

Outcomes of Distal Radius Fractures Managed with Volar Locking Plate Fixation: A Clinical Evaluation

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Abstract

Background: Fractures of the distal radius are among the most common orthopedic injuries and significantly impact wrist function and quality of life. Open reduction and internal fixation (ORIF) using volar locking compression plates (VLCP) has become the preferred surgical method, offering stable fixation and early mobilization. However, variability in functional outcomes necessitates further evaluation of this treatment approach.

Objectives: This study aims to assess the functional and radiological outcomes of distal radius fractures managed surgically with VLCP and to identify factors influencing recovery.

Methods: A retrospective study was conducted with 80 patients who underwent ORIF with VLCP for distal radius fractures over August 2019 to March 2020. Data on demographics, fracture classification (AO/OTA classification), surgical details, and postoperative rehabilitation were collected. Functional outcomes were assessed using the Disabilities of the Arm, Shoulder, and Hand (DASH) score and radiological parameters at a minimum follow-up of 12 months.

Results: The mean age of the study population was 46.2 ± 13.8 years, with females constituting 62% of cases. Most fractures were classified as Type 23-A (48%) and Type 23-C (38%). At the final follow-up, the mean DASH score was 12.4 ± 4.8 , indicating excellent functional recovery in 76% of cases. Radiological parameters, including volar tilt, radial inclination, and ulnar variance, were restored to near-normal values in 85% of patients. Complications included implant-related discomfort (7.5%), tendon irritation (5%), and superficial infection (2.5%).

Conclusions: ORIF with VLCP provides excellent functional and radiological outcomes for distal radius fractures, particularly when anatomical reduction and early mobilization are achieved. Adherence to rehabilitation protocols and meticulous surgical techniques are crucial to minimizing complications and optimizing recovery.

Keywords: Distal Radius Fractures, Volar Locking Compression Plate, Open Reduction and Internal Fixation, DASH Score, Radiological Outcomes

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Introduction

Fractures of the distal radius are among the most frequently encountered orthopedic injuries, accounting for approximately 15% of all adult fractures [1]. These injuries are commonly seen in two distinct patient populations: younger individuals subjected to high-energy trauma, such as road traffic accidents, and older adults with osteoporotic bones experiencing low-energy falls. Despite their frequency, distal radius fractures present a spectrum of challenges due to the need for precise anatomical restoration to ensure optimal wrist function [2].

The goal of treatment for distal radius fractures is to restore joint congruity, achieve stable fixation, and facilitate early mobilization to prevent complications such as stiffness, malunion, and post-traumatic arthritis. While non-operative management remains appropriate for minimally displaced fractures, displaced and unstable fractures often require surgical intervention to achieve these objectives. Open reduction and internal fixation (ORIF) using volar locking compression plates (VLCP) has emerged as the preferred surgical approach due to its biomechanical advantages,

including enhanced stability and support for comminuted and osteoporotic fractures [3].

The AO/OTA classification system provides a structured framework for categorizing distal radius fractures based on their complexity, ranging from extra-articular (Type 23-A) to complete articular involvement (Type 23-C). This classification helps guide treatment strategies and predict outcomes, with more complex fractures requiring advanced surgical techniques and prolonged rehabilitation [4].

Functional recovery following ORIF with VLCP is influenced by several factors, including fracture type, quality of reduction, surgical timing, and adherence to rehabilitation protocols. The Disabilities of the Arm, Shoulder, and Hand (DASH) score is a widely used tool for assessing functional outcomes, while radiological parameters such as volar tilt, radial inclination, and ulnar variance serve as objective measures of anatomical restoration [5]. Despite its success, the procedure is not without risks, with complications such as tendon irritation, implant-related discomfort, and infections being reported in the literature.

This study aims to evaluate the functional and radiological outcomes of distal radius fractures managed with VLCP fixation in a tertiary care setting. Specifically, it seeks to:

1. Assess functional recovery using the DASH score.
2. Evaluate the restoration of radiological parameters.
3. Identify factors influencing outcomes and analyze the incidence of complications.

By providing insights into the effectiveness of this surgical approach, the study aims to contribute to optimizing the management of distal radius fractures and improving patient outcomes.

Methods

Study Design

A retrospective study was conducted at Department of Orthopaedics, Hazaribagh Medical College, Hazaribagh, Jharkhand, India August 2019 to March 2020 to evaluate the outcomes of distal radius fractures managed with open reduction and internal fixation (ORIF) using volar locking compression plates (VLCP). Institutional ethics committee approval was obtained, and written informed consent was secured from all participants.

Study Population: The study included 80 patients who met the following criteria:

Inclusion Criteria:

- Adults aged 18–70 years.

- Distal radius fractures classified as AO/OTA Type 23-A, 23-B, or 23-C confirmed on radiographs and computed tomography (CT) scans.
- Fractures treated surgically with VLCP within three weeks of injury.
- A minimum follow-up of 12 months.

Exclusion Criteria:

- Open fractures with extensive soft tissue damage (Gustilo-Anderson Grade III).
- Pathological fractures or those associated with malignancy.
- Pre-existing wrist deformities or systemic conditions affecting upper limb function.
- Incomplete follow-up or missing data.

Data Collection: Data were collected prospectively using a standardized proforma, including:

1. **Demographic Data:** Age, gender, mechanism of injury (e.g., fall from height, road traffic accident).
2. **Fracture Characteristics:** Classification using the AO/OTA system and preoperative imaging findings.
3. **Surgical Details:** Timing of surgery, surgical approach, plate type, and intraoperative complications.
4. **Postoperative Management:** Rehabilitation protocols, including weight-bearing and range of motion exercises.
5. **Complications:** Tendon irritation, implant-related discomfort, infection, or malunion.
6. **Functional and Radiological Outcomes:**
 - Functional assessment using the Disabilities of the Arm, Shoulder, and Hand (DASH) score.
 - Radiological evaluation of volar tilt, radial inclination, and ulnar variance on postoperative radiographs.

Outcome Measures

Primary Outcome:

- Functional recovery assessed using the **DASH score** at 6, 12, and 18 months. Lower DASH scores indicate better functional outcomes.

Secondary Outcomes:

1. **Radiological Parameters:** Restoration of volar tilt (10° – 15°), radial inclination (20° – 25°), and ulnar variance (neutral to ± 2 mm).

2. **Complication Rates:** Incidence of implant-related discomfort, tendon irritation, infection, and malunion.

Statistical Analysis

1. **Descriptive Statistics:** Continuous variables (e.g., DASH score, radiological parameters) were expressed as mean \pm standard deviation (SD), and categorical variables (e.g., complications, fracture types) were presented as frequencies and percentages.
2. **Comparative Analysis:** Outcomes were compared across AO/OTA fracture types using ANOVA or Kruskal-Wallis tests for continuous variables and chi-square tests for categorical variables.
3. **Correlation Analysis:** Pearson or Spearman correlation coefficients were used to assess the

relationship between DASH scores and factors such as fracture type, surgical timing, and radiological parameters.

4. **Significance Threshold:** A p-value <0.05 was considered statistically significant.

Results

Summary: This study evaluated 80 patients with distal radius fractures treated using open reduction and internal fixation (ORIF) with volar locking compression plates (VLCP). The majority of fractures were AO/OTA Types 23-A and 23-C. Functional outcomes, assessed using the DASH score, were excellent in 76% of cases. Radiological parameters, including volar tilt, radial inclination, and ulnar variance, were restored in 85% of patients. Complications occurred in 15% of cases, with tendon irritation and implant-related discomfort being the most common.

Table 1: Demographic and Clinical Profile

This table summarizes the demographic and clinical characteristics of the study population.

Parameter	Value
Total Patients (n)	80
Mean Age (years)	46.2 \pm 13.8
Gender (Male/Female)	30/50
Mechanism of Injury (%)	Fall from Height (62.5)
	Road Traffic Accidents (37.5)

Table 2: Fracture Classification (AO/OTA)

This table outlines the distribution of fracture types based on the AO/OTA classification system.

Fracture Type	Number of Cases (n=80)	Percentage (%)
Type 23-A (Extra-Articular)	38	47.5
Type 23-B (Partial Articular)	12	15.0
Type 23-C (Complete Articular)	30	37.5

Table 3: Functional Outcomes (DASH Scores)

This table presents functional outcomes based on the DASH score.

Fracture Type	Mean DASH Score \pm SD
Type 23-A	10.8 \pm 3.7
Type 23-B	13.5 \pm 4.2
Type 23-C	15.4 \pm 5.0

Table 4: Radiological Outcomes

This table summarizes the radiological parameters achieved postoperatively.

Parameter	Mean \pm SD	Restored Cases (%)
Volar Tilt (degrees)	12.4 \pm 2.6	87.5
Radial Inclination (degrees)	22.3 \pm 3.4	85.0
Ulnar Variance (mm)	0.8 \pm 0.9	82.5

Table 5: Impact of Surgical Timing on Functional Outcomes

This table shows the correlation between surgical timing and DASH scores.

Timing of Surgery	Mean DASH Score \pm SD	p-value
<7 Days Post-Injury	11.2 \pm 4.1	$<0.05^*$
≥ 7 Days Post-Injury	14.6 \pm 4.9	$<0.05^*$

Table 6: Hospital Stay by Fracture Type

This table highlights the duration of hospital stay based on fracture classification.

Fracture Type	Mean Hospital Stay (days) \pm SD
Type 23-A	4.2 \pm 1.1
Type 23-B	4.9 \pm 1.3
Type 23-C	5.6 \pm 1.4

Table 7: Complications

This table summarizes complications observed in the study.

Complication	Number of Cases (n=80)	Percentage (%)
Tendon Irritation	4	5.0
Implant-Related Discomfort	6	7.5
Superficial Infection	2	2.5
Malunion	2	2.5

Table 8: Recovery by Fracture Type

This table outlines recovery rates based on fracture classification.

Fracture Type	Full Recovery (%)	Mild Disability (%)
Type 23-A	86.8	13.2
Type 23-B	75.0	25.0
Type 23-C	66.7	33.3

Table 9: Patient Satisfaction

This table presents subjective satisfaction levels among patients at the final follow-up.

Satisfaction Level	Number of Patients (n=80)	Percentage (%)
Highly Satisfied	58	72.5
Satisfied	18	22.5
Dissatisfied	4	5.0

Table 10: Impact of Rehabilitation on Functional Recovery

This table shows the role of adherence to rehabilitation protocols on DASH scores.

Rehabilitation Adherence	Mean DASH Score \pm SD	p-value
Complete	11.4 \pm 3.8	<0.05*
Partial	15.2 \pm 4.7	<0.05*

Discussion

Overview of Findings

This study evaluated the functional and radiological outcomes of distal radius fractures managed surgically with volar locking compression plates (VLCP). The results demonstrated excellent functional recovery in 76% of cases, with a mean DASH score of 12.4 ± 4.8 at final follow-up. Radiological parameters, including volar tilt, radial inclination, and ulnar variance, were restored in 85% of patients, reflecting the effectiveness of VLCP in achieving anatomical alignment [6]. Despite these favorable outcomes, complications were observed in 15% of cases, with tendon irritation and implant-related discomfort being the most common.

Fracture Classification and Functional Outcomes

Fracture classification played a significant role in determining functional outcomes. Patients with extra-articular fractures (Type 23-A) achieved the

best recovery, with a mean DASH score of 10.8 ± 3.7 and 86.8% reporting full functional recovery. In contrast, patients with complete articular fractures (Type 23-C) experienced greater difficulty in regaining function, as evidenced by a higher DASH score (15.4 ± 5.0) and only 66.7% achieving full recovery [7]. These findings align with existing literature, emphasizing the complexity of managing intra-articular fractures and the challenges in restoring joint congruity.

Impact of Surgical Timing

Early surgical intervention (<7 days post-injury) was associated with significantly better functional outcomes (mean DASH score: 11.2 ± 4.1) compared to delayed surgery (mean DASH score: 14.6 ± 4.9 , $p < 0.05$). Timely surgery facilitates anatomical reduction and stabilization, reducing the risk of stiffness and malunion [8]. However, careful preoperative planning and soft tissue optimization remain critical to minimizing complications, particularly in delayed cases.

Radiological Parameters and Recovery

The restoration of radiological parameters was achieved in 85% of patients, highlighting the efficacy of VLCP in maintaining alignment and stability. Volar tilt (mean: $12.4 \pm 2.6^\circ$), radial inclination (mean: $22.3 \pm 3.4^\circ$), and ulnar variance (mean: 0.8 ± 0.9 mm) closely approximated normal values in most cases, correlating with better DASH scores and improved wrist function [9]. These findings underscore the importance of achieving anatomical alignment for optimal functional recovery.

Complications and Their Impact

Complications were observed in 15% of patients, with tendon irritation (5%) and implant-related discomfort (7.5%) being the most common. Tendon irritation was attributed to hardware prominence or improper plate positioning, particularly in patients with low body mass index or thin, soft tissue coverage. Implant-related discomfort often necessitated hardware removal, impacting patient satisfaction and recovery. Superficial infections (2.5%) were managed successfully with antibiotics and wound care, and no deep infections were reported. Malunion (2.5%) was observed in cases with delayed surgery or suboptimal reduction, emphasizing the need for meticulous surgical technique [10].

Role of Rehabilitation

Adherence to rehabilitation protocols was a key determinant of functional recovery. Patients who fully adhered to rehabilitation achieved significantly lower DASH scores (mean: 11.4 ± 3.8) compared to those with partial adherence (mean: 15.2 ± 4.7 , $p < 0.05$). Early mobilization, range of motion exercises, and strength training were critical in preventing stiffness and promoting optimal wrist function. These findings reinforce the importance of patient education and structured physiotherapy programs in postoperative care [11].

Comparison with Literature

The outcomes of this study are consistent with global findings on the surgical management of distal radius fractures. DASH scores in this study (mean: 12.4 ± 4.8) align with those reported in similar studies, which range from 10 to 15. Radiological restoration rates (85%) and complication rates (15%) also mirror international benchmarks, further validating VLCP as an effective treatment modality.

Clinical Implications: This study underscores several key points:

- **Early Surgical Intervention:** Timely surgery is critical for achieving optimal functional and radiological outcomes.

- **Tailored Management by Fracture Type:** Extra-articular fractures (Type 23-A) typically have better prognoses, while intra-articular fractures (Type 23-C) require meticulous reduction and stabilization.
- **Importance of Rehabilitation:** Structured physiotherapy programs are essential for maximizing recovery and minimizing complications.

Limitations of the Study

The study's limitations include its single-center design and small sample size, which may limit generalizability. The follow-up duration of 12 months, though adequate for assessing short-term outcomes, may not capture long-term complications such as post-traumatic arthritis. Future studies with longer follow-up periods and larger sample sizes are warranted to validate these findings.

Future Directions: Future research should explore:

1. Comparative studies evaluating minimally invasive approaches versus VLCP fixation.
2. Long-term follow-up studies to assess the progression of complications and their impact on quality of life.
3. Multicentric studies to enhance generalizability and validate findings across diverse populations.

Conclusion

ORIF with VLCP is an effective surgical approach for managing distal radius fractures, offering excellent functional and radiological outcomes. Early intervention, meticulous surgical technique, and adherence to rehabilitation protocols are critical to optimizing recovery. While complications are common, they are manageable with appropriate postoperative care. This study highlights the importance of a multidisciplinary approach to achieving successful outcomes in patients with distal radius fractures.

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