Int J Burn Trauma 2026;16(1):25-32
www.IJBT.org /ISSN:2160-2026/IJBT0169326

Original Article

Radiographic and functional outcomes of dorsal-assisted volar plate fixation in comminuted intra-articular distal radius fractures: a prospective study

Akshay A Shreegan, Deepak Kumar, Anil Kumar Kotteda, Arjit Bansal, Tharun Teja Aduri, Vijay Goni

Department of Orthopaedics, Postgraduate Institute of Medical Education and Research, Sector 12, Chandigarh 160012, India

Received October 14, 2025; Accepted February 23, 2026; Epub February 25, 2026; Published February 28, 2026

Abstract: Objective: Comminuted intra-articular distal radius fractures (DRFs) present significant treatment challenges due to their complex morphology and tendency for post-traumatic arthritis. Volar plating alone may be insufficient to achieve and maintain reduction in dorsally displaced fractures. This prospective study evaluated the radiological and functional outcomes of dorsal-assisted volar plate fixation in dorsally displaced comminuted intra-articular DRFs. Methods: A total of 21 patients treated at a tertiary care trauma centre were enrolled. All underwent dorsal-assisted reduction followed by volar plating without dorsal instrumentation and were followed for a minimum of one year (mean follow-up: 19.6 ± 4.7 months). Radiological outcomes were assessed using radial height, radial inclination, volar tilt, and intra-articular step-off, while functional outcomes were measured using the QuickDASH and modified Mayo Wrist scores. The study was prospectively registered in the Department review board in department of Orthopaedic Surgery, PGIMER, under registration number DRB/Ortho/2023/49. Results: The mean patient age was 38 years, with a male predominance (17/21; 80.9%). Most fractures (15/21; 71.4%) were AO type 2R3C3. Postoperative evaluation demonstrated restoration of wrist alignment with a mean radial inclination of 23.35°, radial height of 11.29 mm, and volar tilt of 6.70°, closely approximating the uninjured wrist. Functional outcomes improved significantly from two months postoperatively to the final follow-up ($P < 0.001$), achieving a mean QuickDASH score of 4.95 and a modified Mayo Wrist Score of 90. Only two patients experienced minor complications related to implant prominence. Conclusions: Dorsal-assisted volar plating is a safe and effective technique for managing dorsally displaced comminuted intra-articular distal radius fractures, providing excellent anatomical restoration and functional recovery with minimal complications. It offers a valuable surgical option where volar plating alone may be inadequate.

Keywords: Distal radius fracture, dorsal-assisted volar plating, intra-articular fractures, comminuted fractures, radiological outcome, functional outcome, QuickDASH, Mayo Wrist Score

Introduction

Fractures of the distal end of the radius represent one of the most commonly encountered injuries in orthopaedic practice, accounting for up to 18% of all fractures in the elderly and 25% in the paediatric population [1]. Among these, the dorsally displaced comminuted intra-articular fracture sub-group poses considerable challenges in terms of anatomical reduction, stability, and long-term functional outcome [2-4].

The morphology of the fracture plays a crucial role in determining the prognosis and appropriate treatment modality. The prognosis is much less favourable for displaced comminuted intra-articular fractures such as AO type 2R3C3 injuries [5]. Inability to reduce these fractures anatomically can lead to malunion and persistent articular incongruity that can result in post-traumatic arthritis, stiffness, and diminished grip strength, ultimately compromising functional recovery [6, 7].

Management strategies for distal radius fractures have evolved considerably; open reduction with internal fixation (ORIF) using volar locking plates has become the preferred method for managing unstable and intra-articular fractures [8-10]. Reduction of dorsally dis-

https://doi.org/10.62347/GFNB2009

placed intra-articular fragments can be difficult through an isolated volar approach, often necessitating excessive manipulation or resulting in suboptimal fixation. Meanwhile, dorsal plating, though offering direct access for reduction, has been associated with higher complication rates [11, 12].

To address these limitations, the concept of dorsal-assisted volar plate fixation has been hypothesised in this study. This technique combines the benefits of both approaches: precise reduction of dorsal fragments via a dorsal window and definitive fixation with a volar locking plate, thereby minimising the need for hardware on the dorsal surface.

This study was conducted to fill a gap in existing evidence to the best of our knowledge and provide orthopaedic surgeons with data to support the use of dorsal exposure solely for reduction purposes, without the need for dorsal fixation. We sought to assess the effectiveness of this approach using objective radiological parameters, functional scoring systems, and comparison with the uninjured contralateral limb (due to variability in the normal radiological parameters in different individuals, we compared it with the uninjured limb of the same subject) over a one-year follow-up period in dorsally comminuted intra-articular distal radius fractures.

Materials and methods

Study design and setting

This prospective interventional study was conducted in a tertiary care trauma centre. The study spanned a total duration of 24 months, beginning on 1st June 2022 and concluding with data analysis on 31st May 2024. Ethical clearance for the study was granted by the Institutional Ethics Committee of Post Graduate Institute of Medical Education and Research, Chandigarh, India, before patient enrolment (IEC-INT/2022/MS-564), and all participants provided written informed consent before inclusion. All surgeries were performed by a single experienced orthopaedic surgeon (DK), ensuring consistency in surgical technique, perioperative care, and rehabilitation. Postoperative evaluations and follow-up visits were similarly standardised and conducted. Radiological and functional evaluation of the patient was done for a minimum of one year. Radiological outcomes were evaluated using parameters like radial height, radial inclination, volar tilt, and intra-articular step-off and functional outcome was assessed in terms of the Quick DASH score and modified Mayo Wrist Score by an independent observer, orthopaedic resident (AS) and range of motion of both affected and normal limb as internal control. Potential measurement bias was minimised by having a single independent observer perform all measurements using standardised protocols. All radiographs were obtained in standard AP and lateral views with identical positioning.

Participant selection

Patients aged 18 years and above presenting with intra-articular distal radius fractures were screened for eligibility. Fractures were included if they demonstrated dorsal comminution, impacted dorsal fragments, or dorsal instability (AO type C2 or C3) on radiographic or CT evaluation and could not be adequately reduced through a volar approach alone. Only acute fractures less than three weeks old were enrolled to ensure comparability of healing dynamics. Patients with extra-articular or simple partial articular fractures, bilateral or open fractures with extensive soft tissue injury, pathological lesions, or prior surgery on the affected wrist were excluded. Those with associated neurological deficits, psychiatric disorders, or systemic conditions precluding functional assessment were also excluded. All eligible participants provided written informed consent, and only those fit for anaesthesia and willing to comply with the postoperative follow-up protocol were included. These criteria ensured a homogeneous study population with comparable injury morphology and adequate follow-up for reliable assessment of functional and radiographic outcomes.

Preoperative evaluation

Following initial clinical stabilisation based on Advanced Trauma Life Support (ATLS) guidelines [13], standard anteroposterior and lateral radiographs of the bilateral wrist joints were obtained for all patients. Non-contrast computed tomography (NCCT) scans were performed to provide a detailed assessment of the fracture morphology. Detailed patient histories were recorded, including demographic data,

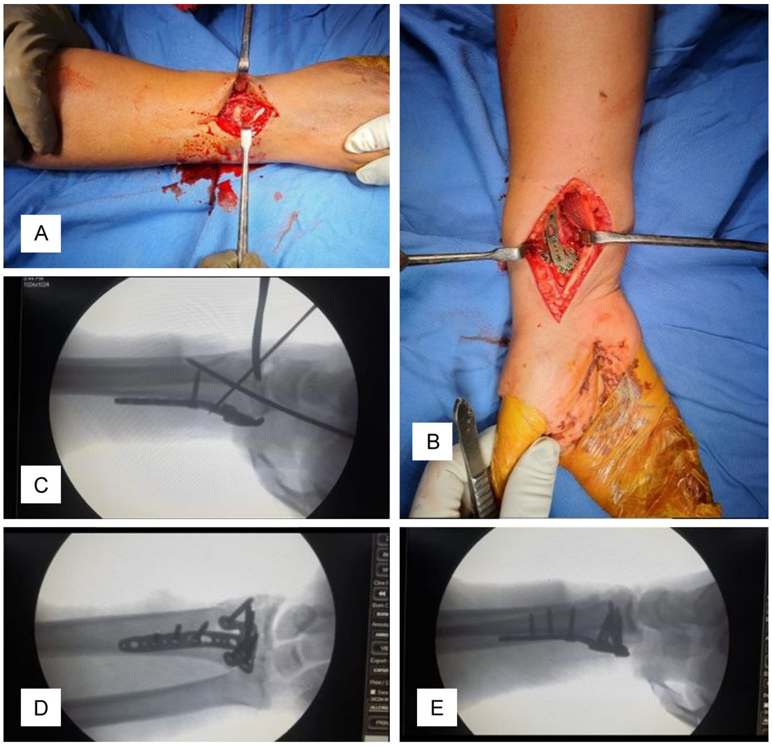

Figure 1. Dorsal-assisted volar plating technique. A. Dorsal exposure; B. Volar exposure showing 4-hole volar locking plate; C. elevation of impacted fragments using a periosteum elevator via dorsal exposure; D. Anteroposterior fluoroscopic view; E. Lateral fluoroscopic view following fixation.

comorbid conditions, mechanism of injury, and dominance of the affected limb.

Surgical technique

All procedures were carried out under regional or general anaesthesia with the patient in the supine position. After aseptic preparation, a pneumatic tourniquet was applied to the upper arm. Closed reduction of the fracture was attempted initially after induction in all cases. In instances where satisfactory alignment could not be achieved by closed means on the table or with a volar-only approach, a dual approach was employed.

The volar exposure was performed first using the modified Henry approach. A longitudinal incision was made along the flexor carpi radialis (FCR) tendon, and the plane between the FCR and radial artery was developed. Care was taken to preserve the radial artery and the palmar cutaneous branch of the median nerve. The pronator quadratus was elevated in an L-shaped fashion, allowing visualisation of the volar aspect of the distal radius. Direct reduction of volar fracture fragments was attempted at this stage, and a limited amount of manipulation of the dorsal fragments was tried using K-wires as joysticks.

Following this, if the reduction of fracture was still unsatisfactory, a dorsal exposure was undertaken through a separate longitudinal incision approximately 4-5 cm in length, placed at the centre of the wrist joint along the line of the third metacarpal. The extensor retinaculum was incised, and the extensor pollicis longus (EPL) tendon was mobilised to expose the underlying dorsal capsule. A dorsal capsulotomy was done along the existing fracture line, exercising caution not to strip off the fracture fragments from the capsule, then the fragments were everted and elevated along with the capsule. The first step was to disimpact the fracture fragments in the lunate fossa by a gentle push with a blunt impactor while maintaining sustained traction. Once the fracture line was identified, it was elevated and reduced by a sharp lever and temporarily fixed using K-wires. Fragments in the scaphoid fossa were addressed similarly and held with subchondral K-wires. Radial deviation and palmar flexion of the wrist were done to achieve radial tilt and inclination, after confirmation of reduction using fluoroscopy. Another K-wire was put from the styloid tubercle towards the medial cortex. In cases where metaphyseal voids remained after reduction, autografts or synthetic bone substitutes were employed for structural support (**Figure 1**).

A volar locking plate-either fixed or variable-angle-was then applied for definitive fixation. Screws were placed subchondrally with intraoperative fluoroscopic guidance and direct visualisation to ensure optimal placement and to avoid joint penetration. Dorsal visualisation through the capsulotomy aided in confirming screw lengths and reduction, and also subchondral support of the articular fragments. The dorsal capsule and retinaculum were repaired using absorbable sutures, and the volar wound was closed in layers. In the immediate post-op period below-elbow splint was applied for one week.

Postoperative care and rehabilitation

Radiographs were obtained within the first 48 hours to assess fracture alignment and implant positioning. A standard rehabilitation protocol was initiated after one week, a wrist immobiliser was applied for the next two weeks, and gradual mobilisation of the wrist was allowed twice daily during this period. Patients were allowed to lift objects at six weeks, but no pushing manoeuvres were allowed till three months. Patients were reviewed regularly up to one year. Clinical evaluation at each visit included pain assessment and range of motion measurement using a goniometer. Radiographs were repeated at each visit to monitor fracture union, hardware status, and maintenance of reduction.

Outcome measures

Radiological evaluation was performed on standard anteroposterior and lateral wrist radiographs obtained in identical positioning at each follow-up visit. Radial height, radial inclination, and volar tilt were measured according to established radiographic definitions, while intra-articular step-off was assessed on the lateral projection as the vertical displacement between fracture fragments at the articular surface. The quality of reduction was graded using Sarmiento's modification of the Lindstrom criteria [14], classifying outcomes as excellent, good, fair, or poor based on residual deformity, radial shortening, and angular alignment. Functional assessment included the Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) questionnaire and the modified Mayo Wrist Score [15-17], both administered at 2, 6, and 12 months postoperatively by an independent blinded observer. Range of motion in dorsiflexion, palmar flexion, pronation, supination, ulnar deviation, and radial deviation was measured with a goniometer and compared with the contralateral uninjured wrist to account for interindividual variability. All measurements were performed by a single trained orthopaedic resident using standardised protocols to minimise observer bias and ensure consistency across follow-up evaluations.

Statistical analysis

All statistical analyses were performed using IBM SPSS Statistics (Version 22.0; IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation, and categorical data as frequencies and percentages. Data normality was assessed using the Kolmogorov-Smirnov test. For parameters measured at multiple postoperative time points (radiological and functional outcomes), repeated measures analysis of variance (ANOVA) was applied to evaluate longitudinal changes, followed by Bonferroni-adjusted post hoc tests for pairwise comparisons. When normality assumptions were not met, the Friedman test with Wilcoxon signed-rank correction was used. Paired t-tests were applied for comparisons between the operated and contralateral limbs at corresponding follow-up intervals. A two-tailed p-value of < 0.05 was considered statistically significant. Ninety-five percent confidence intervals (CI) were calculated for all key outcome measures. The statistical approach was selected to account for within-subject variability across follow-up periods and to ensure robust evaluation of both radiological alignment and functional recovery.

Results

A total of 21 patients with comminuted intra-articular distal radius fractures as per the inclusion criteria were enrolled in the study. The mean age of the cohort was 38.01 ± 11.17 years, with patients ranging from 21 to 65 years of age. The majority of the patients (10/21-47.6%) were above 40 years of age, with males comprising 17/21 (80.9%) of the study population. Most injuries occurred on the non-dominant side 16/21 (76.2%). The average duration between injury and surgery was 4.24 ± 2.66 days, and all patients underwent surgical fixation within 12 days of trauma. The mean duration of surgery was 1.79 ± 0.31 hours. Mean tourniquet time was 68 ± 12 minutes. A total of 13 patients required a graft for the metaphyseal void as described, out of which in nine patients artificial bone graft substitute (Tricalcium phosphate) was used, and in the

Table 1. Radiological parameters (mean ± SD) of the injured wrist at baseline (preoperative), immediate postoperative, and during follow-up compared with the contralateral normal wrist

Parameter	Preoperative (Mean ± SD)	Immediate post-op (Mean ± SD)	2 Months (Mean ± SD)	6 Months (Mean ± SD)	Final followup (Mean ± SD)	Normal side (Mean ± SD)
Radial Inclination (degrees)	6.82 ± 5.19	23.35 ± 2.45	22.76 ± 3.13	22.76 ± 3.13	22.76 ± 3.13	24.12 ± 1.41
Radial Height (mm)	5.06 ± 3.21	11.29 ± 1.21	11.29 ± 1.21	11.29 ± 1.21	11.29 ± 1.21	11.65 ± 0.70
Volar Tilt:lateral inclination (degrees)	-11.70 ± 4.89	6.70 ± 3.33	6.11 ± 3.58	6.11 ± 3.58	6.11 ± 3.58	9.88 ± 0.78
Articular stepoff (mm)	5.4 ± 1.2	1.2 ± 0.6	1.1 ± 0.5	1.1 ± 0.5	1.1 ± 0.5	-

Table 2. Comparison of wrist range of motion (mean ± SD, in degrees) in the operated limb at 2, 6, and 12 months postoperatively with the contralateral normal side

Movement	2 Months (Mean ± SD)	6 Months (Mean ± SD)	Final followup (Mean ± SD)	Normal side (Mean ± SD)
Dorsiflexion (degrees)	63.2 ± 7.0	70.9 ± 3.6	70.9 ± 3.6	79.7 ± 2.1
Palmar flexion (degrees)	55.0 ± 9.0	64.4 ± 5.0	64.4 ± 5.0	70.6 ± 3.5
Ulnar Deviation (degrees)	31.5 ± 7.0	34.4 ± 6.0	34.4 ± 6.0	41.8 ± 2.4
Radial Deviation (degrees)	13.8 ± 2.2	13.8 ± 2.2	13.8 ± 2.2	15.5 ± 1.4
Pronation (degrees)	52.5 ± 8.0	70 ± 6.5	76.4 ± 5.1	82.4 ± 4.5
Supination (degrees)	58.5 ± 10.0	75.1 ± 8.4	79.5 ± 6.5	84.5 ± 4.0

remaining four patients, autograft was used (iliac crest). There were no reported complications related to the bone graft procedure noted in the study period. The mean follow-up period was 19.6 ± 4.7 months.

Radiological parameters

Radiological outcomes of all included patients were assessed at zero weeks (immediate postoperative), two months, six months, and at final follow-up. Radial inclination, radial height, lateral inclination, intra-articular step, and residual deformity were measured (**Table 1**).

Radial inclination improved from 6.82° ± 5.19 preoperatively to 23.35° ± 2.45 postoperatively and remained stable at final follow-up (22.76° ± 3.13), comparable to the contralateral wrist (24.12° ± 1.41, $P < 0.05$). Radial height increased from 5.06 ± 3.21 mm to 11.29 ± 1.21 mm and was maintained through follow-up, closely matching the normal side (11.65 ± 0.70 mm, $P < 0.05$). Lateral inclination improved from a mean dorsal tilt of 11.70° ± 4.89 to a volar tilt of 6.70° ± 3.33, and remained 6.11° ± 3.58 at final follow-up, slightly lower than the contralateral wrist (9.88° ± 0.78, $P < 0.05$). Preoperatively, 16/21 (76.2%) of patients had > 5 mm intra-articular step-off, which was completely corrected in all cases by six months. Residual deformity (Based on Lindstrom criteria) improved markedly, with 18/21 (85.7%) showing no deformity and 3/21 (14.3%) only slight deformity at final follow-up. Repeated Measures ANOVA revealed a significant improvement in all radiological parameters over time ($P < 0.001$), with post hoc comparisons confirming maintenance of reduction at final follow-up without significant deterioration ($P > 0.05$).

Functional outcomes

Progressive improvement in wrist function was observed throughout the follow-up period. In the immediate postoperative period, the mean dorsiflexion was 29.71°, which significantly improved to 63.24° by two months and 70.88° by six months, remaining stable at final follow-up. Similar improvements were recorded in palmar flexion, ulnar deviation, and radial deviation. At six months, the range of motion in the operated limb nearly matched that of the normal wrist across all planes (**Table 2**).

The mean QuickDASH score at six months was 4.95 ± 3.14, indicating minimal disability and near-complete functional recovery. Likewise, the modified Mayo Wrist Score averaged 90.0 ± 9.52, placing most outcomes in the "good to excellent" category. Repeated Measures ANOVA demonstrated statistically significant improvement in all functional outcomes across follow-up intervals (P < 0.001). Bonferroni-adjusted post hoc tests showed no further significant change between six months and final follow-up, indicating functional stabilization.

Complications

Postoperative complications were minimal. Only two patients reported mild tendon irritation-pain with finger extension, which did not necessitate immediate intervention. No cases of infection, wound dehiscence, tendon rupture, or neurological compromise were reported during the study period. None of the patients had to undergo any additional procedures.

Discussion

Dorsal-assisted volar plating is particularly useful in complex intra-articular distal radius fractures with dorsal comminution or dorsoulnar corner fragments that are difficult to reduce through a volar approach alone. Biomechanical evidence supports supplemental dorsal access when the dorsal third of the lunate facet is disrupted, as it enhances fragment control and construct stability [21]. Clinical studies of combined dorsal and volar fixation have reported reliable fracture union and restoration of wrist function, though with higher rates of hardware irritation and implant removal compared to volar plating alone [22, 23]. Recent reports of hybrid methods using a limited dorsal window for reduction followed by volar fixation have achieved excellent alignment and low complication rates [24]. Current AAOS/ASSH guidelines recommend dorsal or fragment-specific exposure when dorsal fragments contribute to joint stability [25]. Thus, dorsal-assisted volar plating offers a balanced approach that ensures precise reduction while minimising dorsal hardware complications.

The key technical considerations in dorsal-assisted volar plating include accurate identification of fracture anatomy, gentle manipulation of dorsal fragments, and maintenance of articular congruity while minimising dorsal soft-tissue trauma. Controlled elevation of impacted fragments under direct visualisation allows precise reduction of the lunate fossa and restoration of the subchondral arc. The dorsal capsulotomy should follow the fracture line to preserve vascularity and facilitate anatomic realignment. Provisional fixation with subchondral K-wires provides temporary stability, while direct dorsal viewing during volar screw insertion ensures avoidance of dorsal cortex penetration, a critical step to prevent extensor tendon irritation or rupture (6, 7). The main intraoperative challenges in these joint-associated fractures include limited dorsal visualisation, maintaining reduction during plate positioning, and avoiding tendon irritation from hardware prominence. The dorsal-assisted approach addresses these difficulties effectively by combining direct articular visualisation with the biomechanical benefits of volar fixation [26].

The radiological outcomes in this study demonstrate that dorsal-assisted volar plating achieves and maintains excellent restoration of distal radius alignment in comminuted intra-articular fractures. Mean radial inclination (23.3°), radial height (11.3 mm), and volar tilt (6.7°) were effectively restored and remained stable at the final follow-up, closely approximating the contralateral wrist. These values are consistent with those reported in previous studies of volar and combined plating techniques. Quadlbauer et al. observed comparable alignment (radial inclination 22.8°, volar tilt 7.5°) using volar plating [19], while Lüdi et al. [22] demonstrated similar radiological restoration with dual plating constructs. In contrast, Rozental et al. noted a tendency for late loss of reduction in dorsally displaced fractures managed with volar plates alone, emphasising the need for dorsal fragment control [18]. The sustained alignment observed in our series highlights the biomechanical advantage of direct dorsal-assisted reduction in preserving joint congruity and preventing secondary collapse, particularly in fractures involving the dorsal lunate facet.

Functional recovery following dorsal-assisted volar fixation in this cohort was excellent, with a mean QuickDASH score of 4.95 and a modified Mayo Wrist Score of 90 at final follow-up, indicating near-normal upper limb function. Progressive improvement in wrist range of motion was observed across all planes, with final values approaching those of the uninjured side. These results are comparable to outcomes reported after volar plating in large prospective series, such as those by Quadlbauer et al. [19] and Karantana et al. [8], and are equivalent to or better than those achieved with combined dorsal-volar constructs [22]. The ability to directly visualise and anatomically reduce dorsal articular fragments may contribute to the rapid functional recovery observed in our series, as precise joint restoration allows for early rehabilitation and minimises stiffness. The use of a limited dorsal window, without dorsal hardware placement, likely facilitated early motion while maintaining the benefits of stable volar fixation.

The complication rate in this study was low, limited to minor transient tendon irritation in two patients (9.5%), both managed conservatively. No cases of infection, tendon rupture, or hardware prominence were observed during the follow-up period. This complication profile compares favourably with previously published series of dorsal or combined plating techniques, where complication rates range from 15% to 25%, largely due to extensor tendon irritation and hardware-related issues [20, 26]. The low incidence of adverse events in the present study may be attributed to minimal dorsal dissection, subchondral screw placement under direct visualisation, and avoidance of dorsal implants. By combining the accuracy of dorsal reduction with the biological and soft-tissue advantages of volar fixation, the dorsal-assisted technique appears to minimise the risk of extensor tendon complications while achieving reliable fracture union. These findings further support its use as a safe and effective alternative in select complex intra-articular distal radius fractures.

Several practical observations emerged during this study. In the early cases, omission of bone grafting in metaphyseal voids resulted in a slight loss of reduction, emphasising the importance of grafting to maintain alignment. We also identified specific fracture patterns-particularly those with impacted dorsal lunate fossa or severe articular comminution - that consistently required dorsal assistance for adequate reduction.

The strengths of this study include a uniform surgical technique performed by a single experienced surgeon, standardised radiographic and functional assessments, and complete follow-up of all patients. However, limitations must be acknowledged. The relatively small sample size restricts generalizability. Also, the shorter follow-up may not capture the longer-term risk of post-traumatic arthritis. Given the distinct morphological characteristics of these injuries and the variability in alternative fixation strategies, establishing a comparable control group within the same timeframe was not feasible. Nevertheless, randomised controlled trials directly comparing dorsal-assisted volar plating with isolated volar or combined dorsal-volar fixation are warranted to further validate the observed advantages and to quantify potential differences in complication rates and long-term functional recovery. Nonetheless, the results offer valuable insight into a hybrid technique that appears to blend the advantages of both approaches while avoiding their respective complications.

In summary, dorsal-assisted volar plate fixation is a reliable technique for managing comminuted intra-articular distal radius fractures where volar-only approaches are inadequate. By enabling precise reduction of dorsal fragments while avoiding dorsal hardware, this approach offers a safe and effective alternative that preserves both radiological alignment and functional recovery.

Conclusion

This study suggests that dorsal-assisted volar plate fixation may be a reliable technique for managing dorsally displaced comminuted intra-articular distal radius fractures in which a volar-only approach is inadequate. The use of limited dorsal exposure allowed direct visualisation and reduction of impacted fragments, while volar plate fixation provided stable support without the complications associated with dorsal hardware. These findings support the selective use of this combined approach in complex fracture patterns, although larger comparative studies are needed to validate its wider application.

Disclosure of conflict of interest

None.

Address correspondence to: Dr. Deepak Kumar, Department of Orthopaedics, Postgraduate Institute of Medical Education and Research, Sector 12, Chandigarh 160012, India. Tel: +91-7087003324; ORCID: 0000-0003-0479-1164; E-mail: drdeepaknegimt@gmail.com

References

[1] Nellans KW, Kowalski E and Chung KC. The epidemiology of distal radius fractures. Hand Clin 2012; 28: 113-125.
[2] Hoare CP, Dickson DR, Armstrong DJ, Nuttall D and Watts AC. Internal fixation for treating distal radius fractures in adults. Cochrane Database Syst Rev 2017; 2017: CD011213.
[3] Mader K and Pennig D. The treatment of severely comminuted intra-articular fractures of the distal radius. Strategies Trauma Limb Reconstr 2006; 1: 2-17.
[4] Gogna P, Selhi HS, Singla R, Devgan A, Magu NK, Mahindra P and Yamin M. Dorsally comminuted fractures of the distal end of the radius: osteosynthesis with volar fixed angle locking plates. ISRN Orthop 2013; 2013: 131757.
[5] Jayakumar P, Teunis T, Giménez BB, Verstreken F, Di Mascio L and Jupiter JB. AO distal radius fracture classification: global perspective on observer agreement. J Wrist Surg 2017; 6: 46-53.
[6] Turner RG, Faber KJ and Athwal GS. Complications of distal radius fractures. Hand Clin 2010; 26: 85-96.
[7] Gutow AP. Avoidance and treatment of complications of distal radius fractures. Hand Clin 2005; 21: 295-305.
[8] Karantana A, Downing ND, Forward DP, Hatton M, Taylor AM, Scammell BE, Moran CG and Davis TR. Surgical treatment of distal radial fractures with a volar locking plate versus conventional percutaneous methods: a randomized controlled trial. J Bone Joint Surg Br 2013; 95: 1737-1744.
[9] Larson AN and Rizzo M. Locking plate technology and its applications in upper extremity fracture care. Hand Clin 2007; 23: 269-278.
[10] Abramo A, Kopylov P, Geijer M and Tägil M. Open reduction and internal fixation compared to closed reduction and external fixation in distal radial fractures: a randomized study of 50 patients. Acta Orthop 2009; 80: 478-485.
[11] Drummond I, Durand-Hill M, Jones N, O'Hagan PJ and Edwards D. Systematic review: dorsal bridge plating in distal radius fractures. Musculoskelet Surg 2024; 108: 359-366.
[12] Alter TH, Sandrowski K, Gallant G, Kwok M and Ilyas AM. Complications of volar plating of distal radius fractures: a systematic review. J Wrist Surg 2019; 8: 255-262.
[13] Ramasamy A. Advanced trauma life support 2025: a brief review of updates. Injury 2026; 57: 113079.
[14] Sarmiento A, Pratt GW, Berry NC and Sinclair WF. Colles' fractures. Functional bracing in supination. JBJS 1975; 57: 311-317.
[15] Green DP and O'Brien ET. Open reduction of carpal dislocations: indications and operative techniques. The Journal of Hand Surgery 1978; 3: 250-265.
[16] Cooney WP, Bussey R, Dobyns JH and Linscheid RL. Difficult wrist fractures perilunate fracture-dislocations of the wrist. Clin Orthop Relat Res 1987; 214: 136-147.
[17] Gummesson C, Ward MM and Atroshi I. The shortened disabilities of the arm, shoulder and hand questionnaire (quick dash): validity and reliability based on responses within the full-length dash. BMC Musculoskelet Disord 2006; 7: 44.
[18] Rozental TD and Blazar PE. Functional outcome and complications after volar plating for dorsally displaced, unstable fractures of the distal radius. The Journal of Hand Surgery 2006; 31: 359-365.
[19] Quadlbauer S, Pezzei C, Jurkowitsch J, Rosenauer R, Pichler A, Schättin S, Hausner T and Leixnering M. Functional and radiological outcome of distal radius fractures stabilized by volar-locking plate with a minimum follow-up of 1 year. Arch Orthop Trauma Surg 2020; 140: 843-852.
[20] Wei J, Yang TB, Luo W, Qin JB and Kong FJ. Complications following dorsal versus volar plate fixation of distal radius fracture: a meta-analysis. J Int Med Res 2013; 41: 265-275.
[21] Hadzhinikolova M, Zderic I, Ciric D, Barcik JP, Enchev D, Baltov A, Rusimov L, Varga P, Stoffel K, Richards G and Gueorguiev B. Volar versus combined dorsal and volar plate fixation of complex intraarticular distal radius fractures with small dorsoulnar fragment-a biomechanical study. BMC Musculoskelet Disord 2022; 23: 35.
[22] Lüdi S, Kurz C, Deforth M, Ghafoor H, Haefeli M and Honigmann P. Radiological, clinical, and functional outcomes of combined dorsal and volar locking plate osteosynthesis for complex distal radius fractures. J Hand Surg Am 2023; 48: 377-387.
[23] Lundqvist E, Fischer P, Wretenberg P, Pettersson K, Lopez Personat A and Sagerfors M. Volar locking plate compared with combined plating of AO type C distal radius fractures: a randomized controlled study of 150 cases. J Hand Surg Am 2022; 47: 813-822.
[24] Yu X, Lu WH, Ma WW, Lu HJ, Ao RG and Liu BL. Volar approach combined with small dorsal incision in the treatment of AO type C distal radius fracture: a retrospective cohort study. Medicine (Baltimore) 2025; 104: e46624.
[25] Kamal RN and Shapiro LM. Practical application of the 2020 distal radius fracture AAOS/ASSH clinical practice guideline: a clinical case. J Am Acad Orthop Surg 2022; 30: e714-e720.
[26] Ring D, Prommersberger K and Jupiter JB. Combined dorsal and volar plate fixation of complex fractures of the distal part of the radius. J Bone Joint Surg Am 2005; 87 Suppl 1: 195-212.