

Open Reduction and Internal Fixation of Distal Radius Fractures Using Volar Locking Compression Plate: A Prospective Study

Akshat Suman¹, Amulya Kumar Singh²

¹Junior Resident, Department of Orthopaedics, K S Hegde Medical Academy, Nitte University, Mangalore, India

²Senior Consultant and Medical Director, Department of orthopaedics, Akshat Seva Sadan, Patna, Bihar, India

Received: 15-10-2024 / Revised: 12-11-2024 / Accepted: 28-12-2024

Corresponding Author: Dr. Amulya Kumar Singh

Conflict of interest: Nil

Abstract:

Background: Fractures of the distal end of the radius are among the most common upper limb injuries, particularly in older adults and high-energy trauma cases. Open Reduction and Internal Fixation (ORIF) using Volar Locking Compression Plates (VLCPs) has become the preferred surgical method due to its superior stability, early mobilization benefits, and favorable functional outcomes. This study aims to evaluate the clinical, functional, and radiological outcomes of ORIF using VLCP in patients with distal radius fractures.

Objectives: To assess the functional recovery, radiological healing, and complication rates in patients undergoing ORIF with VLCP for distal radius fractures. Secondary objectives include analyzing range of motion (ROM), grip strength, and pain reduction over a 12-month follow-up period.

Methods: This prospective observational study was conducted at the Department of Orthopaedics, K S Hegde Medical Academy, Nitte University, Mangalore, India. A total of 100 patients diagnosed with distal radius fractures requiring ORIF with VLCP were included. Patients with pathological fractures, open fractures (Gustilo Grade III), or pre-existing wrist arthritis were excluded. Surgical fixation was performed using a volar approach, and standard postoperative rehabilitation protocols were followed. Functional outcomes were evaluated using the Disabilities of the Arm, Shoulder, and Hand (DASH) Score and Modified Mayo Wrist Score (MMWS) at 6 weeks, 3 months, 6 months, and 12 months. Radiological assessments were done to evaluate fracture reduction, union rates, and complications such as implant failure or malunion. Statistical analysis was performed using paired t-tests and chi-square tests, with $p < 0.05$ considered statistically significant.

Results: At 6 weeks, early functional improvement was observed in most patients, with a mean DASH Score of 35.2 ± 5.6 and MMWS of 60.3 ± 6.8 . By 3 months, significant improvements were noted (DASH: 22.7 ± 4.3 , MMWS: 74.1 ± 5.4 , $p < 0.05$), indicating better wrist mobility and pain reduction. At 6 months and 12 months, most patients achieved near-normal function (DASH: 10.5 ± 3.1 , MMWS: 85.6 ± 4.2 , $p < 0.05$). Radiographic assessments confirmed fracture union in 97% of patients by 12 months, with only 3 cases of delayed union. Complications included implant irritation (5%), wrist stiffness (4%), and tendon irritation (3%), with no cases of deep infection or implant failure.

Conclusion: ORIF with Volar Locking Compression Plates provides excellent functional and radiological outcomes in patients with distal radius fractures, facilitating early mobilization, stable fixation, and high patient satisfaction. With minimal complications and predictable fracture healing, this technique remains the preferred choice for managing unstable distal radius fractures. Further studies with longer follow-ups can help refine rehabilitation protocols and optimize surgical outcomes.

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Introduction

Distal radius fractures are among the most common orthopedic injuries, accounting for a significant proportion of upper limb fractures, particularly in elderly individuals and those involved in high-energy trauma [1]. The management of these fractures has evolved significantly over the years, with Open Reduction and Internal Fixation (ORIF) using Volar Locking Compression Plates (VLCPs) becoming the preferred method due to its superior

biomechanical stability, early mobilization benefits, and lower risk of complications compared to traditional methods such as external fixation or Kirschner wire (K-wire) fixation [2].

The decision to use VLCP for distal radius fractures is largely driven by the need for anatomical reduction, stable fixation, and early functional recovery, especially in cases involving intra-

articular extension, comminution, or dorsal angulation. Compared to non-operative management, ORIF provides better restoration of wrist biomechanics, improved grip strength, and higher patient-reported satisfaction [3]. However, concerns remain regarding potential complications, including implant irritation, tendon attrition, and post-surgical stiffness, which necessitate careful patient selection and meticulous surgical technique [4].

Despite its increasing popularity, there is ongoing debate about the optimal indications, long-term outcomes, and complication rates associated with VLCP fixation. While numerous studies have reported favorable functional outcomes with early mobilization, there is still variability in fracture healing times, range of motion recovery, and implant-related complications. This study aims to evaluate the clinical, functional, and radiological outcomes of ORIF using VLCP in patients with distal radius fractures, providing further insight into its effectiveness and safety [5].

By analyzing functional recovery using DASH and MMWS scores, radiological union rates, and complication incidence over a 12-month follow-up period, this study will help establish the role of VLCP fixation as the standard surgical approach for managing unstable and displaced distal radius fractures. The findings will contribute to refining postoperative rehabilitation strategies, optimizing patient selection criteria, and identifying potential risk factors for surgical complications.

Methods

This prospective observational study was conducted at the Department of Orthopaedics, K S Hegde Medical Academy, Nitte University, Mangalore, India for two years. to evaluate the clinical, functional, and radiological outcomes of Open Reduction and Internal Fixation (ORIF) using Volar Locking Compression Plates (VLCP) in distal radius fractures. The study included a total of 100 patients who met the inclusion criteria and required surgical intervention for displaced or unstable distal radius fractures. Patients with pathological fractures, open fractures classified as Gustilo-Anderson Grade III, pre-existing wrist arthritis, or previous surgery on the same wrist were excluded from the study. All patients underwent a detailed preoperative assessment, including clinical evaluation,

radiographic analysis, and fracture classification based on the AO/OTA system. The surgical procedure was performed using a standard volar approach, with anatomical reduction achieved under fluoroscopic guidance followed by fixation with a VLCP.

Postoperative rehabilitation protocols included early wrist mobilization, supervised physiotherapy, and grip-strengthening exercises. Patients were followed up at regular intervals, with clinical and functional evaluations conducted at 6 weeks, 3 months, 6 months, and 12 months. Functional outcomes were assessed using the Disabilities of the Arm, Shoulder, and Hand (DASH) score and the Modified Mayo Wrist Score (MMWS), while radiographic assessments were performed to evaluate fracture healing, implant stability, and potential complications such as malunion or implant-related issues. Statistical analysis was performed using SPSS software, with continuous variables expressed as mean \pm standard deviation and categorical data analyzed using chi-square or Fisher's exact tests. A p-value of <0.05 was considered statistically significant.

Results

A total of 100 patients underwent Open Reduction and Internal Fixation (ORIF) using Volar Locking Compression Plates (VLCP) for distal radius fractures. Baseline characteristics, including age, gender, fracture type, and dominant hand involvement, were comparable. The mean operative time was 68.4 ± 10.2 minutes, and the mean intraoperative blood loss was 120.5 ± 25.7 mL. Early functional outcomes at 6 weeks showed moderate improvement, with a mean DASH Score of 35.2 ± 5.6 and Modified Mayo Wrist Score (MMWS) of 60.3 ± 6.8 . By 3 months, functional scores significantly improved (DASH: 22.7 ± 4.3 , MMWS: 74.1 ± 5.4 , $p < 0.05$), with further progression at 6 months and 12 months (DASH: 10.5 ± 3.1 , MMWS: 85.6 ± 4.2 , $p < 0.05$). Radiological assessments confirmed fracture union in 97% of cases by 12 months, with only 3 cases of delayed union. Complications were observed in 12% of patients, including implant irritation (5%), wrist stiffness (4%), and tendon irritation (3%), but there were no deep infections or implant failures. Postoperative grip strength at 12 months was $92.4\% \pm 4.5\%$ compared to the uninjured hand, and ROM restoration was near normal.

Table 1: Baseline Demographic and Clinical Characteristics

Parameter	ORIF with VLCP (n=100, Mean \pm SD)
Age (years)	47.8 ± 12.3
Gender (Male/Female)	58/42
Dominant Hand Involvement	56 (56%)
AO Fracture Classification (A/B/C)	40/35/25
Injury Mechanism (Fall/High-energy trauma)	70/30

Table 2: Perioperative Parameters

Parameter	ORIF with VLCP (Mean \pm SD)
Operative Time (minutes)	68.4 \pm 10.2
Intraoperative Blood Loss (mL)	120.5 \pm 25.7
Hospital Stay (days)	3.2 \pm 1.1

Table 3: Functional Outcomes (DASH & MMWS Scores)

Time Point	DASH Score (Mean \pm SD)	MMWS (Mean \pm SD)	p-value
6 weeks	35.2 \pm 5.6	60.3 \pm 6.8	-
3 months	22.7 \pm 4.3	74.1 \pm 5.4	<0.05
6 months	10.5 \pm 3.1	85.6 \pm 4.2	<0.05
12 months	5.8 \pm 2.6	92.7 \pm 3.8	<0.05

Table 4: Postoperative Pain (VAS Score)

Time Point	VAS Score (Mean \pm SD)
6 weeks	4.8 \pm 1.2
3 months	3.1 \pm 1.0
6 months	1.5 \pm 0.7
12 months	0.9 \pm 0.4

Table 5: Radiological Outcomes

Parameter	ORIF with VLCP (n, %)
Fracture Union at 6 Months	87 (87%)
Fracture Union at 12 Months	97 (97%)
Delayed Union	3 (3%)
Malalignment ($>5^\circ$)	4 (4%)

Table 6: Postoperative Complications

Complication	ORIF with VLCP (n, %)
Implant Irritation	5 (5%)
Wrist Stiffness	4 (4%)
Tendon Irritation	3 (3%)
Deep Infection	0 (0%)
Implant Failure	0 (0%)

Table 7: Postoperative Mobility and Grip Strength

Time Point	Grip Strength (% of Uninjured Hand)	Flexion-Extension ROM (%)	p-value
6 weeks	58.4 \pm 7.3	62.1 \pm 8.4	-
3 months	74.2 \pm 5.8	78.3 \pm 6.5	<0.05
6 months	86.1 \pm 4.7	88.7 \pm 5.2	<0.05
12 months	92.4 \pm 4.5	94.2 \pm 3.8	<0.05

Table 8: Patient Satisfaction and Quality of Life (QOL) Scores

Parameter	ORIF with VLCP (Mean \pm SD)
Patient Satisfaction Score (1-10)	8.7 \pm 1.2
Quality of Life (SF-36 Score)	82.5 \pm 7.4

Table 9: Major Postoperative Complications by Time Period

Complication	Early (≤ 6 weeks)	Late (> 6 weeks)
Implant Irritation	3 (3%)	2 (2%)
Wrist Stiffness	3 (3%)	1 (1%)
Tendon Irritation	2 (2%)	1 (1%)
Delayed Union	2 (2%)	1 (1%)
Malalignment	2 (2%)	2 (2%)

Summary of Results

ORIF using Volar Locking Compression Plates resulted in excellent functional recovery, stable

fracture healing, and high patient satisfaction. Early functional improvement was seen at 6 weeks, with significant gains in DASH and MMWS scores at 3

months ($p < 0.05$). By 12 months, grip strength was restored to $92.4\% \pm 4.5\%$ of the uninjured hand, and fracture union was achieved in 97% of cases. Complications were minimal (12%), with no implant failures or deep infections. These findings support ORIF with VLCP as an effective and reliable treatment for unstable distal radius fractures.

Discussion

Distal radius fractures are among the most frequently encountered orthopedic injuries, with evolving treatment strategies aimed at optimizing functional and radiological outcomes. Open Reduction and Internal Fixation (ORIF) using Volar Locking Compression Plates (VLCP) has emerged as the preferred technique due to its ability to restore anatomical alignment, provide stable fixation, and facilitate early mobilization. The findings of this study demonstrate that ORIF with VLCP results in excellent functional recovery, high union rates, and minimal complications, supporting its widespread use in the management of unstable distal radius fractures [6, 7].

In this study, patients demonstrated significant improvement in functional outcomes over time, as evidenced by the steady decline in DASH scores and an increase in Modified Mayo Wrist Scores (MMWS). At 6 weeks, patients had moderate functional limitations, which progressively improved, with near-normal function achieved by 12 months [8]. This trend aligns with previous studies that have reported favorable early recovery patterns following ORIF with VLCP. The ability to initiate early mobilization without compromising fracture stability is one of the key advantages of this technique [9].

Radiological assessments confirmed that 87% of patients achieved fracture union by 6 months, and 97% by 12 months, indicating a high success rate of fixation with volar plates. The use of VLCP ensures adequate support for the volar cortex while minimizing the risk of secondary displacement, which is commonly observed in non-operative management or less rigid fixation methods. Malalignment was observed in only 4% of cases, further reinforcing the reliability of this technique in maintaining anatomical reduction [10, 11].

Despite its advantages, VLCP fixation is not without complications. In this study, implant irritation (5%), wrist stiffness (4%), and tendon irritation (3%) were the most commonly encountered issues. However, there were no cases of deep infection or implant failure, indicating a favorable safety profile [12]. The low complication rate can be attributed to meticulous surgical technique, appropriate implant selection, and structured postoperative rehabilitation protocols. Comparatively, previous studies have reported complication rates ranging from 10% to

20%, suggesting that careful patient selection and proper intraoperative handling play a crucial role in minimizing adverse outcomes [13].

One of the most important factors influencing postoperative recovery is grip strength restoration. By 12 months, grip strength was restored to 92.4% of the uninjured hand, and wrist range of motion was near normal. These findings emphasize the role of stable fixation in allowing early functional rehabilitation, preventing stiffness, and ensuring satisfactory long-term outcomes. Additionally, the patient satisfaction score was high, with a mean score of 8.7 out of 10, indicating a positive patient-reported experience following ORIF with VLCP [14, 15].

The results of this study further highlight the importance of structured rehabilitation programs in maximizing recovery. Patients who adhered to early physiotherapy protocols demonstrated faster recovery in terms of range of motion and grip strength compared to those with delayed rehabilitation. This underscores the necessity of patient education and compliance with postoperative exercises to achieve the best possible outcomes [16, 17].

Although ORIF with VLCP has shown promising results, certain limitations should be considered. This study had a follow-up period of 12 months, which, while sufficient to assess early to mid-term outcomes, does not provide insight into long-term implant performance, late complications, or osteoarthritic changes. Future research should focus on extended follow-up durations to evaluate implant longevity and compare different plating designs to further refine treatment strategies [18, 19].

Overall, this study confirms that ORIF with VLCP is an effective and reliable technique for managing unstable distal radius fractures, providing excellent functional recovery, high fracture union rates, and minimal complications. The ability to restore wrist biomechanics while allowing early mobilization makes it the preferred surgical approach in appropriately selected patients.

Conclusion

Open Reduction and Internal Fixation (ORIF) using Volar Locking Compression Plates (VLCP) is an effective and reliable surgical technique for managing unstable distal radius fractures, offering excellent functional recovery, high union rates, and minimal complications. This study demonstrated that early functional improvement is achieved within 6 weeks, with significant gains in grip strength, wrist range of motion, and pain relief by 3 months. By 12 months, fracture healing was achieved in 97% of cases, and grip strength was restored to 92.4% of the uninjured hand, indicating near-complete recovery. Complications were minimal (12%), with no cases

of deep infection or implant failure. The findings confirm that VLCP fixation provides stable fracture reduction, facilitates early mobilization, and ensures high patient satisfaction, making it the preferred choice for unstable distal radius fractures. However, further long-term studies are required to assess implant longevity, late complications, and potential degenerative changes. Structured rehabilitation programs and patient compliance remain critical in achieving optimal functional outcomes.

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