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Original Research Article

Assessment of Volar Locking Plate Versus External Fixator in the Management of Intra-articular Distal Radius Fractures: A Clinical Comparative Analysis

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Abstract:

Introduction: Intra-articular distal radius fractures commonly result in pain, deformity, and long-term functional limitations. Volar Locking Plates (VLP) and External Fixators (EF) are widely used surgical options, yet their comparative effectiveness remains debated. This study evaluates functional and radiological outcomes of VLP versus EF in a tertiary-care centre in Gujarat.

Materials and Methods: A prospective comparative study was conducted on 60 adults with AO type 23-B and 23-C distal radius fractures. Patients were assigned into two equal groups: EF (n=30) and VLP (n=30). Functional outcomes included wrist range of motion, grip strength, and Mayo Wrist Score. Radiological assessment measured radial height, inclination, volar tilt, and articular step-off. Patients were followed at 6 weeks, 3 months, 6 months, and 12 months. Statistical significance was set at $p<0.05$.

Results: VLP demonstrated superior wrist flexion (76.9° vs. 63.8°), extension (71.3° vs. 60.9°), and grip strength (91.8% vs. 79.2%) compared with EF. Mayo Wrist Scores were significantly higher in the VLP group (86.9 vs. 76.1). Radiological restoration was better maintained with VLP, with reduced articular step-off and improved radial parameters. Complication rates were lower with VLP (17%) than EF (47%).

Conclusion: Volar locking plates offer better functional recovery, improved radiological alignment, and fewer complications than external fixation in intra-articular distal radius fractures, supporting their preferential use in suitable patients.

Keywords: Alignment, Complications, Distal Radius, External Fixation, Volar Locking Pla.

Introduction

Distal radius fractures constitute one of the most common injuries encountered in orthopedic practice in India, with intra-articular variants presenting significant therapeutic challenges due to their propensity for displacement, comminution, and long-term functional disability. The burden of these injuries has risen nationally due to increasing road-traffic trauma and fall-related injuries in both young adults and the elderly.[1] Restoration of normal wrist biomechanics depends on achieving precise reduction of radial height, radial inclination, volar tilt, and articular congruity, as even subtle deviations can influence functional motion and predispose to radiocarpal arthritis. This relationship between anatomical restoration and functional outcome has been emphasized in multiple Indian analyses.[2,3]

External fixation has traditionally served as a practical and cost-effective option, particularly within public hospitals and resource-limited environments. Its reliance on ligamentotaxis facilitates indirect reduction with minimal soft-tissue disruption, making it suitable for polytrauma or compromised soft-tissue conditions. However, several Indian institutional studies, including those by Mahesh et al.[4] in Bengaluru and Bobade et al.[5] in Jaipur, have reported limitations related to maintenance of volar tilt, late collapse, restricted early mobilization, and susceptibility to pin-tract infections. Comparable concerns appear in international literature, such as the work of Esposito J. et al.[6], who noted inferior stability with external fixation in comminuted intra-articular fractures, and Wilcke et al.[7], who observed better early radiological alignment with internal fixation.

Volar locking plate (VLP) fixation has gained prominence over the past decade as a technique capable of providing stable angular fixation, subchondral support, and direct visualization of articular reduction. These attributes promote early mobilization, which is particularly advantageous in Indian settings with inconsistent access to structured physiotherapy. Favourable early and mid-term

outcomes have been reported in multiple Indian studies, including the comparative works of Prakash et al.[8] in Ranchi and Bande et al.[9] at BARC Hospital, Mumbai. These domestic findings echo global evidence presented by Leung et al. [10]., who found VLP to provide faster recovery, better palmar tilt restoration, and improved grip strength and wrist function.

Despite the growing evidence base, results across Indian centers remain heterogeneous due to variability in fracture patterns, implant availability, surgeon experience, and follow-up resources. There is limited Gujarat-specific comparative data addressing intra-articular fractures in particular. Therefore, the present study aims to evaluate and compare the functional and radiological outcomes of VLP versus external fixation in intra-articular distal radius fractures within a tertiary-care setting in Gujarat, contextualizing the findings against relevant national and international literature.

Materials and Methods

Study Design and Setting: This study was designed as a prospective comparative observational analysis conducted in a tertiary-care orthopedic centre in Gujarat, India. The objective was to compare clinical and radiological outcomes between Volar Locking Plate (VLP) fixation and External Fixator (EF) application in adults presenting with intra-articular distal radius fractures.

Sample Size and Allocation: A total of 60 patients were recruited using consecutive sampling. Patients meeting eligibility criteria were allocated into two groups based on alternate-case selection to minimize selection bias:

- **Group A:** External Fixation (n = 30)
- **Group B:** Volar Locking Plate Fixation (n = 30)

Inclusion criteria: The study included adult patients between 18 and 75 years of age who presented with intra-articular distal radius fractures classified under the AO/OTA system as types 23-B and 23-C. Only closed fractures presenting within two weeks of injury were considered eligible, and all participants were required to provide informed consent prior to enrolment.

Exclusion criteria: Patients were excluded if they sustained open fractures, polytrauma, or associated ipsilateral upper-limb fractures. Additional exclusion criteria comprised pathological fractures, any form of neurovascular compromise in the affected limb, a history of prior distal radius fracture on the same side, or medical conditions rendering them unfit for anaesthesia.

Preoperative Evaluation: All patients underwent standardized clinical and radiographic evaluation including PA and lateral wrist radiographs. Fractures were classified using the AO classification. (Sharma et al.,) Baseline demographic data, mechanism of injury, comorbidities, and dominant hand were recorded.

Surgical Technique

External Fixator Group (EF): Closed reduction was performed under fluoroscopy. A bridging external fixator was applied using the principle of ligamentotaxis.
Additional stabilization with 1.5–2 mm K-wires across fragments was performed as required (Jammu cohort)

Volar Locking Plate Group (VLP): Open reduction was performed through a standard modified Henry approach, with fracture reduction under direct visualization and fixation using a 2.4-mm locking plate.

Postoperative Rehabilitation

- **VLP group:** Early finger motion from day one; wrist mobilization initiated at 4 weeks.
- **EF group:** Finger exercises initiated immediately; K-wires removed at 4–6 weeks; fixator removed after radiological signs of union.

Outcome Measures: Outcome measures in the study included both functional and radiological assessments. Functional evaluation was performed using wrist range of motion (ROM), grip strength measured as a percentage of the contralateral limb, and the Mayo Wrist Score (MWS). Radiological analysis focused on key anatomical parameters, including radial height, radial inclination, volar tilt, and the degree of intra-articular step-off, as measured on standard posteroanterior and lateral radiographs. All patients were evaluated at regular follow-up intervals of 6 weeks, 3 months, 6 months, and 12 months to monitor progressive recovery and document final functional and radiographic outcomes.

Statistical Analysis: Data were analysed using SPSS (version 25). Continuous variables were expressed as means ± SD and compared using independent t-tests. Categorical variables were analysed using chi-square tests. A p-value <0.05 was considered statistically significant.

Results

Table 1: Comparison of Baseline characteristics between VLP and EF in Intra-articular Distal Radius Fractures

Parameter	External Fixator (n=30)	Volar Locking Plate (n=30)
Mean Age (years)	49.8 ± 10.7	47.2 ± 11.4
Sex (M/F)	19/11	14 / 16
Dominant side involved (%)	63%	70%
Mechanism (Low/High energy)	20 / 10	18 / 12
Fracture type (Frykman 3,4,7,8)	8 / 10 / 7 / 5	9 / 8 / 7 / 6
Surgery duration (min)	36.5 ± 7.2	74.2 ± 6.4
Blood loss (ml)	14.3 ± 4.1	48.7 ± 10.2

The study included 60 patients, evenly divided between the EF and VLP groups. Baseline characteristics were similar across both cohorts, with comparable age distribution, fracture patterns, mechanism of injury, and side involvement. As expected, surgical duration and blood loss were considerably lower in the EF group (36.5 ± 7.2 minutes; 14.3 ± 4.1 ml) than in the VLP group (74.2 ± 6.4 minutes; 48.7 ± 10.2 ml). This ensured that both groups were demographically and clinically comparable prior to intervention.

Table 2: Comparison of functional outcome between VLP and EF in Intra-articular Distal Radius Fractures

Outcome	External Fixator (EF)	Volar Locking Plate (VLP)
Wrist Flexion (°)	63.8 ± 5.1	76.9 ± 6.2
Wrist Extension (°)	60.9 ± 4.8	71.3 ± 4.9
Supination (°)	69.5 ± 6.0	79.1 ± 5.2
Pronation (°)	67.8 ± 5.7	78.4 ± 5.4
Grip Strength (% of opposite side)	79.2 ± 6.4	91.8 ± 4.8
Mayo Wrist Score (0–100)	76.1 ± 8.8	86.9 ± 7.5
Outcome categories	Excellent: 4 13%) Good: 10 (33%) Fair: 11 (37%) Poor: 5 (17%)	Excellent: 12 (40%) Good: 13 (43%) Fair: 5 (17%) Poor: 0

Functional outcomes strongly favored VLP fixation. Patients in the VLP group demonstrated higher wrist flexion (76.9°), extension (71.3°), and rotational movements compared with those treated with EF. Grip strength recovery was also superior after VLP (91.8%) compared with EF (79.2%). This improvement was reflected in the Mayo Wrist Score, where VLP achieved a higher mean score (86.9 vs. 76.1). Furthermore, excellent-to-good outcome categories were more frequent with VLP, while EF demonstrated a higher proportion of fair and poor outcomes.

Table 3: Comparison of radiological outcome between VLP and EF in Intra-articular Distal Radius Fractures

Parameter	EF (Mean ± SD)	VLP (Mean ± SD)
Radial Height (mm)	9.7 ± 1.3	11.4 ± 1.0
Radial Inclination (°)	19.8 ± 2.5	22.8 ± 2.1
Volar Tilt (°)	5.4 ± 3.2	11.2 ± 2.8
Articular Step-off (mm)	1.2 ± 0.7	0.4 ± 0.6
Ulnar Variance (mm)	+1.3 ± 0.5	+0.9 ± 0.4

Radiological parameters showed clearer anatomical restoration with VLP. Radial height, radial inclination, and volar tilt were better maintained in the VLP group, with substantially reduced intra-articular step-off (0.4 mm vs. 1.2 mm in EF). The EF cohort showed greater residual deformity, particularly with volar tilt and radial height, indicating less precise and less stable reduction compared with volar plating.

Table 4: Comparison of complication between VLP and EF in Intra-articular Distal Radius Fractures

Complication	EF (n=30)	VLP (n=30)
Pin-tract infection	4 (13%)	–
Wrist stiffness	6 (20%)	2 (7%)
Malunion	3 (10%)	0
Implant irritation	–	2 (7%)
CRPS	1 (3%)	1 (3%)
Total complications	14 (47%)	5 (17%)

Complication rates were noticeably higher with EF. Pin-tract infection, wrist stiffness, and malunion were more prevalent in the EF group, contributing to a total complication rate of 47%, compared with only 17% in the VLP cohort. VLP-related complications were minor and limited to implant irritation and mild stiffness, confirming a more favorable safety profile.

Discussion

The findings of the present study demonstrate that volar locking plate fixation results in superior functional recovery, improved radiological restoration, and fewer complications compared with external fixation in the management of intra-articular distal radius fractures. Patients treated with VLP exhibited significantly greater wrist mobility, including flexion of 76.9° compared with 63.8° in the EF group, and similarly improved extension (71.3° vs. 60.9°). Grip strength reached 91.8% of the opposite side in the VLP cohort but only 79.2% following external fixation. These differences contributed to the higher Mayo Wrist Scores recorded in the VLP arm (86.9 vs. 76.1). Comparable functional superiority has been documented in other Indian cohorts, including the Ranchi series reported by Prakash et al.[8] and the Burdwan 2025 evaluation by Fakaruddin et al. [2], both of whom noted faster recovery in flexion–extension arc and improved patient-reported scores following VLP.

Radiological alignment in the present study was more reliably restored and maintained with VLP, particularly in terms of radial height, radial inclination, and volar tilt. The EF group exhibited greater residual dorsal tilt and increased tendency toward late collapse, mirroring the observations of Bande et al. [9] at BARC Mumbai, who emphasized the role of subchondral support from volar locking screws in preventing redisplacement. Similarly, Singh et al.[1] from GMC Jammu reported significant advantages in volar tilt and radial length with VLP, highlighting its mechanical effectiveness in intra-articular configurations. International studies, including the randomized trial by Wilcke et al.[7] support these findings, demonstrating more accurate and durable corrections with volar plating than with ligamentotaxis-based methods.

Complications were more frequent in the EF group in the present study, with a rate of 47% compared with only 17% in the VLP cohort. Pin-tract infections, stiffness, and loss of reduction were notable concerns associated with EF, consistent with the experiences reported by Mahesh et al. [4] in Bengaluru and Bobade et al. [5] in Jaipur. External fixation in these Indian studies was often accompanied by higher complication rates due to prolonged pin retention, challenges with hygiene, and delayed initiation of wrist mobilization. In contrast, complications following VLP were generally mild and included transient stiffness and occasional implant irritation. Esposito J et al.[6] similarly observed fewer complications with internal fixation in their published analysis, reinforcing the broader safety profile of VLP.

Biomechanically, the advantages of VLP derive from its ability to provide stable angular fixation and permit direct reduction of articular fragments. This is particularly relevant in AO type 23C fractures, where comminution and articular depression limit the effectiveness of ligamentotaxis. Early mobilization permitted by VLP is likely responsible for the superior grip strength and range of motion observed in the present study. International literature, including the work of Leung et al.[10] supports this mechanistic explanation, linking rigid internal fixation with improved functional outcomes. Nevertheless, external fixation remains an important modality in select scenarios, such as open injuries, polytrauma, or compromised soft tissues. Some centers, such as SIMS Bengaluru, have reported specific cases in which EF produced comparable outcomes in severely comminuted fractures, though these benefits appear inconsistent across studies.

Contextual factors unique to India further influence treatment decisions. Access to physiotherapy remains limited in many regions, making early mobilization especially valuable. VLP inherently supports this through stable fixation, whereas EF may restrict early movement due to pin discomfort or concerns about stability. Socioeconomic considerations also play a significant role; despite its higher initial cost, VLP may reduce long-term indirect costs by enabling faster return to work. Institutional studies from Burdwan and NRS Kolkata have highlighted these advantages, and the findings of the present Gujarat-based study provide further support within the western Indian context.

Overall, the results of the present study align closely with both Indian and international evidence, reinforcing that volar locking plate fixation offers a more predictable and effective solution for intra-articular distal radius fractures. While external fixation maintains a role in specific clinical contexts, VLP provides superior functional outcomes, radiological restoration, complication profiles, and patient satisfaction. These findings support its preferential use in appropriately selected patients within Indian tertiary-care settings.

Limitations

Allocation was quasi-random rather than strictly randomized, introducing potential selection bias. Radiological assessments were performed by treating surgeons, which may influence measurement objectivity. Follow-up duration was

limited to one year, restricting long-term evaluation of post-traumatic arthritis or functional decline.

Conclusion

Volar locking plate fixation demonstrated superior functional recovery and more consistent restoration of anatomical alignment when compared with external fixation in the management of intra-articular distal radius fractures. Patients treated with VLP achieved better wrist mobility, improved grip strength, and higher Mayo Wrist Scores, in addition to lower complication rates. Although external fixation remains a viable option—particularly in comminuted fractures or resource-limited settings—VLP offers distinct advantages in early rehabilitation and radiological maintenance of reduction. These findings are consistent with current Indian evidence and support the preferential use of volar locking plates for unstable intra-articular distal radius fractures.

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