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Functional and Radiological Outcomes of Volar Locking Plate Versus Percutaneous K-Wire Fixation with or Without JESS for Intra-Articular Distal Radius Fractures: A Prospective Comparative Study

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ABSTRACT

Background- Intra-articular distal end radius fractures are common injuries that may result in pain, stiffness and functional disability if not treated appropriately. This study compared percutaneous K-wire fixation with/without Joshi's External Stabilization System (JESS) and volar buttress plate fixation to determine the superior modality for functional and radiological recovery.

Methodology- A prospective comparative study was conducted on 78 patients with intra-articular distal radius fractures. Patients were allocated into two equal groups (39 each): Group E underwent percutaneous K-wire fixation with/without JESS and Group P underwent open reduction and internal fixation with a volar buttress plate. Clinical and radiological outcomes were assessed over six months using wrist range of motion, grip strength, Cooney's Modified Green and O'Brien score, and Sarmiento radiological criteria.

Results- Baseline characteristics were comparable between groups. Volar buttress plating demonstrated significantly superior wrist range of motion, grip strength, functional scores and radiological restoration at final follow-up. Excellent functional outcomes were achieved in 69.2% of patients treated with volar plating compared with 30.8% in the K-wire/JESS group. Excellent radiological outcomes according to Sarmiento criteria were observed in 61.5% and 20.5% of patients, respectively. Pin tract infection and loss of reduction were more common after K-wire fixation, whereas implant-related complications following plating were minimal.

Conclusion- Both techniques achieved fracture union with acceptable clinical outcomes. However, volar buttress plate fixation provided superior functional recovery, anatomical reduction and radiological alignment, facilitating earlier rehabilitation. Percutaneous K-wire fixation with/without JESS remains a useful, minimally invasive and cost-effective option for selected patients.

Keywords: Distal radius fracture; Intra-articular fracture; Volar buttress plate; Percutaneous K-wire fixation; JESS; Functional outcome; Radiological outcome.

INTRODUCTION

Distal radius fractures (DRFs) are among the most common skeletal injuries encountered in orthopaedic practice, accounting for nearly one-sixth of all fractures presenting to emergency departments and representing the majority of forearm fractures.¹ Intra-articular distal radius fractures are particularly challenging because disruption of the radiocarpal and distal radioulnar joints can compromise wrist biomechanics, resulting in pain, reduced grip strength, restricted range of motion, and early post-traumatic arthritis if anatomical reduction is not achieved.² These fractures demonstrate a bimodal age distribution, occurring in younger individuals following high-energy trauma and in elderly patients as a consequence of low-energy falls associated with osteoporosis.³

The primary objective of treatment is to restore the anatomical alignment and articular congruity of the distal radius while providing sufficient stability to permit early mobilization and optimize functional recovery. Although stable extra-articular fractures may be managed successfully with closed reduction and cast immobilization, unstable intra-articular fractures often require operative intervention to prevent secondary displacement, malunion, and long-term functional impairment.^{4,5} Consequently, several operative techniques have been developed, including percutaneous Kirschner-wire fixation, external fixation, and open reduction with internal fixation using volar locking or buttress plates.^{6,7}

Among these, percutaneous K-wire fixation with or without Joshi's External Stabilization System (JESS) and volar buttress plate fixation remain widely used for the management of unstable intra-articular distal radius fractures. Percutaneous fixation with or without JESS is minimally invasive, preserves fracture biology, is cost-effective, and achieves fracture reduction through the principle of ligamentotaxis.⁸ However, concerns remain regarding maintenance of reduction, pin-tract infection, and prolonged immobilization. In contrast, volar buttress plating provides stable anatomical fixation, facilitates early wrist mobilization, and has demonstrated favorable functional and radiological outcomes, particularly in comminuted fractures, but requires greater soft-tissue dissection and is associated with higher implant costs and hardware-related complications.^{9,10}

Despite the widespread use of both techniques, the optimal operative treatment for intra-articular distal radius fractures remains controversial, particularly in resource-limited settings where both clinical outcomes and cost influence treatment decisions. Therefore, the present prospective comparative study was undertaken to evaluate and compare the functional and radiological outcomes of intra-articular distal radius fractures treated with percutaneous K-wire fixation with or without JESS versus volar buttress plate fixation, with the aim of identifying the most effective surgical approach for restoring anatomy and function.

MATERIALS AND METHODS

Study Design and Participants

This prospective randomized comparative interventional study was conducted in the Department of Orthopaedics, Sardar Patel Medical College and Associated Hospitals, Bikaner, Rajasthan, over a period of six months after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to enrolment. The sample size was calculated based on the study by Rameez Musa et al., assuming acceptable functional outcomes of 80% in the volar plating group and 50% in the external fixation group, with a 95% confidence level and 80% study power. A minimum sample size of 39 patients per group was required, resulting in a total sample of 78 patients. Eligible patients were enrolled consecutively and randomized by simple random allocation into two equal groups.

Patients aged 18–65 years with closed intra-articular distal radius fractures (Frykman type III–VIII/AO-OTA type C), presenting within two weeks of injury and requiring operative treatment, were included. Patients with open fractures (Gustilo grade II/III), extra-articular fractures (AO type A), pathological fractures, associated neurovascular injuries, previous ipsilateral wrist pathology or surgery, polytrauma, or those unwilling or unfit for surgery were excluded.

Preoperative Assessment

A detailed history, clinical examination, and neurovascular assessment were performed in all patients. Standard anteroposterior and lateral radiographs of the affected wrist were obtained, and computed tomography with three-dimensional reconstruction was performed when necessary to define complex intra-articular fracture patterns. Fractures were classified according to the AO/OTA classification. Routine preoperative laboratory investigations and anaesthetic evaluation were completed before surgery.

Surgical Technique

Patients were randomly allocated into two treatment groups.

- **Group A (Volar Buttress Plate):** Open reduction and internal fixation were performed using a volar buttress locking plate through a standard volar Henry approach under regional or general anaesthesia. Anatomical reduction of the articular surface was achieved under fluoroscopic guidance, followed by fixation with an appropriately sized locking

plate. Restoration of radial height, radial inclination, and volar tilt was confirmed intraoperatively before layered wound closure. (Fig. 1)



Fig 1 Intra-articular distal end fracture treated by ORIF with Volar T plate

- **Group B (Percutaneous K-wire ± JESS):** Closed reduction was performed under fluoroscopic guidance using the principle of ligamentotaxis. Fractures were stabilized with percutaneous Kirschner wires, and in unstable or comminuted fractures requiring additional stability, Joshi's External Stabilization System (JESS) was applied using Schanz pins inserted into the radial shaft and second metacarpal. Adequacy of reduction and implant position was confirmed fluoroscopically before completion of the procedure. (Fig. 2)

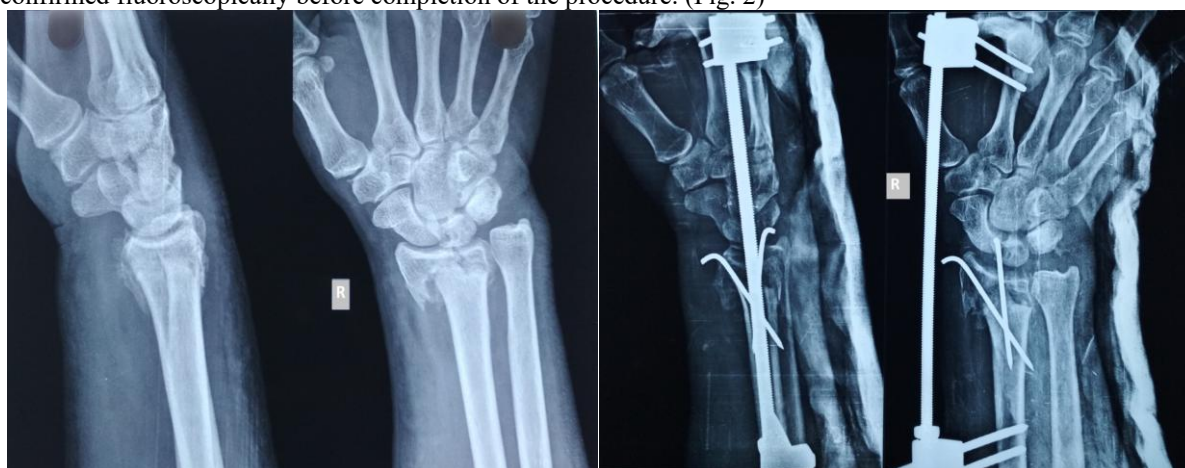


Fig 2 Fracture in distal end of radius, JESS fixator applied with K wire in distal side of radius

Postoperative Management and Follow-up

All patients received standard postoperative analgesia and antibiotic prophylaxis. Active finger, elbow, and shoulder mobilization was encouraged from the first postoperative day. Patients treated with volar plating underwent suture removal at two weeks, whereas pin-site care was performed regularly in patients treated with external fixation. Clinical and radiographic follow-up was scheduled at 2 weeks, 6 weeks, 3 months, and 6 months. K-wires and external fixators were removed after radiological evidence of fracture union, following which supervised wrist mobilization and physiotherapy were initiated.

Outcome Measures

The primary outcome was functional recovery assessed using Cooney's modification of the Green and O'Brien score, which evaluates pain, functional status, wrist range of motion, and grip strength. Wrist movements were measured with a goniometer, while grip strength was assessed using a hand dynamometer and compared with the contralateral side.

Radiological assessment was performed on standard posteroanterior and lateral wrist radiographs by measuring radial height, radial inclination, volar tilt, and articular congruity. Radiological outcomes were graded according to Sarmiento's modification of Lindstrom criteria. Fracture union was defined by the absence of local tenderness together with radiographic evidence of trabecular bridging across the fracture site. Procedure-related complications, including pin-tract infection, wound infection, loss of reduction, malunion, wrist stiffness, tendon-related complications, median nerve

neuropathy, distal radioulnar joint instability, complex regional pain syndrome, and post-traumatic arthritis, were recorded throughout follow-up.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 21.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean $\pm$ standard deviation, whereas categorical variables were presented as frequencies and percentages. A *p* value of <0.05 was considered statistically significant.

RESULTS

A total of 78 patients with intra-articular distal radius fractures were included in the study, with 39 patients each in Group P (volar buttress plate) and Group E (percutaneous K-wire with/without JESS).

The majority of patients (51.3%) belonged to the 51–65 years age group, followed by 36–50 years (34.6%), while only 1.3% were aged 20–35 years. The mean age was 53.45 ± 9.76 years in Group P and 54.46 ± 9.63 years in Group E. Male patients constituted 75.6% of the study population, and fractures were slightly more frequent on the right side (53.8%) than the left (46.2%). Falls were the predominant mechanism of injury (78.2%), whereas road traffic accidents accounted for 21.8% of cases. According to the AO classification, 79.5% of fractures were Type B and 20.5% were Type C, with no patient presenting with a Type A fracture. (Table 1)

Table 1 Baseline Demographic and Injury Characteristics

VARIABLE	GROUP P (N=39)	GROUP E (N=39)	TOTAL (N=78)
Age (years), Mean $\pm$ SD	53.45 $\pm$ 9.76	54.46 $\pm$ 9.63	—
Age group (years)			
20–35	1	0	1 (1.3)
36–50	13	14	27 (34.6)
51–65	21	19	40 (51.3)
>65	4	6	10 (12.8)
Sex			
Male	33	26	59 (75.6)
Female	6	13	19 (24.4)
Side involved			
Right	20	22	42 (53.8)
Left	19	17	36 (46.2)
Mode of injury			
Fall	29	32	61 (78.2)
Road traffic accident	10	7	17 (21.8)
AO fracture type			
Type B	30	32	62 (79.5)
Type C	9	7	16 (20.5)

Functional Outcomes

At the 3-month follow-up, patients treated with volar buttress plating demonstrated significantly better functional outcomes than those treated with percutaneous K-wire fixation with or without JESS. The mean pain score was significantly higher in Group P (23.03 ± 2.48) than in Group E (19.49 ± 2.51 ; $p<0.001$). Similarly, the mean range of motion score was significantly greater in Group P (13.29 ± 2.67) compared with Group E (10.00 ± 0.00 ; $p<0.001$). Grip strength scores were comparable between the two groups (15.13 ± 0.81 vs. 15.00 ± 0.00 ; $p=0.324$). The activity score was significantly higher in Group P (23.03 ± 2.48) than in Group E (20.77 ± 1.83 ; $p<0.001$). Consequently, the overall Modified Green and O'Brien score was significantly superior in Group P (74.47 ± 7.33) compared with Group E (65.26 ± 3.80 ; $p<0.001$).

According to the Modified Green and O'Brien grading system, 63.2% of patients in Group P achieved good functional outcomes at three months, whereas 79.5% of patients in Group E had fair outcomes and 20.5% had poor outcomes.

At the 6-month follow-up, pain, range of motion, and activity scores were comparable between the two groups ($p>0.05$). However, grip strength remained significantly higher in Group P (22.11 ± 4.60) than in Group E (18.08 ± 4.68 ; $p<0.001$). The mean overall Modified Green and O'Brien score also remained significantly better in Group P (87.50 ± 4.79) than in Group E (83.85 ± 6.64 ; $p=0.008$). (Table 2)

Functional grading at six months demonstrated excellent outcomes in 69.2% of patients treated with volar plating compared with 30.8% of those treated with percutaneous K-wire fixation with or without JESS. Good functional outcomes were observed in 30.8% and 64.1% of patients, respectively.

Table 2 Comparison of Functional Outcome Scores (Modified Green and O'Brien Score)

Parameter	3 Months Group P	3 Months Group E	p-value	6 Months Group P	6 Months Group E	p-value
Pain	23.03 ± 2.48	19.49 ± 2.51	<0.001	25.00 ± 0.00	24.74 ± 1.12	0.160
Range of motion	13.29 ± 2.67	10.00 ± 0.00	<0.001	15.39 ± 1.37	16.03 ± 2.05	0.115
Grip strength	15.13 ± 0.81	15.00 ± 0.00	0.324	22.11 ± 4.60	18.08 ± 4.68	<0.001
Activities	23.03 ± 2.48	20.77 ± 1.83	<0.001	25.00 ± 0.00	25.00 ± 0.00	1.000
Final Score	74.47 ± 7.33	65.26 ± 3.80	<0.001	87.50 ± 4.79	83.85 ± 6.64	0.008

Radiological Outcomes

Radiological evaluation using the Sarmiento criteria at 3 months demonstrated superior outcomes in the volar plating group. Good radiological results were achieved in 63.2% of Group P, whereas the majority of patients in Group E had fair (79.5%) or poor (20.5%) radiological outcomes.

At the 6-month follow-up, excellent radiological outcomes were observed in 61.5% of patients treated with volar buttress plating compared with 20.5% of patients treated with percutaneous K-wire fixation with or without JESS. Good radiological outcomes were noted in 38.5% and 74.4% of patients, respectively, indicating better restoration and maintenance of anatomical alignment in the volar plating group. (Fig 3)

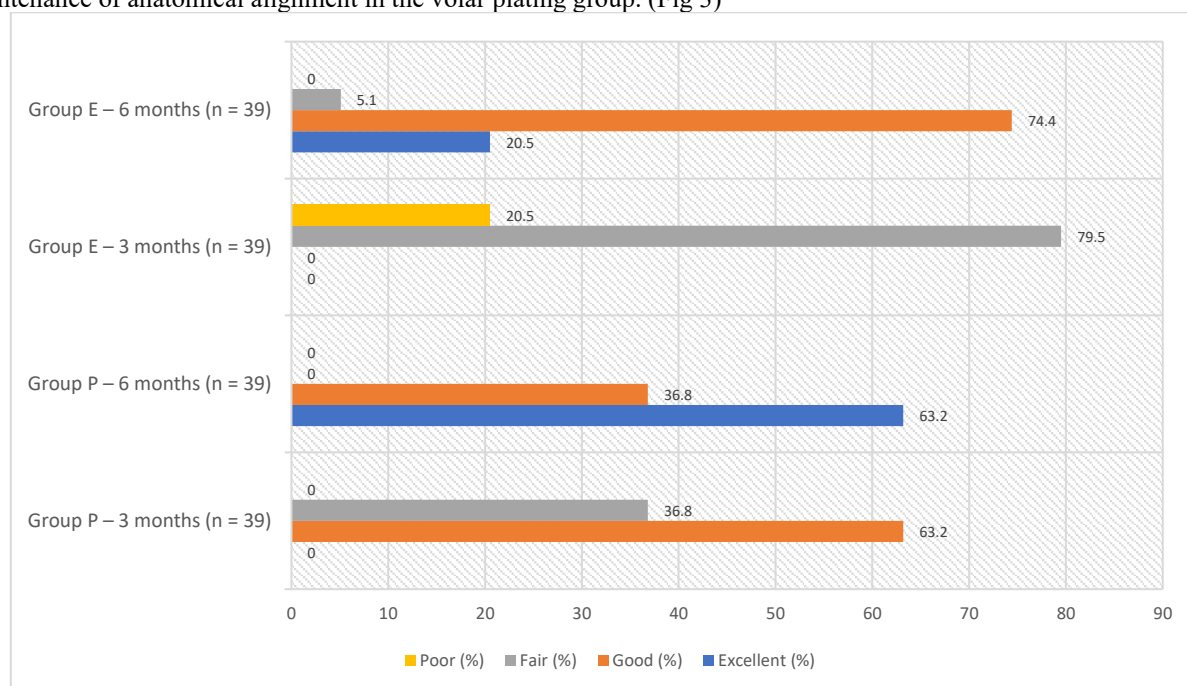


Fig 3 Radiological Outcome According to Sarmiento Criteria

Complications

Wrist stiffness was the most frequently encountered complication and was observed in 10 patients. Pin-tract infection occurred in three patients, malunion in two, tendon irritation in one, and radiographic osteoarthritis in three patients. No cases of deep infection, loss of reduction, or complex regional pain syndrome were observed in either treatment group.

Overall, both treatment modalities resulted in progressive improvement in functional and radiological outcomes during follow-up. However, patients managed with volar buttress plate fixation demonstrated earlier functional recovery, superior maintenance of anatomical reduction, and a higher proportion of excellent functional and radiological outcomes at final follow-up compared with percutaneous K-wire fixation with or without JESS.

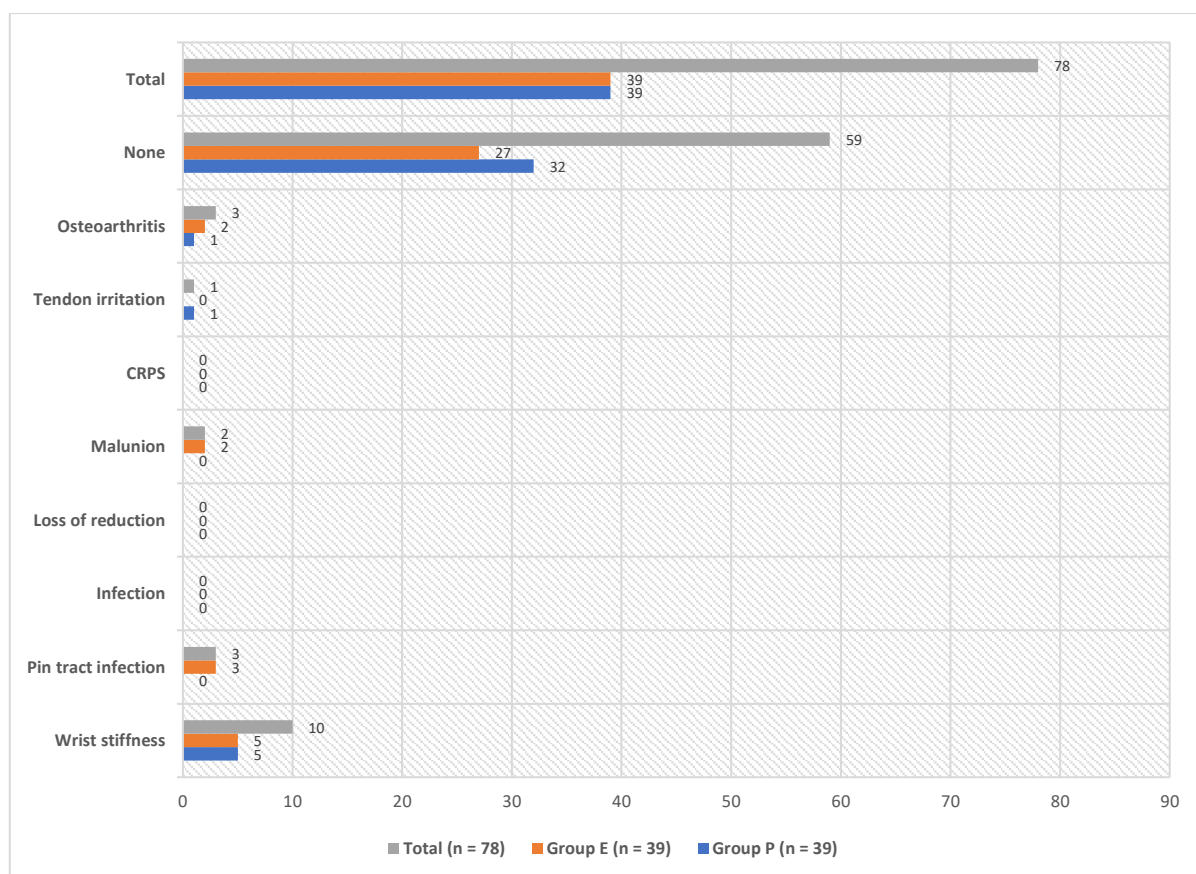


Fig. 4 Distribution of postoperative complications following operative treatment of intra-articular distal radius fractures (n = 78).

DISCUSSION

The present prospective randomized comparative study evaluated the functional and radiological outcomes of volar locking plate fixation and percutaneous K-wire fixation with or without JESS in the management of intra-articular distal radius fractures. The findings demonstrated that although both techniques achieved satisfactory fracture healing and functional recovery, volar locking plate fixation resulted in superior early functional recovery, better maintenance of anatomical reduction, and improved final functional and radiological outcomes. These findings are consistent with contemporary evidence supporting stable internal fixation for unstable intra-articular distal radius fractures.

The demographic characteristics of the study population were comparable between the two groups, minimizing potential selection bias. Most patients were in the fifth and sixth decades of life, with a clear male predominance, while falls constituted the most common mechanism of injury. These observations are comparable with previous reports by Court-Brown and Caesar¹¹, Nellans et al.¹², Mukhopadhyay et al.¹³, and Bahadur et al.¹⁴, who similarly identified middle-aged and elderly individuals, predominantly males, as the principal population requiring operative management of distal radius fractures.

At 3 months, patients treated with volar locking plates demonstrated significantly superior pain relief, wrist mobility, activity scores, and overall Modified Green and O'Brien scores compared with the percutaneous fixation group, while grip strength remained comparable. The improved early functional recovery is likely attributable to stable fixation, accurate restoration of articular congruity, and early postoperative mobilization. Similar findings have been reported by Tronci et al.¹⁵, Xie et al.¹⁶, Roh et al.¹⁷, and Gouk et al.¹⁸, who consistently demonstrated better short-term functional outcomes following volar plate fixation.

Although differences in pain, range of motion, and activity scores diminished by the 6-month follow-up, grip strength and the overall Modified Green and O'Brien score remained significantly better in the volar plating group. Furthermore, a greater proportion of patients achieved excellent functional outcomes following volar plate fixation, whereas good outcomes predominated after percutaneous fixation. These findings agree with those of Pande et al.¹⁹, Singh et al.²⁰, and Kumar et al.²¹, who reported superior long-term functional recovery with volar locking plates despite satisfactory outcomes with both techniques.

Radiological assessment similarly favored volar locking plate fixation. Better restoration and maintenance of anatomical alignment were observed at both follow-up intervals, resulting in a higher proportion of excellent radiological outcomes at final assessment. These results are consistent with previous comparative studies Khajotia et al.²² and Bhosale et al.²³ demonstrating that rigid fixed-angle constructs provide superior maintenance of radial height, inclination, and volar tilt compared with percutaneous fixation techniques.

The overall complication rate was low in both groups. Wrist stiffness was the most frequent complication, whereas pin-tract infection and malunion occurred only in the percutaneous fixation group. Tendon irritation was uncommon following volar plating, and no cases of deep infection, loss of reduction, or complex regional pain syndrome were encountered. These findings indicate that both procedures are safe when performed appropriately; however, volar locking plate fixation appears to provide more reliable fixation with fewer fixation-related complications²⁴.

CONCLUSION

Both volar locking plate fixation and percutaneous K-wire fixation with or without JESS provided satisfactory outcomes in the management of intra-articular distal radius fractures. However, volar locking plate fixation resulted in superior early functional recovery, better maintenance of anatomical reduction, and improved functional and radiological outcomes at final follow-up. Although percutaneous K-wire/JESS fixation remains a safe, minimally invasive, and cost-effective alternative in appropriately selected patients, volar locking plate fixation appears to be the preferred treatment for unstable intra-articular distal radius fractures. Further multicenter studies with larger sample sizes and longer follow-up are warranted to validate these findings.

DECLARATIONS

Funding: None.

Conflict of Interest: The authors declare no conflict of interest.

Ethical Approval: The study was conducted in accordance with applicable ethical standards and approved by the appropriate ethics committee where required.

Informed Consent: Informed consent was obtained from all participants involved in the study where applicable.

Author Contributions: All authors contributed to the study conception, design, data collection, analysis, manuscript preparation, and approved the final version of the manuscript.

Data Availability: Data supporting the findings of this study are available from the corresponding author upon reasonable request.

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