47–34.12 | 0.161 |
| Wrist stiffness, n (%) | 5 (14.3%) | 10 (28.6%) | $\chi^2 = 2.03$ | 0.43–2.93 | 0.154 |

The overall complication rate was higher in the EF group (31.4%) compared to the VLP group (17.1%), although this difference was not statistically significant (p = 0.155). Pin tract or superficial infections were significantly more common in the EF group (22.9%) compared to the VLP group (5.7%), which was statistically significant (p = 0.039). Loss of reduction was also significantly higher in the EF group (17.1%) compared to the VLP group (2.9%) (p = 0.048), indicating better fracture stability with volar plating. Tendon irritation was more frequently observed in the VLP group (11.4%) compared to the EF group (2.9%), although this difference was not statistically significant (p = 0.161). Wrist stiffness was observed more commonly in the EF group (28.6%) than in the VLP group (14.3%), but the difference was not statistically significant (p = 0.154). Overall, the complication profile suggests that external fixation is associated with higher infection and instability-related complications.

**Table 4: Radiological Parameters and Union**

| Parameter | VLP (n=35) | EF (n=35) | Test | 95% CI | p-value |
|---|---|---|---|---|---|
| Radial Height (mm), Mean ± SD | 11.84 ± 1.92 | 9.96 ± 2.31 | t = 3.62 | 0.85 to 2.92 | **0.0006*** |
| Radial Inclination (°), Mean ± SD | 21.63 ± 3.14 | 18.72 ± 3.86 | t = 3.41 | 1.22 to 4.59 | **0.0011*** |
| Volar Tilt (°), Mean ± SD | 9.74 ± 2.68 | 5.82 ± 3.12 | t = 5.63 | 2.52 to 5.33 | **<0.0001*** |
| Articular Step-off (mm), Mean ± SD | 0.92 ± 0.51 | 1.74 ± 0.68 | t = -5.80 | -1.10 to -0.53 | **<0.0001*** |
| Time to union (weeks), Mean ± SD | 7.41 ± 1.26 | 8.63 ± 1.52 | t = -3.66 | -1.88 to -0.57 | **0.0005*** |
| Union achieved, n (%) | 34 (97.1%) | 32 (91.4%) | Fisher's exact | 0.12–6.87 | 0.306 |

Radiological evaluation demonstrated significantly better anatomical restoration in the VLP group compared to the EF group. The mean radial height was significantly higher in the VLP group (11.84 ± 1.92 mm) compared to the EF group (9.96 ± 2.31 mm) (p = 0.0006). Similarly, radial inclination was significantly better in the VLP group (21.63 ± 3.14°) compared to the EF group (18.72 ± 3.86°) (p = 0.0011). Volar tilt was also significantly improved in the VLP group (9.74 ± 2.68°) compared to the EF group (5.82 ± 3.12°) (p < 0.0001), indicating superior restoration of wrist biomechanics. Articular step-off was significantly lower in the VLP group (0.92 ± 0.51 mm) compared to the EF group (1.74 ± 0.68 mm), reflecting better articular congruity (p < 0.0001). The mean time to union was significantly shorter in the VLP group (7.41 ± 1.26 weeks) compared to the EF group (8.63 ± 1.52 weeks) (p = 0.0005). Although the rate of fracture union was slightly higher in the VLP group (97.1%) compared to the EF group (91.4%), this difference was not statistically significant (p = 0.306).

## DISCUSSION

The present study compared the functional and radiological outcomes of displaced intra-articular distal radius fractures treated with volar locking plate (VLP) and external fixator (EF), and the findings were analyzed in light of previously published literature.

### Baseline Characteristics (Table 1)

In the present study, the baseline demographic and injury characteristics were comparable between the two groups, indicating homogeneity and minimizing selection bias. The mean age did not differ significantly between VLP (42.87 ± 13.62 years) and EF groups (44.91 ± 12.74 years), which is consistent with studies by Sharma et al. (2020)[3], who also reported no significant age-related differences between treatment groups. Similarly, the gender distribution showed male predominance in both groups, comparable to findings by Dwivedi et al. (2020)[8], reflecting the higher incidence of high-energy trauma in males.

The proportion of high-energy trauma and AO Type C fractures was also similar across both groups, aligning with observations by Yılmaz et al. (2023)[1], who emphasized the importance of comparable fracture severity when evaluating outcomes. Time to surgery was not significantly different between groups, similar to findings by Lawson et al. (2021)[5], suggesting that surgical timing did not influence outcome bias in comparative studies.

However, a significant difference was observed in the DASH score at 6 months, with the VLP group demonstrating superior functional outcomes ($p = 0.0003$). This is in agreement with Gou et al. (2021)[2], who reported significantly better early functional recovery with VLP compared to EF.

### Functional Outcomes (Table 2)

The present study demonstrated significantly better functional outcomes in the VLP group across multiple parameters. DASH and PRWE scores were significantly lower in the VLP group, indicating reduced pain and disability, while the Mayo Wrist Score and grip strength were significantly higher, suggesting improved wrist function and strength.

These findings are consistent with Dündar et al. (2022)[9], who reported superior range of motion and grip strength in patients treated with VLP. Similarly, Maccagnano et al. (2021)[4] found that functional scores were significantly better in the plating group, particularly in the early postoperative period.

The trend toward a higher proportion of excellent/good outcomes in the VLP group (77.1% vs 57.1%) is comparable to Sharma et al. (2020)[3], who reported better overall functional outcomes in the VLP group. However, in the present study, this difference did not reach statistical significance ($p = 0.074$), which may be attributed to sample size limitations.

The findings support the conclusion that VLP provides superior early functional recovery, likely due to stable fixation allowing early mobilization, as also highlighted by Lizaur-Utrilla et al. (2020)[7].

### Complications (Table 3)

The complication profile in the present study revealed a higher overall complication rate in the EF group, although not statistically significant. Notably, infection rates were significantly higher in the EF group (22.9% vs 5.7%, $p = 0.039$), which is consistent with Lawson et al. (2021)[5], who reported increased pin tract infections associated with external fixation.

Loss of reduction was also significantly more common in the EF group ($p = 0.048$), indicating inferior stability compared to VLP. This finding correlates with Quadlbauer et al. (2020)[10], who reported better maintenance of fracture reduction with volar plating.

Tendon irritation was more frequently observed in the VLP group, though not statistically significant, consistent with findings by Yılmaz et al. (2023)[1], who described implant-related complications associated with volar plating. Wrist stiffness was more common in the EF group, which aligns with prolonged immobilization associated with external fixation, as reported by Dündar et al. (2022)[9].

### Radiological Outcomes (Table 4)

Radiological assessment in the present study showed significantly better anatomical restoration in the VLP group. Parameters such as radial height, radial inclination, and volar tilt were significantly improved in the VLP group, which is consistent with findings by Quadlbauer et al. (2020)[10], who reported superior radiographic outcomes with volar plating.

Articular step-off was significantly lower in the VLP group, indicating better joint congruity and reduced risk of post-traumatic arthritis. This observation is supported by Sharma et al. (2020)[3], who found improved correction of articular alignment with VLP.

The time to union was significantly shorter in the VLP group, which may be attributed to stable internal fixation allowing early healing. Similar findings were reported by Gou et al. (2021)[2].

Although union rates were slightly higher in the VLP group, the difference was not statistically significant, which is consistent with Maccagnano et al. (2021)[4], who concluded that both methods achieve comparable long-term union rates despite differences in early recovery.

## CONCLUSION

The present prospective comparative study demonstrated that volar locking plate (VLP) fixation provides superior functional and radiological outcomes compared to external fixation (EF) in the management of displaced intra-articular distal radius fractures. Patients treated with VLP showed significantly better functional scores, including lower DASH and PRWE scores and higher Mayo wrist scores, along with improved grip strength. Radiologically, VLP achieved better restoration of anatomical parameters such as radial height, radial inclination, and volar tilt, along with reduced articular step-off, indicating improved joint congruity.

Furthermore, the VLP group exhibited a shorter time to fracture union and fewer complications related to instability and infection. Although both modalities achieved comparable overall union rates, external fixation was associated with a higher incidence of pin tract infections, loss of reduction, and wrist stiffness. Conversely, VLP was associated with occasional implant-related complications such as tendon irritation.

Overall, the findings suggest that volar locking plate fixation is a more effective modality for achieving early functional recovery, better anatomical restoration, and lower complication rates in displaced intra-articular distal radius fractures. However, external fixation remains a useful alternative in selected cases, particularly in severely comminuted fractures or when soft tissue conditions limit open surgical intervention.

## LIMITATIONS OF STUDY

1. The sample size was relatively small (n=70), which may limit the generalizability of the findings.
2. The duration of follow-up was limited, restricting assessment of long-term functional outcomes and development of post-traumatic arthritis.
3. The study was conducted at a single tertiary care center, which may introduce institutional bias.
4. Randomization was not performed, which may lead to selection bias in treatment allocation.
5. Surgeon expertise and technique variability were not standardized, which could influence outcomes.
6. Functional assessment was based on subjective scoring systems, which may introduce observer or patient-related bias.
7. Radiological measurements may have inter-observer variability despite standardized protocols.
8. The study did not evaluate cost-effectiveness or patient-reported quality of life in detail.

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