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Evaluation of Outcomes of Intra-Articular Distal Radius Fractures Treated by Open Reduction and Internal Fixation Using Locking Buttress Plate

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Abstract: ***Background: Intra - articular distal end radius fractures are among the most common orthopedic injuries, often resulting in functional impairment if not managed appropriately. Open reduction and internal fixation (ORIF) using locking plates has emerged as a reliable option for restoring anatomy and function in such fractures. Objectives: To assess the functional and radiological outcomes of intra - articular distal radius fractures treated with ORIF using a locking buttress plate. Methods: This prospective study included 25 skeletally mature patients with AO Type B and C distal radius fractures. All underwent ORIF via the modified Henry approach using volar locking plates. Functional outcomes were assessed using the Modified Mayo Wrist (MMW) Score, and radiological parameters (volar tilt, radial height, radial inclination, and ulnar variance) were evaluated at postoperative intervals up to 1 year. Results: The mean age was 34.2 years; 84% were male. Road traffic accidents were the most common cause (56%). Excellent to good MMW scores were noted in the majority by the end of 1 year (mean score: 83.06 ± 9.30). Radiological parameters remained within functional range throughout follow - up with no significant change ($p > 0.05$). Significant improvements were observed in all wrist movements over time ($p < 0.001$). No major complications were reported. Conclusion: ORIF using volar locking plates provides stable fixation, maintains anatomical alignment, and allows early mobilization, resulting in excellent functional and radiological outcomes in intra - articular distal radius fractures.***

Keywords: Intra - articular distal radius fracture, Volar locking plate, Open reduction internal fixation (ORIF), Functional outcome, Radiological outcome

1. Introduction

Fractures of the distal radius represent one of the most frequently encountered skeletal injuries, accounting for nearly 17% of all fractures and 75% of forearm fractures treated in emergency departments worldwide. [1] Among these, intraarticular distal radius fractures pose a particular challenge due to their complex nature, involvement of the radiocarpal and distal radioulnar joints, and the potential for long - term functional impairment if not anatomically reduced and adequately stabilized. [2, 3]

These injuries typically demonstrate a bimodal distribution: high - energy trauma in younger patients and low - energy fragility fractures in the elderly, often associated with osteoporotic bone. [4] Despite the diverse mechanisms of injury, the overarching goal in managing these fractures remains the same—restoration of anatomical alignment and joint congruity to prevent complications such as malunion, reduced grip strength, loss of motion, and post - traumatic arthritis. [5]

Conservative treatment with closed reduction and casting has traditionally been employed; however, it often results in suboptimal outcomes in intraarticular and comminuted fractures, particularly with secondary displacement or malunion. [2, 6] In contrast, open reduction and internal fixation (ORIF), especially using volar locking plates, has gained popularity due to its ability to provide stable fixation, maintain reduction, and allow early mobilization. Several studies have demonstrated superior functional outcomes and patient satisfaction with ORIF compared to conservative or percutaneous methods. [1, 4]

The volar approach, most commonly via the modified Henry technique, has become the standard for internal fixation of these fractures due to its favorable biomechanical profile, reduced risk of extensor tendon irritation, and robust fixation even in osteoporotic bone. [1, 3] Locking plates, in particular, have revolutionized treatment by providing angular stability, resisting axial loads, and ensuring subchondral support in comminuted fractures.

Given the importance of anatomical restoration and early rehabilitation in improving outcomes, it is essential to continually evaluate the effectiveness of current surgical techniques. The present study was designed to assess the functional and radiological outcomes of intraarticular distal radius fractures treated by open reduction and internal fixation using a volar locking plate, and to validate the efficacy and safety of this approach in a prospective patient cohort.

2. Methods

This prospective study was conducted in the Department of Orthopaedics at Autonomous state medical college, Hardoi over a period one year. Patients skeletally mature presenting with intraarticular distal radius fractures to the OPD/IPD basis. Patients with AO type B1, B2, B3, C1, C2, and C3 distal radius fractures, who presented within 3 weeks of injury and were fit and willing for surgery, were included. Exclusion

criteria comprised patients younger than 18 years, open fractures, pathological fractures, AO type A and bilateral fractures, associated neurovascular injuries, other ipsilateral limb injuries, and patients medically unfit for anesthesia.

Initial management included splintage, limb elevation, analgesics, and standard radiographs (AP and lateral views). Preoperative assessment involved clinical examination, routine hematological investigations, and imaging, including X - ray and CT scan in select cases to assess comminution and intraarticular extension. Surgical fixation was performed via the modified Henry approach under regional or general anesthesia. A volar incision was made, pronator quadratus was elevated, fracture fragments were reduced using manual instruments and temporarily fixed with K - wires, followed by application of a juxta - articular volar locking plate secured with 2.7 mm and 3.9 mm locking screws. The pronator quadratus was repaired, and a short arm splint was applied postoperatively.

Postoperative care included elevation, finger mobilization, and early active range - of - motion exercises for the elbow and shoulder. The splint was removed at 2 weeks with suture removal, and wrist mobilization exercises were initiated based on pain tolerance. Strengthening exercises were started after radiological evidence of fracture union. Patients were followed up at 2 weeks, 6 weeks, 3 months, 6 months, and 1 year. Radiographs at each visit were used to evaluate union and radiological parameters including volar tilt, radial inclination, ulnar variance, and radial height as per standardized techniques described by Mann et al.

Functional outcomes were assessed using the Modified Mayo Wrist Score (MMWS), which includes domains for pain, satisfaction, range of motion, and grip strength, with a maximum score of 100. Scores were interpreted as excellent (90–100), good (80–89), fair (65–79), and poor (<65). Additionally, wrist movements—palmar flexion, dorsiflexion, radial and ulnar deviation, pronation, and supination—were measured at each follow - up. Primary outcomes included MMWS scores, while secondary outcomes were radiographic alignment, time to union, complication rate, and range of motion recovery.

3. Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics version 25.0. Continuous variables such as age, range of motion, and radiological parameters (volar tilt, radial inclination, ulnar variance, and radial height) were expressed as mean ± standard deviation, while categorical variables such as gender, AO classification, and complications were summarized as frequencies and percentages. Repeated measures ANOVA was used to compare functional outcomes (Modified Mayo Wrist Score) and range of motion across follow - up intervals at 6 weeks, 3 months, 6 months, and 1 year. A p - value of less than 0.05 was considered statistically significant.

4. Results

A total of 25 patients with intra - articular distal end radius fractures were treated with open reduction and internal fixation using volar locking plates in the Department of Orthopaedics at our state medical college. The age distribution revealed that the majority of patients were between 21–40 years, with 36% in the 21–30 age group and another 36% in the 31–40 age group. A male preponderance was noted, with 21 males (84%) and only 4 females (16%). Most patients (76%) presented within 7 days of injury, while 16% and 8% presented between 8–14 and 15–21 days respectively. The most common mechanism of injury was road traffic accidents (56%), followed by falls on an outstretched hand (FOOSH) in 36%. The dominant side (right) was affected in 60% of cases (Table 1).

Table 1: Demographic and Injury Profile

		n	%
Age (years)	21 - 30	9	36.00
	31 - 40	9	36.00
	41 - 50	6	24.00
	51 - 60	1	4.00
Gender	Male	21	84.00
	Female	4	16.00
Duration of Injury	<7 days	19	76.00
	8 - 14 days	4	16.00
	15 - 21 days	2	8.00
Mode of Injury	RTA	14	56.00
	FOOSH	9	36.00
Side	Right	15	60.00
	Left	10	40.00

In terms of fracture classification, 44% had AO Type B fractures and 52% had Type C, indicating a slightly higher occurrence of complex intra - articular fractures. Complications were minimal; no patients developed nerve injuries (radial or median), tendon impingement, or malunion. However, restricted wrist movements were observed in 3 patients (12%), with no cases of persistent pain reported (Table 2).

Table 2: AO Type and Complications

Parameter		n	%
AO Type	Type B	11	44
	Type C	13	52
Complications	Paraesthesia (radial nerve)	0	0
	Tendon impingement	0	0
	Median nerve complication	0	0
	Residual pain	0	0
	Restricted wrist movement	3	12
	Malunion	0	0

Functional outcomes assessed using the Modified Mayo Wrist (MMW) Score showed statistically significant improvement over time. At 6 weeks, the mean MMW score was 43.55 ± 9.32, which improved to 58.18 ± 10.04 at 3 months, 72.43 ± 11.11 at 6 months, and 83.06 ± 9.30 at 1 year ($p < 0.001$). Radiological parameters including volar tilt, radial inclination, ulnar variance, and radial height were maintained consistently throughout the follow - up, showing no statistically significant change over time ($p > 0.05$), indicating good maintenance of anatomical reduction (Table 3).

Table 3: Functional and Radiological Outcomes

		Mean ± SD	P - Value
MMW Score	6 week	43.55 ± 9.32	<0.001
	3 month	58.18 ± 10.04	
	6 month	72.43 ± 11.11	
	1 year	83.06 ± 9.30	
Volar Tilt	Post op	11.79 ± 0.71	>0.05
	6 week	11.79 ± 0.71	
	3 month	11.75 ± 0.70	
	6 month	11.75 ± 0.70	
	1 year	11.29 ± 2.42	
Radial Inclination	Post op	22.33 ± 1.21	>0.05
	6 week	22.33 ± 1.21	
	3 month	22.40 ± 1.22	
	6 month	22.40 ± 1.22	
	1 year	22.49 ± 1.25	
Ulnar Variance	Post op	- 1.35 ± 0.49	>0.05
	6 week	- 1.16 ± 0.82	
	3 month	- 1.30 ± 0.08	
	6 month	- 1.35 ± 0.49	
	1 year	- 1.33 ± 0.43	
Radial Height	Post op	12.46 ± 1.10	>0.05
	6 week	12.46 ± 1.10	
	3 month	12.46 ± 1.10	
	6 month	12.46 ± 1.10	
	1 year	12.46 ± 1.10	

Assessment of range of motion demonstrated progressive and statistically significant improvement at each follow - up. Palmar flexion improved from 70.22° ± 5.12 at 3 months to 77.32° ± 3.34 at 1 year ($p < 0.001$). Similarly, dorsiflexion improved from 60.33° ± 3.22 to 67.10° ± 2.40, and ulnar deviation from 21.20° ± 2.01 to 27.22° ± 2.14. Radial deviation, although less pronounced, improved significantly from 19.54° ± 1.21 at 3 months to 25.03° ± 1.11 at 1 year ($p < 0.05$). Supination and pronation also showed favorable gains over time, with supination reaching 78.16° ± 4.96 and pronation 79.44° ± 3.40 at 1 year, both achieving statistical significance (Table 4).

Table 4: Range of Motion Over Time

		Mean ± SD	P - Value
Palmar Flexion	3 month	70.22 ± 5.12	<0.001
	6 month	74.06 ± 5.30	
	1 year	77.32 ± 3.34	
Dorsiflexion	3 month	60.33 ± 3.22	<0.001
	6 month	64.42 ± 3.16	
	1 year	67.10 ± 2.40	
Ulnar Deviation	3 month	21.20 ± 2.01	<0.001
	6 month	23.16 ± 2.11	
	1 year	27.22 ± 2.14	
Radial Deviation	3 month	19.54 ± 1.21	<0.05
	6 month	22.88 ± 1.98	
	1 year	25.03 ± 1.11	
Supination	3 month	70.88± 5.07	<0.05
	6 month	74.12 ± 4.89	
	1 year	78.16 ± 4.96	
Pronation	3 month	72.34 ± 3.12	<0.001
	6 month	76.15 ± 3.15	
	1 year	79.44 ± 3.40	

5. Discussion

In our study evaluating intra - articular distal radius fractures treated with open reduction and internal fixation (ORIF) using a locking buttress plate, we observed promising functional and radiological outcomes. Most patients demonstrated restoration of key anatomical parameters such as radial length, volar tilt, radial inclination, and ulnar variance. Functionally, the majority of patients achieved good to excellent outcomes based on range of motion and patient - reported functional scores. The use of locking plates facilitated early mobilization, reduced the risk of articular incongruity, and minimized loss of reduction. These benefits translated to early recovery of wrist strength and range of motion, aligning with the principle that rigid internal fixation helps preserve joint mobility and functional use of the limb.

Our mean patient age closely resembled that reported by Orbay et al. (2004), who noted a mean age of 59 years, and Anakwee et al. (2010), who reported a mean age of 48 years, supporting the observation that distal radius fractures are common among active middle - aged and elderly individuals. [7, 8] Similarly, our sex distribution showed a male predominance, consistent with the findings of Gill et al. (2019), who reported 73% male patients, and Jupiter et al. (1996), with 60% male predominance. [9, 10]

Regarding laterality and mode of injury, our findings also paralleled those of previous literature. Jupiter et al. (1996) reported a higher involvement of the right side (61%) and road traffic accidents (67%) as the leading cause of injury, a trend also observed in our cohort. [10] While Catalano et al. (2004) observed more cases due to fall on an outstretched hand (FOOSH), our study emphasized high - energy trauma such as RTA, reflecting demographic and behavioral factors specific to our population. [11]

Functional outcome comparison with previous studies shows that our results are in concordance with Ankwe et al. (2010), who reported 84% of patients with very good to good outcomes following ORIF. [8] Similarly, Dennison et al. (2007) noted that 80% of their patients had excellent results. [12] Our patients demonstrated comparable wrist motion recovery, with flexion, extension, pronation, and supination measurements aligning closely with those of Gill et al. (2019) and Lee et al. (2018). [9, 13]

Radiological parameters achieved in our study, including volar tilt (VT), radial length (RL), and radial inclination (RI), were comparable to the outcomes reported by Orbay et al. (2004) and Williksen et al. (2015), who found volar tilt between 10–13°, radial length around 10–12 mm, and inclination near 21–23°. [7, 14] These values are indicative of accurate anatomical restoration, crucial in preventing post - traumatic arthritis and functional limitation.

In contrast to external fixation or ligamentotaxis, our approach with locking plates offered superior fragment control and facilitated early mobilization. As supported by Karthikeyan et al. (2019), although ligamentotaxis is cost - effective and achieves decent outcomes, it is less precise in restoring articular congruity in comminuted intra - articular fractures. [15] Our study reaffirms that ORIF using volar locking plates is an effective modality for managing complex intra - articular distal radius fractures, offering both excellent functional and radiographic outcomes with minimal

complications when performed with appropriate surgical technique.

6. Conclusion

The present study demonstrates that open reduction and internal fixation (ORIF) using a locking buttress plate is a highly effective treatment modality for intra - articular distal radius fractures. This approach allows for accurate anatomical reduction, stable internal fixation, and early mobilization, which collectively contribute to excellent functional recovery and maintenance of radiological alignment. The majority of patients achieved good to excellent outcomes in terms of wrist range of motion and Modified Mayo Wrist Scores, with minimal postoperative complications. Restoration of volar tilt, radial inclination, ulnar variance, and radial height was consistently maintained throughout follow - up. Given its favorable results and low complication profile, ORIF with locking plates should be considered the preferred treatment strategy for displaced intra - articular distal radius fractures, particularly in active individuals requiring early return to function.

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