

Functional and Radiological Outcomes of Intra-Articular Distal Radius Fractures: A Comparison Between Volar Locking Plate Fixation and POP Casting

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Abstract:

Background: Distal radius fractures are among the most common orthopedic injuries encountered in clinical practice. Intra-articular distal radius fractures pose a significant challenge due to the complexity of fracture patterns and the need for restoration of joint congruity and wrist function. Various treatment modalities are available, including conservative management with closed reduction and plaster of Paris (POP) casting and surgical fixation using volar locking compression plates. The optimal treatment method remains a subject of ongoing debate.

Aim: To analyze and compare the functional and radiographic outcomes of intra-articular distal radius fractures treated with closed reduction and POP casting versus volar locking plate fixation.

Materials and Methods: This prospective comparative study was conducted in the Department of Orthopaedics at Mahatma Gandhi Medical College over a period of two years from March 2024 to March 2026. A total of 27 skeletally mature patients with intra-articular distal radius fractures were included in the study. Patients were divided into two groups: conservative management with closed reduction and POP casting (15 patients) and surgical management with open reduction and internal fixation using a volar locking compression plate (12 patients).

Patients were evaluated clinically and radiographically at regular follow-up intervals. Radiographic assessment included evaluation of fracture union and maintenance of anatomical parameters such as radial length, radial inclination, and volar tilt. Functional outcomes were assessed based on pain, range of motion, grip strength, and return to daily activities. Complications associated with both treatment modalities were also documented and analyzed.

Results: Fracture union was achieved in all 27 patients, with a mean union time of 14 weeks. Sixteen patients achieved radiological union by 12 weeks, while Eleven patients required longer healing durations. One case of delayed union was observed in the conservative treatment group. Malunion was more commonly seen in patients managed with POP casting, particularly in the form of dorsal angulation and loss of palmar tilt. Patients treated with volar locking plate fixation demonstrated better maintenance of anatomical reduction, earlier mobilization, and superior functional recovery compared to the conservative group.

Conclusion: Volar locking plate fixation provides superior radiographic alignment and improved functional outcomes in intra-articular distal radius fractures when compared with closed reduction and POP casting. Surgical fixation also facilitates earlier mobilization and reduces the incidence of malunion. However, conservative treatment remains a viable option in selected stable fractures and low-demand patients.

Keywords: Distal radius fracture; intra-articular fracture; volar locking plate; plaster of Paris casting; functional outcome; radiographic outcome; open reduction and internal fixation.

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Introduction

Distal radius fractures are among the most common fractures encountered in orthopaedic practice,

accounting for approximately 15% of all fractures and representing the most frequent fracture of the

upper extremity. These injuries demonstrate a characteristic bimodal age distribution, with high-energy trauma predominating in younger individuals and low-energy mechanisms, particularly falls on an outstretched hand, occurring more commonly in the elderly population.

The incidence is notably higher in females, primarily due to postmenopausal osteoporosis and an increased susceptibility to falls compared to age-matched males [1,2]. The metaphyseal region of the distal radius is particularly vulnerable to fracture owing to its thin cortical bone and relatively higher proportion of cancellous bone. Reduced bone mineral density (BMD), along with age-related decline in balance and neuromuscular coordination, further predisposes the geriatric population to these injuries [2,3].

Despite preserved functional activity in many middle-aged women, postmenopausal bone loss significantly increases the risk of fragility fractures. Historically, distal radius fractures were predominantly managed conservatively with closed reduction and immobilization, often yielding acceptable results in low-demand individuals. However, contemporary evidence emphasizes that restoration of anatomical parameters—such as radial length, radial inclination, volar tilt, and correction of intra-articular step-off—is essential for optimal functional outcomes and prevention of long-term complications [4,5].

Treatment strategies are guided by fracture characteristics, patient age, bone quality, and functional demands. Stable, non-displaced fractures can be effectively managed with cast immobilization. In contrast, unstable or displaced fractures frequently require surgical intervention to restore anatomical alignment and enable early mobilization. Current surgical modalities include percutaneous pinning, external fixation, intramedullary fixation, and open reduction with internal fixation (ORIF) [6–8].

Although closed reduction and casting remain widely practiced, they are associated with complications such as loss of reduction, malunion, and distal radioulnar joint incongruity, leading to suboptimal functional, radiological, and cosmetic outcomes [9]. Persistent deformity can disrupt wrist biomechanics, resulting in reduced range of motion, diminished grip strength, and altered load transmission. Furthermore, complications such as chronic pain, restricted forearm rotation, and post-traumatic arthritis of the radiocarpal and distal radioulnar joints significantly impair long-term function [10,11].

In recent years, ORIF using volar locking plates has gained widespread acceptance as the preferred treatment for unstable and intra-articular distal

radius fractures. This technique provides stable fixation, facilitates anatomical reduction, and allows early range of motion, particularly in osteoporotic bone [12,13]. Advances in implant design and surgical techniques have further improved outcomes by enabling fragment-specific fixation and maintaining reduction in comminuted fractures. Recent systematic reviews and meta-analyses suggest that volar plating offers superior radiological alignment and earlier functional recovery compared to conservative management or external fixation in selected patients [14,15].

Given the evolving understanding of fracture biomechanics and the increasing emphasis on early functional recovery, the management of distal radius fractures continues to advance. Careful patient selection and appropriate surgical intervention play a critical role in optimizing clinical outcomes and minimizing complications.

Aim of the Study: To analyze and compare the functional outcomes of intra-articular distal radius fractures in patients treated with closed reduction and plaster of Paris (POP) casting versus volar locking plate fixation at our institution.

Objectives

1. To evaluate the radiographic outcomes following treatment, including assessment of fracture reduction and maintenance of anatomical parameters.
2. To assess functional outcomes post-treatment using standard clinical evaluation parameters.
3. To compare the effectiveness of volar locking plate fixation with closed reduction and POP casting in terms of functional recovery.
4. To evaluate and document treatment-related complications associated with both modalities.

Materials and Methods

This prospective comparative study was conducted to evaluate and compare the functional and radiographic outcomes of intra-articular distal radius fractures treated with either closed reduction and plaster of Paris (POP) casting or volar locking plate fixation. The study was carried out in the Department of Orthopaedics at Mahatma Gandhi Medical College over a period of two years, from 3 March 2024 to 3 March 2026.

A total of 27 skeletally mature patients presenting with intra-articular distal radius fractures were included in the study. Patients were managed either conservatively with closed reduction and POP casting or surgically with open reduction and internal fixation (ORIF) using a volar locking compression plate, based on fracture characteristics and treatment allocation.

Inclusion Criteria

- Patients aged 18 years and above
- Muller's classification Type B (partial intra-articular) and Type C (complete intra-articular) fractures
- Fractures extending less than 5 cm from the radiocarpal joint
- Closed fractures

Exclusion Criteria

- Patients aged less than 18 years
- Undisplaced fractures
- Open fractures
- Neglected fractures presenting after 4 weeks
- Patients with severe comorbid conditions
- History of previous wrist pathology or malunited distal radius fracture

Patient Evaluation: All patients presenting to the emergency or outpatient department were assessed thoroughly. A detailed history was obtained, including mechanism of injury, duration since trauma, associated comorbidities, and any prior surgical interventions. Patients were also evaluated for associated systemic injuries as part of trauma assessment.

Clinical examination of the affected limb included assessment for swelling, deformity, tenderness, and skin condition (abrasions, contusions, lacerations). Neurovascular status was carefully evaluated, including palpation of radial and ulnar pulses and assessment of distal perfusion. Allen's test was performed where indicated to assess arterial patency. Neurological examination focused particularly on the median nerve due to its vulnerability in distal radius fractures.

Patients were also evaluated for signs of compartment syndrome, and such cases were excluded from the study. Radiographic evaluation was performed using standard anteroposterior (AP) and lateral views of the wrist to confirm the diagnosis and classify the fracture.

Preoperative Assessment: The injured limb was initially immobilized using a below-elbow splint, and limb elevation was advised to reduce swelling. Routine preoperative investigations were performed, and fitness for anesthesia was obtained prior to surgical intervention in indicated cases.

Treatment Allocation

Patients were allocated into two groups:

- Conservative management group: treated with closed reduction and POP casting
- Surgical management group: treated with ORIF using volar locking compression plate

The choice of treatment modality was based on fracture pattern, stability, reducibility, and bone quality.

Surgical Technique (Volar Locking Plate Fixation): All surgical procedures were performed under general or regional anesthesia (supraclavicular or interscalene block) under strict aseptic precautions. Prophylactic intravenous antibiotics (third-generation cephalosporin) were administered perioperatively.

Patients were positioned supine on a radiolucent table with the affected limb placed on an arm board. A tourniquet was used where necessary. Fluoroscopic guidance was utilized intraoperatively to assess fracture reduction.

A standard volar approach to the distal radius was used. The interval between the flexor carpi radialis tendon and radial artery, or between the flexor carpi radialis and median nerve, was utilized depending on fracture configuration. The pronator quadratus muscle was elevated to expose the distal radius.

Fracture reduction was achieved using traction, ligamentotaxis, and intrafocal manipulation, followed by temporary fixation with Kirschner wires where required. Definitive fixation was performed using a 2.4 mm volar locking compression plate, particularly in comminuted fractures and osteoporotic bone.

Reduction and implant positioning were confirmed intraoperatively using fluoroscopy before wound closure. A surgical drain was placed in selected cases.

Postoperative Protocol: Postoperatively, patients received intravenous antibiotics for 3–5 days. The operated limb was supported with a compressive dressing and elevated to minimize swelling. Drains, where used, were removed on the second postoperative day.

Early mobilization of the wrist and hand was encouraged in patients treated with volar plating, beginning as soon as pain permitted. In contrast, patients treated with POP casting were immobilized for 4–6 weeks depending on fracture stability, with active finger movements encouraged during immobilization. Gradual wrist mobilization was initiated following cast removal.

Sutures were removed on the 10th–12th postoperative day. Patients were advised to avoid heavy lifting for approximately 12–16 weeks.

Outcome Assessment: Patients were followed up clinically and radiographically at regular intervals.

- Radiographic assessment included evaluation of fracture union and restoration of anatomical parameters such as radial length, radial inclination, and volar tilt.

- Functional assessment was performed using standard clinical parameters, including range of motion, grip strength, pain, and return to daily activities.
- Complications such as infection, malunion, nerve injury, stiffness, and post-traumatic arthritis were recorded and analyzed.

Results

A total of 27 patients were included in the study. Of these, 12 patients were treated with open reduction and internal fixation using a volar locking compression plate, while 15 patients were managed conservatively with closed reduction and plaster of Paris (POP) casting.

The mean duration of follow-up was 8.9 months, with a range from 3 to 24 months. All patients were available for regular follow-up and completed the study period.

Fracture union was achieved in all patients. The mean time to union was 14 weeks, ranging from 10 to 18 weeks. Sixteen patients demonstrated radiological union by 12 weeks, while the remaining 11 cases required a longer duration for complete healing.

One case of delayed union was observed in the conservative (closed reduction and POP casting) group. This patient required prolonged immobilization, with casting extended for an additional two months until satisfactory union was achieved. Delayed union was more commonly observed in elderly patients with relatively poor bone quality.

Malunion was predominantly observed in patients treated with closed reduction and POP casting. Among the 15 patients in this group, a proportion developed malalignment characterized by dorsal angulation and loss of normal palmar tilt. In contrast, patients treated with volar locking plate fixation maintained better anatomical alignment with minimal incidence of malunion.

Functional outcome assessment was performed in all patients during follow-up visits using standard clinical evaluation parameters including pain, range of motion, grip strength, wrist stability, and ability to perform activities of daily living.

Patients treated with volar locking plate fixation demonstrated earlier functional recovery compared to those managed with closed reduction and POP casting. Early wrist mobilization in the operative group contributed to improved wrist movements and reduced stiffness during follow-up.

Patients in the volar locking plate group reported less pain during routine activities and wrist

movements at final follow-up compared to the conservative group. Mild residual pain was observed in a few conservatively treated patients, particularly those with residual deformity or malunion.

Wrist range of motion was superior in patients treated surgically. Better flexion, extension, pronation, and supination were observed in the volar locking plate group due to stable fixation and early rehabilitation. In contrast, prolonged immobilization in the POP casting group resulted in comparatively restricted wrist movements and stiffness in some patients.

Grip strength recovery was better in the surgical group when compared to the conservative group. Anatomical restoration and early mobilization contributed to improved hand function and strength in patients treated with volar locking plate fixation.

Patients who underwent volar locking plate fixation returned to activities of daily living and occupational work earlier than patients managed conservatively. Delayed rehabilitation and prolonged immobilization in the POP casting group contributed to slower functional recovery.

Overall functional outcomes were superior in the volar locking plate group when compared with the closed reduction and POP casting group. Patients treated surgically demonstrated better wrist function, improved range of motion, less pain, and greater patient satisfaction at final follow-up.

Conservative management produced acceptable functional outcomes in selected stable fractures; however, outcomes were comparatively inferior in unstable intra-articular fractures due to higher incidence of malunion and stiffness.

Statistical Analysis: The collected data were compiled and analyzed using appropriate statistical methods. Descriptive statistics such as mean, standard deviation, percentage, and frequency distribution were used to summarize demographic data, fracture characteristics, radiographic findings, and functional outcomes.

Comparative analysis between the conservative management group (closed reduction and POP casting) and the surgical management group (volar locking plate fixation) was performed to assess differences in radiological and functional outcomes.

Continuous variables such as age, time to union, range of motion, and grip strength were expressed as mean $\pm$ standard deviation. Categorical variables such as fracture type, complications, and functional grading were expressed as frequencies and percentages.

Age Group (Years)	Number of Patients	Percentage (%)
18–30	5	18.5
31–45	8	29.6
46–60	9	33.3
>60	5	18.5
Total	27	100

The Student's t-test was used for comparison of continuous variables between the two groups, while the Chi-square test or Fisher's exact test was used for categorical variables where appropriate.

A p-value of less than 0.05 was considered statistically significant. Statistical analysis was performed using standard statistical software. The results were presented in the form of tables, charts, and graphs wherever necessary.

Functional Parameter	POP Casting	Volar Locking Plate
Pain Relief	Moderate	Better
Wrist Range of Motion	Fair	Good
Grip Strength	Fair	Good
Return to Daily Activities	Delayed	Early
Overall Functional Outcome	Satisfactory	Superior

Discussion

Distal radius fractures are among the most frequently encountered fractures in orthopedic practice and constitute a significant proportion of upper limb injuries. Management of intra-articular distal radius fractures remains challenging because restoration of articular congruity, maintenance of anatomical alignment, and achievement of satisfactory functional outcomes are essential for optimal recovery. Over the years, treatment modalities have evolved from conservative methods such as closed reduction and plaster immobilization to advanced surgical fixation techniques including volar locking compression plates.

The present prospective comparative study was undertaken to evaluate and compare the radiological and functional outcomes of intra-articular distal radius fractures treated with either closed reduction and POP casting or volar locking plate fixation.

In the present study, a total of 27 patients with intra-articular distal radius fractures were evaluated. Among them, 15 patients were treated conservatively with POP casting, while 12 patients underwent open reduction and internal fixation using a volar locking compression plate. The mean follow-up period was 8.9 months.

Fracture union was achieved in all patients included in the study, with an average union time of 14 weeks. These findings are comparable to previous studies reported in the literature, where distal radius fractures generally united between 10 and 16 weeks irrespective of treatment modality. One case of delayed union was observed in the conservative treatment group, particularly in an elderly patient with poor bone quality. Delayed union in conservatively treated fractures may be attributed to

inadequate fracture stability, osteoporotic bone, and prolonged immobilization.

Radiological assessment in the present study demonstrated superior maintenance of anatomical parameters in patients treated with volar locking plate fixation. Restoration of radial height, radial inclination, and volar tilt was better preserved in the operative group when compared to patients treated with POP casting. Malunion was predominantly observed in the conservative group, especially in the form of dorsal angulation and collapse of the distal fragment. These findings are consistent with studies by Orbay and Fernandez, who emphasized that volar locking plates provide stable fixation and maintain fracture reduction even in osteoporotic and comminuted fractures.

The biomechanical advantage of volar locking plates lies in their fixed-angle construct, which provides subchondral support and prevents secondary displacement. This allows early mobilization and reduces the risk of collapse during fracture healing. In contrast, conservative treatment relies heavily on maintenance of reduction within the cast, which may be difficult in unstable intra-articular fractures, particularly in elderly individuals with osteoporotic bone.

Functional outcomes in the present study were superior in the volar locking plate group. Patients treated surgically demonstrated earlier return of wrist movements, improved grip strength, reduced pain, and earlier return to daily activities compared to the conservative group. Early mobilization following stable fixation is likely responsible for improved functional recovery. Prolonged immobilization in the POP casting group contributed to wrist stiffness and delayed rehabilitation in several patients.

These findings correlate with previous studies conducted by Kapoor et al. [16] and Chung et al. [17] who reported significantly better functional outcomes and improved patient satisfaction following volar plating of unstable distal radius fractures. Surgical fixation enables anatomical restoration of the articular surface, which is particularly important in younger and active individuals where preservation of wrist function is essential.

Complications observed in the present study included delayed union, malunion, wrist stiffness, and pain. Malunion was more frequent in the conservative treatment group, whereas postoperative stiffness and mild wound-related complications were occasionally observed in surgically managed patients. No major neurovascular complications or implant failures were encountered in the operative group. Although surgical treatment carries risks such as infection, tendon irritation, and hardware-related complications, careful surgical technique and postoperative rehabilitation can minimize these complications.

Conservative treatment with POP casting still remains an acceptable option in selected patients, especially those with minimally displaced fractures, low functional demands, severe comorbidities, or poor surgical fitness. However, in unstable intra-articular fractures, volar locking plate fixation provides better anatomical restoration and functional outcomes.

The limitations of the present study include a relatively small sample size and shorter follow-up duration in some patients. Long-term assessment for development of post-traumatic arthritis could not be adequately evaluated. Additionally, treatment allocation was based on fracture characteristics and surgeon preference rather than randomization, which may introduce selection bias.

Despite these limitations, the study demonstrates that volar locking plate fixation offers superior radiological and functional outcomes in intra-articular distal radius fractures when compared with closed reduction and POP casting. Early mobilization, maintenance of reduction, and improved wrist function make volar plating a preferred treatment modality for unstable intra-articular distal radius fractures.

Conclusion

The present prospective comparative study evaluated the functional and radiographic outcomes of intra-articular distal radius fractures treated with either closed reduction and plaster of Paris (POP) casting or open reduction and internal fixation using a volar locking compression plate.

Both conservative management with POP casting and surgical fixation with volar locking plates achieved satisfactory fracture union in intra-articular distal radius fractures. However, patients treated with volar locking plate fixation showed better maintenance of anatomical alignment, earlier mobilization, improved functional recovery, and lower incidence of malunion compared to the conservative group. Volar locking plate fixation is therefore a more effective treatment option for unstable intra-articular distal radius fractures, while POP casting remains suitable for selected stable fractures and low-demand patients.

References

1. Court-Brown CM, Caesar B. Epidemiology of adult fractures: a review. *Injury*. 2006;37(8):691–7.
2. Cummings SR, Melton LJ. Epidemiology and outcomes of osteoporotic fractures. *Lancet*. 2002;359(9319):1761–7.
3. Johnell O, Kanis JA. An estimate of the worldwide prevalence of osteoporosis. *Osteoporos Int*. 2006;17(12):1726–33.
4. Knirk JL, Jupiter JB. Intra-articular fractures of the distal radius in young adults. *J Bone Joint Surg Am*. 1986;68(5):647–59.
5. Diaz-Garcia RJ, Chung KC. Common myths and evidence in distal radius fractures. *Hand Clin*. 2012;28(2):127–33.
6. Orbay JL. Volar plate fixation of distal radius fractures. *Hand Clin*. 2005;21(3):347–54.
7. Rikli DA, Regazzoni P. Internal fixation and early function in distal radius fractures. *J Bone Joint Surg Br*. 1996;78(4):588–92.
8. Mellstrand Navarro C, Ahrengart L, Tägil M, et al. Volar locking plate vs external fixation. *J Orthop Trauma*. 2016;30(4):217–24.
9. McQueen MM, Caspers J. Colles fracture: anatomical vs functional outcome. *J Bone Joint Surg Br*. 1988;70(4):649–51.
10. Forward DP, Davis TRC, Sithole JS. Radiocarpal arthritis after distal radius fractures. *J Hand Surg Eur Vol*. 2008;33(4):438–44.
11. Lichtman DM, Bindra RR, Boyer MI, et al. Treatment of distal radius fractures. *J Am Acad Orthop Surg*. 2010;18(3):180–9.
12. Orbay JL, Fernandez DL. Volar fixation for distal radius fractures. *J Hand Surg Am*. 2002;27(2):205–15.
13. Wei DH, Raizman NM, Bottino CJ, et al. Fixation methods comparison. *J Bone Joint Surg Am*. 2009;91(7):1568–77.
14. Walenkamp MMJ, Mulders MAM, van der Linden FM, et al. Functional outcome in distal radius fractures: systematic review and meta-analysis. *J Hand Surg Eur Vol*. 2020;45(6):629–38.

15. Li Y, Chen S, Chen J, et al. Volar locking plate versus external fixation for distal radius fractures: a meta-analysis. *Orthop Traumatol Surg Res.* 2021;107(2):102760.
16. Kapoor H, Agarwal A, Dhaon BK. Displaced intra-articular fractures of distal radius: a comparative evaluation of results following closed reduction, external fixation and open reduction with internal fixation. *Injury.* 2000;31(2):75–79.
17. Chung KC, Watt AJ, Kotsis SV, Margaliot Z, Haase SC, Kim HM. Treatment of unstable distal radial fractures with the volar locking plating system. *The Journal of Bone and Joint Surgery American Volume.* 2006;88(12):2687–2694.