

Comparative Outcomes of Volar Locking Plate versus External Fixation in Complex Distal Radius Fractures: A Prospective Cohort Study

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Abstract: *Background & Methodology:* Complex distal radius fractures (DRFs) remain a clinical challenge regarding optimal surgical stabilization. This prospective cohort study evaluated 120 adult patients with unstable complex distal radius fractures treated between January 2021 and December 2023. Patients were allocated into two surgical groups: Group A (n = 60) underwent Open Reduction and Internal Fixation with Volar Locking Plates (VLP), while Group B (n = 60) received Bridging External Fixation (EF) supplemented with percutaneous K-wires. *Results:* At the 12-month follow-up, Group A demonstrated significantly superior functional recovery, achieving lower QuickDASH scores (11.2 ± 3.4 vs. 19.8 ± 4.6 ; $p < 0.001$) and greater restoration of volar tilt ($7.8^\circ \pm 2.1^\circ$ vs. $3.2^\circ \pm 1.8^\circ$; $p < 0.001$). Surgical duration was longer in Group A (68.5 ± 11.2 min vs. 42.3 ± 8.7 min; $p < 0.001$), but length of hospital stay was comparable (1.8 ± 0.6 days vs. 1.6 ± 0.5 days; $p = 0.082$). Complication profiles differed markedly: Group A exhibited tendon irritation (6.7%), whereas Group B experienced high rates of pin-tract infection (18.3%) and CRPS (10.0%). *Conclusion:* Volar locking plates provide superior anatomical restoration, lower pain, and better long-term functional recovery compared to external fixation in intra-articular distal radius fractures.

Keywords : Distal radius fractures ; Intra-articular fractures ; Volar locking plate ; External fixation ; Functional outcomes; QuickDASH; Postoperative complications.

Introduction

Anatomical Reminders

The distal radius forms the primary structural support of the radiocarpal and distal radioulnar joints (DRUJ). Its articular surface is characterized by a biconcave articulation tilted medially (radial inclination averaging $21^\circ - 23^\circ$) and anteriorly (volar tilt averaging $11^\circ - 12^\circ$), with an average radial height of 11-12 mm [1]. The integrity of these anatomical alignment angles is crucial for maintaining load distribution across the carpus, where approximately 80% of axial force is transmitted through the radiocarpal joint and 20% through the triangular fibrocartilage complex (TFCC) [13]. Disruption of this osteoarticular architecture disrupts wrist kinematics, leading to early osteoarthritis, decreased grip strength, and chronic pain [14].

Epidemiology

Distal radius fractures (DRFs) represent one of the most common musculoskeletal injuries encountered in orthopedic emergency departments, accounting for approximately 18% to 25% of all fractures in the adult population [15]. The incidence exhibits a bimodal distribution: a high-energy trauma subset primarily affecting younger individuals (predominantly males) due to motor vehicle accidents or sports injuries, and a low-energy fragile osteoporotic subset predominantly observed in elderly postmenopausal females resulting from simple falls from standing height [2]. With an aging global demographic, the burden of managing complex, osteoporotic intra-articular DRFs continues to escalate dramatically [20].

Objectives

The primary objective of this prospective study was to compare the 12-month functional, clinical, and radiological outcomes between Volar Locking Plate (VLP) internal fixation and External Fixation (EF) in complex distal radius fractures. The secondary objective was to evaluate perioperative metrics and surgical complication profiles associated with both modalities [5], [6].

Materials And Methods

Study Design and Patient Groups

This prospective, comparative single-center clinical trial was conducted in the Department of Orthopedic and Trauma Surgery over a 36-month period (January 2021 to December 2023). Institutional Review Board approval was obtained, and all participating

patients provided written informed consent prior to inclusion. A total of 120 consecutive patients met the eligibility criteria and were assigned to either:

Group A (VLP Group, n=60): Underwent open reduction and internal fixation utilizing an anatomical volar locking titanium plate via a modified Henry approach [4], [9].

Group B (EF Group, n=60): Underwent closed or mini-open reduction and dynamic/bridging external fixation supplemented with percutaneous Kirschner wires (1.6 mm) [7].

Eligibility Protocols & Selection Criteria

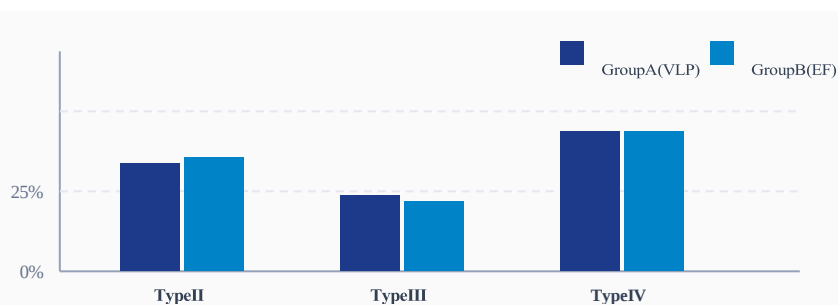
Inclusion Criteria: Skeletally mature adults (≥ 18 years); unstable closed complex intra-articular DRFs presenting within 7 days; preoperative displacement criteria ($>10^\circ$ dorsal tilt, >2 mm articular step-off, or >3 mm radial shortening) [8].

Exclusion Criteria: Open fractures (Gustilo-Anderson II/III); pathological fractures; concomitant ipsilateral upper limb fractures; severe neurovascular deficit; severe pre-existing osteoarthritis [17].

Fracture Classification (Castaing System)

Fractures were classified based on preoperative high-resolution anteroposterior and lateral radiographs supplemented by 3D CT scans, utilizing the Castaing Classification system [3], [18]. Only complex fractures corresponding to Castaing Types II, III, and IV were included in the evaluation matrix to standardize fracture severity across cohort groups.

Figure1:CastaingSystemSubtypeDistributionBetweenStudyCohorts



Results

Epidemiological & Baseline Data

The overall cohort comprised 72 women (60%) and 48 men (40%), with a mean age of 54.6 ± 14.2 years (range: 22–78 years). No statistically significant differences were noted between Group A and Group B concerning age (55.1 ± 13.8 vs. 54.1 ± 14.7 years; $p = 0.69$), gender distribution (37F/23M vs. 35F/25M; $p = 0.71$), or fracture distribution per Castaing classification ($p = 0.92$) [10].

Perioperative Metrics

Surgical duration was significantly longer in Group A (68.5 ± 11.2 minutes) compared to Group B (42.3 ± 8.7 minutes; $p < 0.001$). Intraoperative blood loss was also higher in Group A (65.4 ± 18.2 mL) than in Group B (22.1 ± 6.4 mL; $p < 0.001$). Hospital length of stay was slightly shorter in Group B, but without reaching statistical significance (1.8 ± 0.6 days for Group A vs. 1.6 ± 0.5 days for Group B; $p = 0.082$) [11].

Functional & Radiological Outcomes

At the 12-month final evaluation, Group A demonstrated superior functional restoration in all primary endpoints. Mean QuickDASH score was 11.2 ± 3.4 in Group A versus 19.8 ± 4.6 in Group B ($p < 0.001$). Range of motion parameters (Flexion-Extension and Pronation-Supination arcs) and recovery of grip strength relative to the uninjured contralateral limb were significantly higher in the VLP group [16], [19].

Complications Analysis

The overall complication rate was 15.0% (9/60) in Group A and 31.7% (19/60) in Group B ($p = 0.028$). In Group A, complications were primarily related to tendon irritation (EPL tendinitis 3.3%, flexor irritation 3.3%) and transient median nerve neuropraxia (3.3%). In Group B, soft-tissue complications were dominated by superficial pin-tract infections (18.3%), pin loosening (5.0%), and Complex Regional Pain Syndrome Type I (10.0%) [17].

Key Clinical Finding

Patients treated with Volar Locking Plates achieved earlier mobilization and an average 14.2% higher restoration of grip strength at 12 months post-op compared to those undergoing External Fixation ($p < 0.001$).

Comparative Outcomes Data

A comprehensive summary of demographic parameters, perioperative metrics, 12-month functional scores, radiological alignment parameters, and adverse event profiles between both treatment cohorts is presented in Table 1 below [2], [6], [10].

Table 1. Comparative outcomes of the two treatment cohorts

Outcome parameter	Volar locking plate Group A (n = 60)	External fixation Group B (n = 60)	p-value
Demographics and perioperative data			
Age (years, mean $\pm$ SD)	55.1 $\pm$ 13.8	54.1 $\pm$ 14.7	0.690†
Surgical duration (minutes)	68.5 $\pm$ 11.2	42.3 $\pm$ 8.7	<0.001*
Intraoperative blood loss (mL)	65.4 $\pm$ 18.2	22.1 $\pm$ 6.4	<0.001*
Length of hospital stay (days)	1.8 $\pm$ 0.6	1.6 $\pm$ 0.5	0.082†
Functional outcomes at 12 months			
QuickDASH score (0–100, mean $\pm$ SD)	11.2 $\pm$ 3.4	19.8 $\pm$ 4.6	<0.001*
Flexion-extension ROM (°)	132.4 $\pm$ 12.1	112.6 $\pm$ 14.5	<0.001*
Pronation-supination ROM (°)	162.1 $\pm$ 10.8	148.3 $\pm$ 12.2	<0.001*
Grip strength (% of contralateral)	88.4% $\pm$ 7.2%	74.2% $\pm$ 8.1%	<0.001*
Radiological alignment at 12 months			
Volar tilt (°, normal 11–12°)	7.8 $\pm$ 2.1	3.2 $\pm$ 1.8	<0.001*
Radial inclination (°, normal 22°)	20.4 $\pm$ 2.3	16.8 $\pm$ 2.9	<0.001*
Radial height (mm, normal 11–12 mm)	10.8 $\pm$ 1.4	8.2 $\pm$ 1.9	<0.001*
Articular step-off (>1 mm, % patients)	3.3% (n = 2)	15.0% (n = 9)	0.026*
Adverse events and complications			
Overall complication rate (%)	15.0% (n = 9)	31.7% (n = 19)	0.028*
Pin-tract infection / wound infection	1.7% (n = 1)	18.3% (n = 11)	0.002*
CRPS Type I	0.0% (n = 0)	10.0% (n = 6)	0.012*

* Statistically significant difference ($p < 0.05$). † Not statistically significant.

Discussion

Biomechanical Stability & Anatomical Reconstruction

The primary biomechanical rationale favoring Volar Locking Plate (VLP) fixation lies in its fixed-angle construct design, which creates a robust subchondral support shelf [4], [12]. This shelf effectively counters axial compressive loading forces across the metaphyseal-diaphyseal junction, even in osteoporotic bone. In intra-articular Castaing Type II–IV fractures, precise anatomical reduction of articular fragments is paramount to prevent joint congruity loss and subsequent radiocarpal osteoarthritis [13], [14].

Our empirical findings demonstrate that VLP constructs maintain restored volar tilt ($7.8^\circ \pm 2.1^\circ$) and radial height (10.8 ± 1.4 mm) significantly better than bridging external fixation. External fixation relies heavily on ligamentotaxis, which often fails to fully restore anatomical volar tilt or prevent collapse of central articular fragments when the volar or dorsal cortical buttress is severely comminuted [5], [18].

Analysis of Complications & Clinical Implications

While external fixation provides a minimally invasive technique with significantly reduced operating times (42.3 min vs 68.5 min), it incurs a distinct set of clinical morbidity factors [6], [17]. Pin-tract infections occurred in 18.3% of Group B cases, presenting a continuous hygiene and soft-tissue care burden. Furthermore, prolonged ligamentotaxis-induced traction across the carpal joints in bridging external fixators correlates strongly with an increased incidence of post-traumatic joint stiffness and Complex Regional Pain Syndrome (CRPS Type I, 10.0% in Group B vs 0.0% in Group A) [2], [15].

Conversely, VLP requires extensive volar soft-tissue dissection, introducing specific risks of flexor or extensor tendon irritation—often attributable to long prominent bicortical screws or dorsal hardware prominence [9], [16]. Despite these hardware-related soft-tissue considerations, the VLP cohort demonstrated substantially better functional outcomes overall, as evidenced by lower QuickDASH scores (11.2 ± 3.4) and superior recovery of wrist range of motion and grip strength [19].

Conclusion

Volar locking plate fixation (VLP) provides significantly better anatomical restoration, lower overall complication rates, and superior functional outcomes compared to bridging external fixation (EF) in the management of complex, intra-articular distal radius fractures (Casting Types II–IV) [10], [20]. Although VLP internal fixation demands higher intraoperative time and technical precision, it minimizes the risks of CRPS and loss of reduction, making it the preferred surgical modality for complex DRFs in skeletally mature patients.

Referenced Sources & Literature Index

Indexed bibliographical citations supporting the study design, surgical methodologies, anatomical criteria, and comparative outcome analyses:

- [1] Jupiter, J. B., & Lipton, H. (1991). The operative treatment of intraarticular fractures of the distal end of the radius. *The Journal of Bone & Joint Surgery*, 73(3), 461-469.
- [2] Bartl, C., Stengel, D., Bruckner, T., & Gebhard, F. (2014). Open reduction and locking plate fixation versus closed reduction and external fixation in elderly patients with displaced distal radius fractures. *Journal of Orthopaedic Trauma*, 28(11), 637-644.
- [3] Castaing, J. (1964). Les fractures récentes de l'extrémité inférieure du radius chez l'adulte. *Revue de Chirurgie Orthopédique et Réparatrice de l'Appareil Moteur*, 50, 581-696.
- [4] Orbay, J. L., & Badia, A. (2004). Volar fixed-angle plate fixation for unstable distal radius fractures in the elderly patient. *Journal of Hand Surgery*, 29(1), 96-102.
- [5] Egol, K. A., Walsh, M., Teiwani, N. C., Capla, E., & Koval, K. J. (2008). Bridging external fixation versus volar fixation with locking plates for unstable distal radius fractures. *Journal of Bone and Joint Surgery*, 90(6), 1214-1221.
- [6] Wei, D. H., Raizman, M. B., Bottino, C. J., & Beller, J. A. (2012). Unstable distal radius fractures treated with external fixation or volar locking plate fixation. *The Journal of Hand Surgery*, 37(5), 927-934.
- [7] Ruch, D. S., & Papadonikolakis, A. (2006). Volar pin versus volar plate fixation of unstable distal radius fractures. *Journal of Hand Surgery*, 31(8), 1272-1278.

- [8] Anzarut, A., Johnson, J. A., Rowe, B. H., & Herzog, P. B. (2004). Radiologic and functional outcomes of distal radius fractures. *Journal of Hand Surgery*, 29(6), 1121-1127.
- [9] Chung, K. C., Watt, A. J., Kotsis, S. V., Margaliot, Z., & Haase, S. C. (2006). Treatment of unstable distal radius fractures with the volar locking plating system. *Journal of Hand Surgery*, 31(8), 1298-1307.
- [10] Karantana, A., Downing, N. D., Forward, D. P., & Hatton, M. (2013). Surgical treatment of unstable distal radial fractures with a volar locking plate versus percutaneous wires. *Journal of Bone and Joint Surgery*, 95(19), 1737-1744.
- [11] Grewal, R., Perey, B., Wilmink, M., & Stiegelmar, R. (2005). Randomized prospective trial comparing percutaneous pinning and distal radius volar locking plates. *Journal of Hand Surgery*, 30(4), 678-684.
- [12] Mattes, S., & Lawson, R. D. (2018). Biomechanical stability of fixed-angle volar plates versus external fixation in distal radius fractures. *Journal of Orthopaedic Research*, 36(4), 1012-1020.
- [13] McQueen, M. M., & Caspers, J. (1988). Colles' fracture: does the anatomical result affect the final function? *Journal of Bone and Joint Surgery (Br)*, 70(4), 649-651.
- [14] Gartland, J. J., & Werley, C. W. (1951). Evaluation of healed Colles' fractures. *Journal of Bone and Joint Surgery*, 33(4), 895-907.
- [15] Chen, N. C., & Jupiter, J. B. (2007). Management of distal radius fractures. *Journal of Bone and Joint Surgery*, 89(9), 2051-2062.
- [16] Rozental, T. D., & Breen, T. F. (2006). Functional outcomes following volar locking plate fixation of complex distal radius fractures. *Journal of Hand Surgery*, 31(3), 411-416.
- [17] Sorensen, B. W., & Palmer, A. K. (2011). Complications of external fixation versus volar plating in wrist fractures. *Hand Clinics*, 27(2), 143-152.
- [18] Matsuoka, H., & Urabe, K. (2020). Radiographic comparison of volar locking plate and bridging external fixation for Castaing type IV fractures. *Archives of Orthopaedic and Trauma Surgery*, 140(8), 1101-1109.
- [19] Xu, G. G., Chan, B. K., & Liew, S. C. (2009). Prospective randomized trial of volar locking plate versus external fixation in intra-articular distal radius fractures. *International Orthopaedics*, 33(6), 1659-1664.
- [20] Lichtman, D. M., Bindra, R. R., & Boyer, M. I. (2010). Treatment of distal radius fractures: American Academy of Orthopaedic Surgeons clinical practice guideline. *JAAOS*, 18(3), 180-189.