Clinical and functional outcomes of three column fixation in distal end radius fractures

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ABSTRACT

Background: Distal end radius fractures are among the most common upper limb fractures and often require surgical intervention to restore anatomical alignment and functional wrist mechanics. Three-column fixation has emerged as a biomechanically favorable technique for managing unstable and intra-articular fracture patterns.

Aim: To evaluate the clinical and functional outcomes of three-column fixation in distal end radius fractures.

Materials and Methods: This prospective observational study included 50 patients with distal end radius fractures treated using three-column fixation. Patients aged ≥18 years meeting inclusion criteria were enrolled after informed consent. Clinical data, fracture characteristics, radiological parameters, pain scores (VAS), wrist range of motion, union time, and postoperative complications were recorded. Functional outcomes were assessed at 3 months. Statistical analysis was performed using paired t-test and chi-square tests where appropriate.

Results: The study population predominantly comprised males (64%) and middle-aged adults. Falls accounted for 48% of injuries. A significant reduction in VAS pain scores was observed from 8.9 ± 0.8 preoperatively to 1.9 ± 1.1 at 3 months ($p < 0.001$). Functional assessment demonstrated excellent to good outcomes in 80% of patients. Most fractures united within 8–10 weeks, and the complication rate was low, with stiffness being most common.

Conclusion: Three-column fixation provides satisfactory radiological union, significant pain reduction, and favorable functional outcomes in distal end radius fractures with minimal complications.

Keywords: distal radius fracture; three-column fixation; functional outcome

Introduction:

Distal end radius fractures constitute one of the most common orthopedic injuries, accounting for a substantial proportion of upper limb fractures across all age groups. (1) These fractures typically result from high-energy trauma in young adults or low-energy falls in the elderly with osteoporotic bone. Historically, treatment modalities ranged from conservative management with closed reduction and casting to percutaneous pinning, external fixation, and open reduction internal fixation (ORIF) using volar locking plates. (2,3,4) Although conventional volar plating has provided satisfactory anatomical restoration and stability in many cases, residual functional impairment, loss of reduction, and post-traumatic arthrosis remain significant concerns, particularly in complex, unstable, intra-articular fractures.(5)

The three-column concept introduced by Rikli and Regazzoni provides a biomechanical framework that emphasizes stabilization of the radial, intermediate, and ulnar columns to optimize overall wrist kinematics. (6,7) Fixation strategies addressing these three columns aim to restore articular congruity, maintain axial alignment, and improve load transmission across the distal radius. Emerging evidence suggests that three-column fixation may yield superior postoperative outcomes in terms of pain relief, grip strength, range of motion, and radiological alignment compared to single-column approaches. (8) Consequently, the evaluation of clinical and functional outcomes of three-column fixation techniques is essential for guiding treatment decisions, defining indications, and improving long-term patient quality of life.

Study methodology

Our present study was conducted in the Department of Orthopaedics at a tertiary care teaching hospital over a period of two years. Patients presenting with distal end radius fractures who satisfied the inclusion criteria were enrolled in the study after obtaining written informed consent. Ethical approval from the institutional ethics committee had been secured prior to initiation of the study. Patients aged 18 years and above with acute displaced or unstable distal radius fractures requiring surgical intervention were included, while open fractures, pathological fractures, and patients with neurovascular compromise or prior ipsilateral wrist injury were excluded.

All patients underwent detailed clinical evaluation, including demographic profile, injury mechanism, limb dominance, and associated comorbidities. Standard radiological assessment was performed using posteroanterior and lateral wrist radiographs, and fractures were classified based on the AO/OTA classification system. Pre-operative baseline functional status was assessed using grip strength, range of motion measurements, and patient-reported pain scores. Surgical planning and implant selection were executed according to the three-column fixation concept to achieve anatomical reduction and biomechanical stability.

Surgical procedures were performed under anesthesia by experienced orthopedic surgeons. Fixation techniques involved stabilization of the radial, intermediate, and ulnar columns utilizing volar locking plates, K-wires, or supplementary implants as deemed necessary. Intraoperative fluoroscopy was used to confirm adequacy of reduction and fixation, and postoperative immobilization was standardized. Patients received postoperative analgesia, antibiotic prophylaxis, and physiotherapy protocols emphasizing early wrist mobilization to minimize stiffness and optimize recovery.

All patients were followed up at regular intervals at 6 weeks, 3 months, and 6 months postoperatively. Follow-up evaluation included radiological assessment for fracture union, maintenance of reduction, and evidence of arthritic changes. Functional outcomes were assessed using grip strength, wrist range of motion, and the Disabilities of the Arm, Shoulder, and Hand (DASH) score. Complications such as infection, implant failure, complex regional pain syndrome, and malunion were documented. Data were compiled and analyzed using appropriate statistical tests, and results were interpreted with a sample size of 50 patients.

Results:

TABLE A. DEMOGRAPHIC AND INJURY CHARACTERISTICS (n = 50)

Variable	Category	n	%
Age (years)	18–30	8	16.0
	31–40	10	20.0
	41–50	14	28.0
	51–60	12	24.0
	>60	6	12.0
Gender	Male	32	64.0
	Female	18	36.0
Mode of Injury	FOOSH	24	48.0
	RTA	22	44.0
	Others/Assault	4	8.0
Side	Right	30	60.0
	Left	20	40.0
Fracture Type	Extra-articular	18	36.0
	Partial Articular	14	28.0
	Complete Articular	18	36.0

Middle-aged male patients with FOOSH-related right-sided injuries constituted the predominant cohort.

TABLE B. PRE- AND POSTOPERATIVE PAIN & FUNCTIONAL RECOVERY (n = 50)

Parameter	Preoperative	Postoperative (3 months)	Test	p-value
Mean VAS Score	8.9 ± 0.8	1.9 ± 1.1	Paired t-test	<0.001 (Significant)
ROM Flexion (°)	–	62 ± 8	–	–
ROM Extension (°)	–	58 ± 7	–	–
ROM Supination (°)	–	72 ± 6	–	–
ROM Pronation (°)	–	75 ± 5	–	–
Radial Deviation (°)	–	16 ± 3	–	–
Ulnar Deviation (°)	–	28 ± 4	–	–

Significant pain improvement with acceptable functional ROM restoration at 3 months.

TABLE C. COMPLICATIONS AND RADIOLOGICAL OUTCOME (n = 50)

Outcome Variable	Category	n	%
Time to Union	<8 weeks	20	40.0
	8–10 weeks	24	48.0
	>10 weeks	6	12.0
Postoperative Swelling (2 weeks)	Mild	34	68.0
	Moderate	12	24.0
	Severe	4	8.0
Complications	None	42	84.0
	Stiffness	4	8.0
	Superficial Infection	3	6.0
	Implant Irritation	1	2.0

Union was satisfactory with low complication rates and mild soft tissue response in most patients.

TABLE D. FUNCTIONAL OUTCOME CLASSIFICATION (n = 50)

Outcome Measure	Category	n	%	Significance
Functional Outcome (ROM-based)	Excellent	22	44.0	–
	Good	18	36.0	–
	Fair	8	16.0	–
	Poor	2	4.0	–
Overall Outcome	Satisfactory (Excellent+Good)	40	80.0	χ^2 test
	Unsatisfactory (Fair+Poor)	10	20.0	$p < 0.05$ (Significant)

Overall satisfactory outcome in 80% of cases with statistically favorable results.

Discussion:

The present study evaluated the clinical and functional outcomes of three-column fixation in distal end radius fractures in a cohort of 50 patients. The demographic profile indicated that middle-aged individuals formed the predominant group, with the highest proportion in the 41–50 years age group, followed by the 51–60 years group. A male predominance was noted, consistent with occupational exposure and higher participation in outdoor activities, which increases the likelihood of high-energy trauma. Falls on an outstretched hand constituted the most common mode of injury, aligning with the well-recognized biomechanical mechanism responsible for distal radius fractures, whereas road traffic accidents accounted for a substantial minority of cases, typically involving younger patients and higher energy impact.

Radiological classification revealed a nearly equal distribution between extra-articular and complete articular fractures, highlighting the complex spectrum of injury in distal radius pathology. The presence of articular involvement in a considerable percentage of participants underscores the need for fixation strategies capable

of restoring joint congruity and maintaining long-term wrist biomechanics. In this context, three-column fixation addresses the radial, intermediate, and ulnar columns to optimize stability, which is particularly relevant in multi-fragmented or unstable fracture patterns. (9,10,11)

Preoperative pain scores were uniformly high, indicating significant functional impairment before intervention. A statistically significant reduction in pain was observed at three months postoperatively, demonstrating the efficacy of surgical fixation in alleviating symptomatic burden. Restoration of wrist motion was favorable across all assessed planes, including flexion, extension, pronation, and supination, reflecting satisfactory rehabilitation and effective fixation. The high proportion of patients achieving excellent to good functional outcomes (80%) further supports the biomechanical rationale for three-column fixation, which aims to restore normal load-bearing and articular dynamics. (12,13)

Radiological union was achieved in the majority of patients within 8–10 weeks, consistent with normal fracture healing timelines for distal radius fractures following stable fixation. Early mobilization, enabled by the inherent stability of this fixation construct, likely contributed to reduced stiffness, which was the most commonly observed complication. The overall complication rate was low, with only a small number of patients developing superficial infection or implant irritation, suggesting that the procedure is relatively safe and associated with minimal morbidity when performed with standardized protocols. (14)

The findings of this study are in concordance with the observations reported by Rikli and Regazzoni, who emphasized the importance of addressing all three anatomical columns to optimize wrist biomechanics and functional recovery. Similar studies examining volar plate fixation have demonstrated improvements in radiological alignment and functional scores; however, conventional volar plating alone may not adequately address articular fragments or intermediate column displacement in complex fractures. The present study reinforces the value of adopting a column-based fixation strategy, particularly in intra-articular and unstable distal radius fractures.

Conclusion:

Overall, the results indicate that three-column fixation offers excellent pain relief, satisfactory radiological healing, and favorable functional outcomes with low complication rates. Given the increasing prevalence of distal end radius fractures in both younger and elderly populations, this fixation technique represents a viable and effective option for managing complex patterns. Future studies with larger sample sizes, longer follow-up periods, and comparative analyses against other fixation modalities may provide additional insight into long-term outcomes and potential benefits in preventing post-traumatic osteoarthritis.

References:

1. Conti Mica M A, Bindra R, Moran S L. Anatomic considerations when performing the modified Henry approach for exposure of distal radius fractures. J Orthop. 2016;14(01):104–107.
2. Walenkamp M M, Aydin S, Mulders M A, Goslings J C, Schep N W. Predictors of unstable distal radius fractures: a systematic review and meta-analysis. J Hand Surg Eur Vol. 2016;41(05):501–515.

3. Shehovych A, Salar O, Meyer C, Ford D J. Adult distal radius fractures classification systems: essential clinical knowledge or abstract memory testing? Ann R Coll Surg Engl. 2016;98(08):525–531.
4. Hruby L A, Haider T, Laggner R.Standard radiographic assessments of distal radius fractures miss involvement of the distal radioulnar joint: a diagnostic study Arch Orthop Trauma Surg 2021(e-pub ahead of print).
5. He B, Tian X, Ji G, Han A. Comparison of outcomes between nonsurgical and surgical treatment of distal radius fracture: a systematic review update and meta-analysis. Arch Orthop Trauma Surg. 2020;140(08):1143–1153.
6. Walenkamp M, Aydin S, Mulders M, Goslings J, Schep N. Predictors of unstable distal radius fractures: a systematic review and metaanalysis.. J Hand Surg Eur. 2016;41(05):501–515.
7. Leixnering M, Rosenauer R, Pezzei C. Indications, surgical approach, reduction, and stabilization techniques of distal radius fractures. Arch Orthop Trauma Surg. 2020;140(05):611–621.
8. Alluri R K, Hill J R, Ghiassi A. Distal radius fractures: approaches, indications, and techniques. J Hand Surg Am. 2016;41(08):845–854.
9. Disseldorp D J, Hannemann P F, Poeze M, Brink P R. Dorsal or volar plate fixation of the distal radius: does the complication rate help us to choose? J Wrist Surg. 2016;5(03):202–210.
10. Kumar S, Khan A N, Sonanis S V. Radiographic and functional evaluation of low profile dorsal versus volar plating for distal radius fractures. J Orthop. 2016;13(04):376–382.
11. Erhart S, Toth S, Kaiser P, Kastenberger T, Deml C, Arora R. Comparison of volarly and dorsally displaced distal radius fracture treated by volar locking plate fixation. Arch Orthop Trauma Surg. 2018;138(06):879–885.
12. Rosenauer R, Pezzei C, Quadlbauer S. Complications after operatively treated distal radius fractures. Arch Orthop Trauma Surg. 2020;140(05):665–673.
13. Jones C, Beredjiklian P, Matzon J L, Kim N, Lutsky K. Incidence of an anomalous course of the palmar cutaneous branch of the median nerve during volar plate fixation of distal radius fractures. J Hand Surg Am. 2016;41(08):841–844.
14. O'Shaughnessy M A, Shin A Y, Kakar S. Stabilization of volar ulnar rim fractures of the distal radius: current techniques and review of the literature. J Wrist Surg. 2016;5(02):113–119.