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Research Article

FUNCTIONAL AND RADIOLOGICAL OUTCOME OF INTRA-ARTICULAR DISTAL RADIUS FRACTURES TREATED WITH VOLAR PLATE OSTEOSYNTHESIS: A PROSPECTIVE STUDY

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Abstract

Background: Distal radius fractures are among the most common fractures of the upper extremity, frequently involving the articular surface and leading to functional impairment if inadequately treated. Stable anatomical restoration is crucial for optimal wrist function.

Aim: To evaluate the functional and radiological outcomes of intra-articular distal radius fractures treated with volar plate osteosynthesis.

Materials and Methods: This prospective descriptive study included 20 patients with intra-articular distal radius fractures (AO type C1 and C2) treated with volar locking plate fixation over a period of one year in patients admitted in Department of Orthopaedics, Chettinad Hospital and Research Institute, Kancheepuram District.

Patients were followed up for 24 weeks. Functional outcomes were assessed using the Modified Gartland and Werley score, Visual Analogue Scale (VAS), and Patient-Rated Wrist Evaluation (PRWE). Radiological outcomes were evaluated using the Modified Lidström score. Statistical analysis was performed using SPSS version 16.0.

Results: Of the 20 patients, 16 (80%) were male and 4 (20%) female, with a mean age of 29.4 years. At final follow-up, functional outcomes were excellent in 30%, good in 45%, and fair in 25% of patients. Radiological assessment showed excellent results in 20%, good in 55%, and fair in 25%. Mean time to union was 6.65 weeks. VAS and PRWE scores showed significant improvement over time. Complications were minimal, with one case of transient median nerve neuropraxia and one case of wrist stiffness.

Conclusion: Volar plate osteosynthesis provides stable fixation, satisfactory anatomical reduction, and good functional outcomes in intra-articular distal radius fractures, enabling early mobilization and minimal complications.

Keywords: Distal radius fracture, Volar plating, Internal fixation, Gartland and Werley score, Lidström score.

INTRODUCTION

Distal radius fractures are among the most common injuries encountered in orthopedic practice, accounting for approximately one-sixth of all fractures treated in emergency departments worldwide. These fractures exhibit a bimodal age distribution, affecting young adults following high-energy trauma and elderly individuals after low-energy falls. Intra-articular distal radius fractures constitute a challenging subset due to disruption of the radiocarpal joint surface, metaphyseal comminution, and a higher risk of post-traumatic arthritis if anatomical reduction is not achieved [1,2].

Restoration of articular congruity, radial length, volar tilt, and radial inclination is essential for optimal functional recovery. Previous studies have demonstrated that residual intra-articular step-off and malalignment are associated with persistent pain, reduced grip strength, restricted wrist motion, and early degenerative changes [3,4]. Hence, stable fixation that allows early mobilization has become the cornerstone of modern management.

Traditional treatment options such as cast immobilization, percutaneous pinning, and external fixation often fail to maintain reduction in unstable intra-articular fractures and are associated with stiffness and loss of alignment [5]. Dorsal plating, although effective in certain patterns, has been linked to extensor tendon irritation and higher complication rates [6]. The introduction of volar locking plate systems has significantly improved outcomes by providing fixed-angle stability, especially in comminuted and osteoporotic bone, while minimizing soft-tissue complications [7].

Several clinical studies have reported favorable functional and radiological outcomes following volar plate osteosynthesis, with improved wrist motion, early return to activities of daily living, and acceptable complication rates [8,9]. However, the correlation between radiological restoration and functional outcome remains controversial, particularly in intra-articular fracture patterns. Therefore, this prospective study was undertaken to evaluate the functional and radiological outcomes of intra-articular distal radius fractures treated with volar plate osteosynthesis using standardized scoring systems [10].

MATERIALS AND METHODS

This prospective descriptive study was conducted in the Department of Orthopaedics at Chettinad Hospital and Research Institute, Kelambakkam,

Kancheepuram District, Tamilnadu over a one-year period. Patients presenting to the outpatient department or emergency services with intra-articular distal radius fractures and fulfilling the inclusion criteria were enrolled consecutively. A total of 20 patients diagnosed with intra-articular distal radius fractures were included in the study. All patients underwent operative management with volar plate osteosynthesis, and no patient was lost to follow-up during the study period.

Inclusion and Exclusion Criteria:

Patients were included in the study if they had intra-articular distal radius fractures with one or more of the following features: presence of dorsal or volar metaphyseal comminution, loss of palmar tilt greater than 20 degrees, radial shortening exceeding 5 mm, or associated ulnar styloid or ulnar fractures. Patients were excluded if they had open fractures, fractures older than two weeks at presentation, pathological fractures, gross osteoporosis, or associated fractures in the same limb.

Surgical Technique:

All patients were operated on under either regional or general anesthesia. The fractures were approached using the modified volar flexor carpi radialis (FCR) approach. Fracture reduction was achieved under fluoroscopic guidance, followed by internal fixation using pre-contoured volar locking plates. Locking screws were placed into the distal fragment to provide angular stability. Adequacy of fracture reduction and implant position was confirmed intraoperatively using image intensification.

Postoperative Protocol and Follow-up:

Postoperatively, the operated limb was immobilized in a below-elbow splint until suture removal. Early wrist mobilization exercises were initiated thereafter as per patient tolerance. Patients were followed up at 3 weeks, 6 weeks, 12 weeks, and 24

weeks postoperatively. At each follow-up visit, detailed clinical evaluation and radiological assessment were performed.

Outcome Measures:

Functional outcomes were assessed using the Modified Gartland and Werley score, Patient-Rated Wrist Evaluation (PRWE), and the Visual Analogue Scale (VAS) for pain. Radiological outcomes were evaluated using the Modified Lidström score, which assessed parameters such as volar tilt, radial inclination, radial length, and ulnar variance

Statistical Analysis

Data were analyzed using **SPSS version 16.0**. Categorical variables were expressed as frequencies and percentages and analyzed using the **Chi-square test**. Continuous variables were expressed as **mean ± standard deviation**. **Mann–Whitney U test** was used for comparison between independent groups. Changes in functional, radiological, pain, and PRWE scores over time were analyzed using the **Friedman test** and **repeated-measures ANOVA** with Bonferroni correction. A **p-value < 0.05** was considered statistically significant.

Ethical Considerations

The study was conducted after getting ethical clearance from the Institutional Ethics Committee of Chettinad Hospital and Research Institute, Kancheepuram District prior to commencement of the study. Written informed consent was obtained from all patients after explaining the nature of the study, surgical procedure, potential risks, and expected outcomes. Patient confidentiality was maintained throughout the study, and participation was entirely voluntary.

Figure 1 : Intra-operative Fluoroscopy – Anteroposterior view

Figure 2 : Intra-operative fluoroscopy – Lateral view

Fig 4: Pre operative radiograph

Fig 5: Post operative radiographs

Fig 6: Followup at 6 months

Fig 7: Functional outcome – Good movements

RESULTS

A total of 20 patients with intra-articular distal radius fractures (AO type C1 and C2) were included. The study population comprised 16 males (80%) and 4 females (20%). The most common mechanism of injury was fall on the outstretched hand (70%), followed by road traffic accidents (30%). The dominant wrist was involved in 70% of cases. All patients presented within 48 hours of injury, and the mean interval between injury and surgery was 5 days.

All patients were between 21 and 40 years of age, with 55% in the 21–30-year group and 45% in the 31–40-year group. AO type C1 fractures accounted for 60%, while 40% were type C2. No statistically significant association was observed between demographic variables and fracture type (Table 1).Fracture union was achieved in all patients, with a mean union time of 6.65 ± 0.82 weeks (range: 6–8 weeks). There was no significant difference in union time between age groups ($p > 0.05$) (Table 3).Functional outcome assessed using the Modified Gartland and Werley score showed significant improvement over time ($p < 0.001$). At 3 weeks, all patients had fair outcomes. By 12 weeks, 75% achieved good to excellent outcomes (Tables 5 and 6).Radiological assessment using the Modified Lidström score demonstrated maintenance of reduction throughout

follow-up, with no statistically significant change over time (p> 0.05) (Table 7,8).Pain scores (VAS) showed a significant reduction over follow-up, with most patients becoming pain-free by 12 weeks (p< 0.001) (Table 9). Similarly, PRWE scores demonstrated a significant and progressive improvement, indicating enhanced patient-reported wrist function (p< 0.001) (Table 10).Cross-tabulation analysis revealed no statistically significant correlation between radiological and functional outcomes at final follow-up (p> 0.05) (Table 11).Wrist range of motion improved significantly across all planes over time (p< 0.001), with marked gains observed between the 3rd and 12th weeks and continued improvement up to 24 weeks (Table 12).

TABLE 1.

Mechanism	n (%)	Mean G&W Score (Final)	p value

BASELINE CHARACTERISTICS OF STUDY POPULATION (N = 20)

Variable	Category	n (%)	p value
Age group	21–30 yrs	11 (55)	>0.05
	31–40 yrs	9 (45)	
Gender	Male	16 (80)	>0.05
	Female	4 (20)	
Side involved	Right	14 (70)	>0.05
	Left	6 (30)	
AO type	C1	12 (60)	>0.05
	C2	8 (40)	

P value >0.05 Not Significant using Chi square Test

TABLE 2. MECHANISM OF INJURY AND FUNCTIONAL OUTCOME

FOOSH	14 (70)	5.4 ± 1.4	>0.05
RTA	6 (30)	5.6 ± 1.6	

FOOSH –Fall on Outstreched Hand ; RTA- Road Traffic Accident
P value >0.05 Not Significant using Mann–Whitney U Test

TABLE 3. TIME TO UNION ACCORDING TO AGE GROUP

Age Group	Union Time (weeks) Mean ±SD	p value
21–30 yrs	7.0± 0.68	>0.05
31–40 yrs	7.0 ±0.97	

P value >0.05 Not Significant Mann–Whitney U

TABLE 4 . POSTOPERATIVE COMPLICATIONS

Complication	Number of Patients	Percentage (%)
Median nerve neuropraxia	1	5.0
Wrist stiffness	1	5.0
No complications	18	90.0

TABLE 5. FUNCTIONAL OUTCOME (GARTLAND AND WERLEY SCORE) AT DIFFERENT FOLLOW-UP PERIODS (N = 20)

Follow-up	Excellent n (%)	Good n (%)	Fair n (%)	Poor n (%)
3rd week	0 (0)	0 (0)	20 (100)	0 (0)
6th week	0 (0)	6 (30)	14 (70)	0 (0)
12th week	6 (30)	9 (45)	5 (25)	0 (0)

Statistical test used: Friedman test ; **p value:< 0.001 (Statistically significant)**

TABLE 6. FUNCTIONAL OUTCOME (GARTLAND & WERLEY SCORE) OVER TIME

Follow-up	Mean Score	p value
3rd week	16.25± 1.1	<0.001*
6th week	10.70± 0.9	
12th week	5.60± 1.7	
24th week	5.45± 1.8	

*Statistically significantusing Friedman test

TABLE 7. RADIOLOGICAL OUTCOME AT FINAL FOLLOW-UP (MODIFIED LIDSTRÖM SCORE)

Outcome	Number of Patients	Percentage (%)
Excellent	4	20.0
Good	11	55.0
Fair	5	25.0
Poor	0	0.0

Table 8. FUNCTIONAL OUTCOME (GARTLAND & WERLEY SCORE) OVER TIME

Follow-up	Mean Score	p value
3rd week	2.50± 0.9	>0.05
6th week	2.50± 0.7	
12th week	2.45± 1.1	
24th week	2.45± 1	

*Not Statistically significant using Friedman test

TABLE 9. PAIN ASSESSMENT (VAS SCORE) OVER TIME

Follow-up	Mean VAS ± SD	p value
3rd week	5.0 ± 0.9	

6th week	1.0 ± 0.6	<0.001*
12th week	0.0 ± 0.0	
24th week	0.0 ± 0.0	

*Statistically significant using Friedman Test

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TABLE 10. PATIENT-RATED WRIST EVALUATION (PRWE) SCORE OVER TIME

Follow-up	Mean PRWE ± SD	p value
3rd week	65.8 ± 3.43	<0.001*
6th week	30.2 ± 3.52	
12th week	5.9 ± 1.02	
24th week	5.6 ± 0.82	

*Statistically significant using Repeated Measures ANOVA

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TABLE 11. CROSS-TABULATION OF FUNCTIONAL (GARTLAND & WERLEY) AND RADIOLOGICAL (MODIFIED LIDSTRÖM) OUTCOMES AT FINAL FOLLOW-UP (N = 20)

Modified Lidström Score	Gartland & Werley – Excellent n (%)	Good n (%)	Fair n (%)	Total n (%)
Excellent	4 (100.0)	0 (0.0)	0 (0.0)	4 (100.0)
Good	2 (18.2)	8 (72.7)	1 (9.1)	11 (100.0)
Fair	0 (0.0)	1 (20.0)	4 (80.0)	5 (100.0)
Total	6 (30.0)	9 (45.0)	5 (25.0)	20 (100.0)

Statistical test: Chi-square test **p value:> 0.05 (Not statistically significant)**

TABLE 12. FUNCTIONAL OUTCOME – MEAN WRIST RANGE OF MOTION OVER FOLLOW-UP PERIOD (N = 20)

Range of Motion	Normal Range (°)	3rd Week Mean ± SD (°)	6th Week Mean ± SD (°)	12th Week Mean ± SD (°)	24th Week Mean ± SD (°)
Dorsal flexion	0–75	37.9 ± 6.8	47.4 ± 8.2	50.5 ± 9.6	51.5 ± 11.4
Palmar flexion	0–75	36.8 ± 7.1	46.0 ± 8.9	49.0 ± 9.8	50.0 ± 10.6

Radial deviation	0–20	10.5 ± 2.1	13.1 ± 2.9	14.0 ± 3.1	14.3 ± 3.4
Ulnar deviation	0–35	10.5 ± 2.0	13.1 ± 2.7	14.0 ± 2.8	14.3 ± 2.9
Supination	0–80	39.2 ± 7.5	49.0 ± 8.6	52.2 ± 9.1	53.3 ± 9.4
Pronation	0–75	38.6 ± 6.9	48.3 ± 7.8	51.5 ± 8.2	52.5 ± 7.9

Statistical test used: Friedman test (repeated-measures non-parametric test)
Overall p value:< 0.001 (Statistically significant)

DISCUSSION

Intra-articular distal radius fractures represent a complex injury pattern due to disruption of the radiocarpal joint surface, metaphyseal comminution, and the potential for long-term functional impairment. The primary objective of treatment is restoration of anatomical alignment with stable fixation to permit early mobilization and optimal functional recovery. The present prospective study evaluated the functional and radiological outcomes of intra-articular distal radius fractures treated with volar plate osteosynthesis and demonstrated favorable results.

The demographic profile of the study population showed a predominance of young adult males, which is consistent with previous epidemiological studies reporting a higher incidence of high-energy distal radius fractures in this age group [11,12]. Fall on the outstretched hand was the most common mechanism of injury, followed by road traffic accidents, similar to findings reported in other Indian and international series [13,14]. No statistically significant association was observed between demographic variables and fracture type or outcome, suggesting that fracture morphology and fixation stability play a greater role than patient-related factors.

Fracture union was achieved in all patients, with a mean union time of approximately 6.65 weeks. There was no significant difference in union time between age groups, which is comparable

to studies by Orbay and Fernandez and Rozental et al., who reported reliable union with volar locking plate fixation irrespective of patient age [15,16]. The stable fixation provided by volar locking plates likely contributed to early union and maintenance of reduction.

Functional outcome assessment using the Modified Gartland and Werley score showed a statistically significant improvement over time. At the 3-week follow-up, all patients demonstrated fair outcomes, attributable to postoperative pain and restricted wrist motion. By 12 weeks, 75% of patients achieved good to excellent outcomes, reflecting effective rehabilitation and early mobilization. Similar improvements have been reported by Arora et al. and Fok et al., who observed progressive functional recovery within the first three months following volar plate fixation [17,18].

Radiological evaluation using the Modified Lidström score demonstrated stable alignment throughout follow-up, with no statistically significant change over time. This finding supports the biomechanical advantage of volar locking plates in maintaining radial length, volar tilt, and radial inclination. Previous studies have shown that volar fixed-angle constructs resist secondary collapse even in comminuted intra-articular fractures [15,19].

Cross-tabulation analysis in the present study revealed no statistically significant correlation between radiological outcome and functional recovery at final follow-up. Although patients with excellent radiological outcomes tended to have excellent functional results, this association did not reach statistical significance. This observation is consistent with the findings of Knirk and Jupiter and Ranjeet et al., who emphasized that functional outcome is influenced not only by radiographic alignment but also by associated soft-tissue injury, rehabilitation, and patient compliance [20,21].

Pain assessment using the Visual Analogue Scale showed a rapid and statistically significant reduction, with most patients becoming pain-free by the 12th week. Similarly, PRWE scores demonstrated marked improvement over time, indicating substantial recovery of wrist function and activities of daily living. These findings align with previous studies highlighting the benefits of stable fixation and early mobilization on patient-reported outcomes [16,18].

Range of motion analysis demonstrated progressive and statistically significant improvement across all planes. Flexion–extension and forearm rotation showed substantial gains by the 12th week, with continued improvement up to the 24th week. Preservation of radial length and volar tilt likely contributed to improved wrist mechanics and forearm rotation. Palmer and Werner demonstrated that even minor alterations in radial anatomy significantly affect load transmission across the wrist joint, emphasizing the importance of anatomical restoration [22].

Overall, the findings of this study support volar plate osteosynthesis as an effective and reliable method for managing intra-articular distal radius fractures. The technique provides stable fixation, allows early mobilization, and results in satisfactory functional and radiological outcomes with minimal complications.

CONCLUSION

Volar locking plate osteosynthesis provides stable fixation for intra-articular distal radius fractures, enabling early mobilization and predictable functional recovery. Maintenance of radiological alignment reduces the risk of secondary displacement, while early rehabilitation contributes significantly to pain reduction and restoration of wrist function. Functional outcomes may not always correlate directly with radiographic parameters, emphasizing the importance of individualized rehabilitation protocols and patient compliance. Volar plate fixation

can therefore be considered a reliable treatment option for unstable intra-articular distal radius fractures in active adults.

REFERENCES

1. Chung KC, Spilson SV. The frequency and epidemiology of hand and forearm fractures in the United States. J Hand Surg Am. 2001;26(5):908-915.
2. Court-Brown CM, Caesar B. Epidemiology of adult fractures: A review. Injury. 2006;37(8):691-697.
3. Knirk JL, Jupiter JB. Intra-articular fractures of the distal end of the radius in young adults. J Bone Joint Surg Am. 1986;68(5):647-659.
4. Fernandez DL. Fractures of the distal radius: Operative treatment. Instr Course Lect. 1993;42:73-88.
5. Cooney WP. External fixation of distal radial fractures. Clin Orthop Relat Res. 1983;180:44-49.
6. Ring D, Jupiter JB. Dorsal plating of the distal radius. Tech Hand Up Extrem Surg. 2004;8(4):196-203.
7. Orbay JL, Fernandez DL. Volar fixed-angle plate fixation for unstable distal radius fractures. J Hand Surg Am. 2004;29(1):96-102.
8. Rozental TD, Blazar PE. Functional outcome and complications after volar plating for unstable distal radius fractures. J Hand Surg Am. 2006;31(3):359-365.
9. Arora R, Lutz M, Hennerbichler A, Krappinger D, Espen D, Gabl M. Complications following internal fixation of unstable distal radius fractures with a palmar locking-plate. J Orthop Trauma. 2007;21(5):316-322.
10. Fok MW, Klausmeyer MA, Fernandez DL, Orbay JL, Bergada AL. Volar plate fixation of intra-articular distal radius fractures: A retrospective study. J Wrist Surg. 2013;2(3):247-254.
11. Chung KC, Spilson SV. The frequency and epidemiology of hand and forearm

fractures in the United States. J Hand Surg Am. 2001;26(5):908–915.

12. Court-Brown CM, Caesar B. Epidemiology of adult fractures. Injury. 2006;37(8):691–697.
13. Jupiter JB, Fernandez DL. Comparative classification for fractures of the distal end of the radius. J Hand Surg Am. 1997;22(4):563–571.
14. Cooney WP. External fixation of distal radial fractures. Clin Orthop Relat Res. 1983;180:44–49.
15. Orbay JL, Fernandez DL. Volar fixed-angle plate fixation for unstable distal radius fractures. J Hand Surg Am. 2004;29(1):96–102.
16. Rozental TD, Blazar PE. Functional outcome and complications after volar plating for unstable distal radius fractures. J Hand Surg Am. 2006;31(3):359–365.
17. Arora R, Lutz M, Hennerbichler A, Krappinger D, Espen D, Gabl M. Complications following internal fixation of unstable distal radius fractures with a palmar locking-plate. J Orthop Trauma. 2007;21(5):316–322.
18. Fok MW, Klausmeyer MA, Fernandez DL, Orbay JL, Bergada AL. Volar plate fixation of intra-articular distal radius fractures. J Wrist Surg. 2013;2(3):247–254.
19. Drobetz H, Bryant AL, Pokorny T, et al. Volar fixed-angle plating of distal radius fractures. J Hand Surg Am. 2006;31(4):615–622.
20. Knirk JL, Jupiter JB. Intra-articular fractures of the distal end of the radius in young adults. J Bone Joint Surg Am. 1986;68(5):647–659.
21. Ranjeet N, Kumar R, Singh S. Distal radius fractures: does radiological reduction correlate with functional outcome? J Clin Diagn Res. 2012;6(8):1388–1392.
22. Palmer AK, Werner FW. Biomechanics of the distal radioulnar joint. Clin Orthop Relat Res. 1984;187:26–35.