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Original Research Article

A Prospective Study of Maintenance of Reduction in Displaced Distal end Radius Fracture Fixed with Distal Volar Locking Plate in Elderly Patients with Clinical and Radiological Outcome Evaluation

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Conflict of interest: Nil

Abstract:

Background: Distal radius fractures (DRFs) are common orthopedic injuries in elderly patients, with volar locking plate (VLP) fixation emerging as preferred treatment for unstable intra-articular patterns. Limited Indian data exists on elderly outcomes.

Methods: This prospective observational study evaluated 36 patients (>50 years) with intra-articular DRFs treated with VLP fixation at Metro Heart Institute, Faridabad (18-month duration). Frykman classification assessed fracture patterns; Sarmiento score evaluated radiological outcomes (palmar tilt, radial shortening, inclination); Mayo Wrist Score (MWS) measured functional recovery. Follow-up occurred at 6 weeks, 3 months, and 6 months. Statistical analysis used paired t-tests (SPSS v24.0).

Results: Mean age was 65.5 years (53% aged 61–80); males predominated (58%). Frykman type 3 (44%) and 4 (33%) were common; 94% operated within 2 days. Radiological outcomes: excellent Sarmiento grades in 92% immediately post-op, stabilizing at 86% by 6 months (palmar tilt 0.4°→1.1°; shortening 1.5→2.1 mm). MWS improved significantly from 89.3±8.1 (6 weeks) to 91.3±6.6 (6 months; $p<0.05$), with 72% excellent at final follow-up. Complications were minimal (8%): carpal tunnel (6%), CRPS (3%).

Conclusion: VLP fixation provides excellent radiological stability and functional recovery in elderly intra-articular DRFs, with low complication rates comparable to younger cohorts. Prompt surgery and standardized rehabilitation optimize outcomes in osteoporosis-prone Indian populations. Multicenter RCTs are recommended for broader validation.

Keywords: Distal radius fracture, volar locking plate, elderly, Mayo Wrist Score, Sarmiento score, intra-articular.

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Introduction

Distal radius fractures are one of the most common injuries encountered in orthopedic practice. They make up 8%−15% of all bony injuries in adults. [1] Colles' fracture specifically is defined as metaphyseal injury of cortico-cancellous junction (within 2−3 cm of articular surface) of the distal radius. Smith's fractures, also referred to as reverse Colles' fracture, have palmar tilt of the distal fragment. Barton's fracture is the displaced intra articular coronal plane fracture-subluxation of dorsal lip of the distal radius with displacement of carpus with the fragment. Chauffer's fracture is an intra-articular fracture of radial styloid. The articular surface of the distal aspect of the radius tilts 21 degrees in the antero posterior plane and 5 to 11 degrees in the lateral plane. [2] The dorsal cortical surface of radius thickens to form the Lister tubercle as well as osseous prominences that support the extensors of the wrist in second dorsal compartment. A central ridge divides the articular surface of the radius into a scaphoid facet and a lunate facet. The triangular fibrocartilage extends from the rim of the sigmoid notch of the radius to the ulnar styloid process. Only the brachioradialis tendon inserts onto the distal aspect of the radius; the other tendons of the wrist pass across the distal aspect of the radius to insert onto the carpal bones or the bases of the metacarpals. Most of the fractures are caused by a fall on the outstretched hand with the wrist in dorsiflexion. Pronation, supination and abduction determine the direction of the force and the compression of carpus and different appearances of ligamentary injuries. The radius initially fails in tension on the volar aspect, with the fracture

progressing dorsally where bending forces induce compressive stresses, resulting in dorsal comminution. Cancellous impaction of the metaphysis further compromises dorsal stability. Additional shearing forces influence the injury pattern, resulting in articular surface involvement. [3] Earliest classification was made during 1930s, by Nissenlie, Gartland & Werley in 1951 and Lindstorm in 1959 developed systems of classification that were based on the presence of, not extent of, displacement at the site of fracture and involvement of radio-carpal joint. Frykman established a system of classification that identified involvement of radio ulnar and radio-carpal joints along with the presence or absence of the fracture of ulnar styloid process. [1] There are various techniques for management of distal radius fractures including close reduction & cast immobilization, percutaneous Kirschner wire pinning, screw fixation, external fixation, and internal fixation using a plate. Close reduction often leads to malunion and dislocation of DRUJ, hence resulting in poor functional, radiographic outcome. Of those, open reduction and internal fixation (ORIF), allowing for anatomic reduction of the fractured distal radius bone, has been closely associated with better clinical outcomes and functional recovery. [4] ORIF using a volar locking plate (VLP) has been proved to provide good functional outcomes and to be cost-effective for both intra-articular and extra-articular DRFs. In the elderly, volar locking plate fixation (VLPF) also seems to be a safe and effective procedure that facilitates early recovery of hand and wrist functions, and it leads to a similar complication rate to that from younger patients. [5] There are limited studies from India which have assessed the efficacy of volar locking plates in the management of distal radius fracture among elderly patients. Thus, the aim of the study was to prospectively evaluate the maintenance of reduction in distal radius fractures of elderly patients treated by volar-locking plate along with clinical & radiological outcome.

Methodology

Study Design: This was a prospective observational study conducted to evaluate clinical and radiological outcomes in patients with intra-articular distal radius fractures.

Study Duration: The study was conducted over a period of 18 months.

Study Site: The study was carried out in the Department of Orthopedics, Metro Heart Institute with Multispeciality, Faridabad, Haryana.

Study Population: The study population consisted of patients presenting with intra-articular distal radius fractures.

Inclusion Criteria

1. Patients with clinically and radiologically confirmed distal radius fractures with or without associated ulnar styloid fractures.
2. Patients aged more than 50 years.
3. Patients who could understand the nature and purpose of the study, and who gave informed written consent to participate throughout the study period.
4. Patients who were mentally alert and medically fit for surgery.

Exclusion Criteria

1. Nondisplaced distal radius fractures.
2. Previous wrist fractures on either side.
3. Open fractures.
4. Bilateral distal radius fractures.
5. Pathological or malignant fractures.
6. Patients lost to follow-up.

Sample Size and Sampling Technique: The estimated sample size was 30 patients, assuming a 95% confidence level and a prevalence of 13% for distal radius fractures. The sample size was calculated using the formula:

$$n = \frac{Z^2 \times p(1-p)}{e^2}$$

where:
n= required sample size

Z= Z-score (1.96 for 95% confidence level)

p= estimated prevalence (13%)

e= margin of error (12%)

Substituting these values:

$$n = (1.96)^2 \times 0.13(1-0.13)/(0.12)^2 = 30.17$$

Thus, a sample size of 30 patients was included in the study. All consecutive patients meeting inclusion criteria during the study period were enrolled.

Treatment Details: After obtaining detailed informed and written consent, all surgeries were performed under regional block or general anesthesia. The patient was placed supine on the orthopedic table with a radiolucent side table for imaging access. Dissection was done using the standard FCR approach. Open reduction and internal fixation (ORIF) were performed using a volar locking plate of appropriate size as per fracture pattern. Reduction and hardware placement were confirmed intraoperatively under fluoroscopy. A below-elbow POP slab was applied postoperatively for 14 days to provide pain relief and immobilization. All patients received broad-spectrum intravenous antibiotics for at least one day, followed by oral antibiotics until suture removal.

Postoperative radiographs (AP and lateral views of the wrist) were taken on the first postoperative day. Physiotherapy for fingers, elbow, and shoulder was initiated early. The first dressing was changed within 48 hours. Sutures were removed on the 14th postoperative day. Gentle wrist mobilization was started after suture removal, depending on patient tolerance and compliance. Patients were discharged with advice to continue active wrist and finger exercises, along with grip-strengthening physiotherapy.

Data Collection

Data were collected using a pre-designed semi-structured proforma.

1. Clinical Assessment: A general examination was carried out for all patients, including local and systemic examination of the skeletal system, soft-tissue injuries, and neurovascular status.
2. Radiological Assessment:
    - Pre- and postoperative X-rays (PA and lateral views) of both wrists were obtained.
    - Fractures were classified according to the Frykman classification.
3. Outcome Measures:
    - Clinical outcome was assessed using the Mayo Wrist Score.
    - Radiological outcome was evaluated using the Sarmiento Score based on the following parameters:
        - Radial length: Normal ≈ 11 mm (8–18 mm)
        - Palmar angulation: Normal ≈ 11° (0–28°)
        - Radial inclination: Normal ≈ 23° (13–30°)
        - Radioulnar variance: Normal ≈ –0.9 mm (–4.2 to +2.3 mm)

Grading under Sarmiento Score:

Outcome	Loss of Palmar Tilt	Loss of Radial Deviation	Radial Shortening
Excellent	< 0°	< 3 mm	—
Good	1–10°	3–6 mm	< 4 mm
Fair	5–9°	11–14°	7–11 mm
Poor	≥10°	>15°	>12 mm

4. Follow-up:
    - Patients were followed up at 6 weeks, 3 months, and 6 months postoperatively.
    - Clinical union was defined as the absence of tenderness, pain, or instability with restoration of wrist function.
    - Radiological union was defined as the disappearance of the fracture line on X-ray.

Statistical Analysis: All data were analyzed using SPSS software version 24.0. Quantitative variables were expressed as mean ± standard deviation (SD). While categorical variables were expressed as frequency and percentage. Paired t-test was applied to compare the mean Mayo Wrist Scores at different follow-up intervals. A p-value < 0.05 was considered statistically significant.

Ethical Considerations: The study protocol adhered to the Declaration of Helsinki (2013 revised version) and received approval from the Institutional Ethics Committee prior to commencement. Written informed consent was obtained from all participants after explaining study objectives, procedures, and potential risks. Patients were not subjected to any additional financial burden or risk beyond standard care.

Results

Demographic and injury profile: In this study, a total of 36 patients with distal radius fractures were evaluated, with the majority belonging to the elderly age group; 53% of patients were between 61 and 80 years, 39% were 50–60 years, and 8% were older than 80 years, highlighting that distal radius fractures are particularly common in older adults. There was a male predominance, with males constituting 58% of the cohort and females 42%. The right wrist was more frequently involved than the left, accounting for 61% and 39% of cases respectively, which may reflect handedness and typical fall mechanics, although left-sided predominance is reported in some larger epidemiological series. Most patients (83%) did not sustain any additional injuries, while a minority presented with associated trauma, including fracture shaft femur in 8%, contusional head injury in 6%, and distal third ulna fracture in 3%, indicating that high-energy or multi-trauma mechanisms were less common in this series. With respect to the mechanism of injury, low-energy falls predominated: 58% of fractures resulted from a fall from standing height and 42% from road traffic accidents, consistent with the recognized pattern of distal radius fractures in the elderly, where osteoporosis, poor balance, and simple falls are major contributors.

Fracture pattern and timing of surgery

- According to Frykman classification, type 3 fractures were most common (44%), followed

by type 4 (33%), type 5 (8%), type 7 (8%), and type 8 (6%).
- Surgery was performed predominantly within 2 days of injury: 36% operated on day 1, 58% on day 2, and only 3% each on days 3 and 4.

Radiological outcomes (Sarmiento score parameters)

- Mean palmar tilt was 0.4° immediately post-op and 1.1° at 6 weeks, 3 months, and 6 months, showing minimal change over time.
- Mean radial shortening increased from 1.5 mm immediately post-op to 2.4 mm at 6 weeks, then slightly decreased to 2.3 mm at 3 months and 2.1 mm at 6 months.
- Mean loss of radial deviation rose slightly from 3.1° immediately post-op to 3.5–3.6° at subsequent follow-ups up to 6 months.
- On Sarmiento grading, excellent radiological results were seen in 92% immediately post-op and in 86% at 6 weeks, 3 months, and 6 months; good results in 8% at all time points; fair results appeared in 6% from 6 weeks onward; no poor results were recorded.

Functional outcomes (Mayo Wrist Score)

Mean Mayo Wrist Score was 89.3 ± 8.1 at 6 weeks, 90.5 ± 6.6 at 3 months, and 91.3 ± 6.6 at 6 months, indicating progressive functional improvement over time. The improvement between 6 weeks and 6 months was statistically significant ($p < 0.05$).

Table 1: Comparison of Mayo score at different follow ups

Follow up	Mayo score	p value
6 weeks post op	89.3 ± 8.1	Reference value
3 months post op	90.5 ± 6.6	0.16
6 months post op	91.3 ± 6.6	<0.05

At 6 weeks, 56% of patients had excellent, 33% good, and 11% fair functional outcomes; by 3 and 6 months, 72% had excellent, 22% good, and 6% fair results, with no poor outcomes at any follow-up.

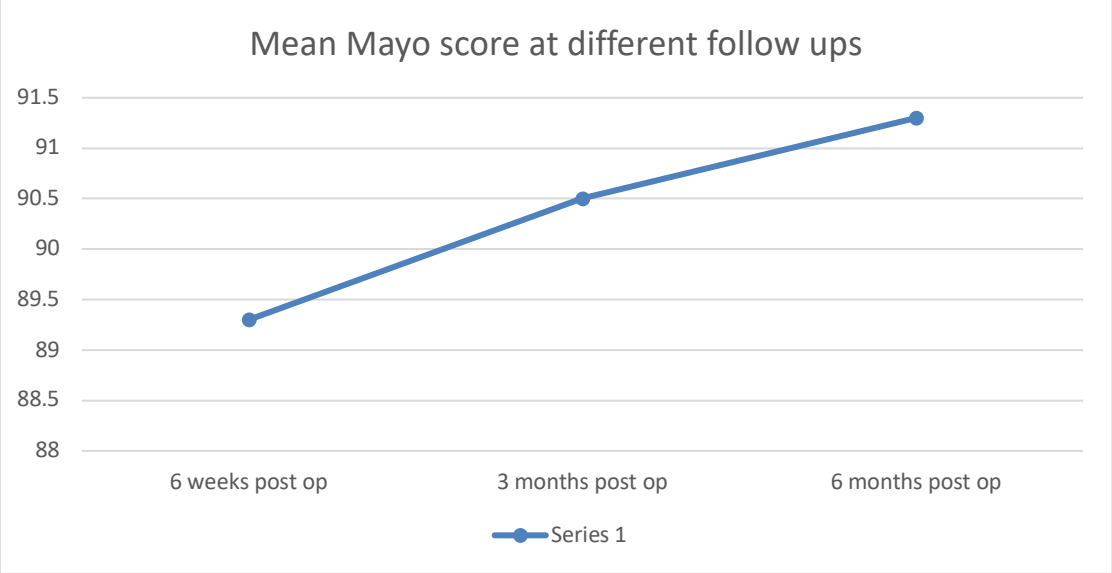

Figure: Mean mayo score at different follow ups

These functional results are comparable to other series using volar locking plates for distal radius fractures, which also report predominantly excellent and good outcomes.

Table 2: post operative complications among patients

Post operative complications	Frequency	Percentage
Carpal tunnel	2	6%
Complex Regional Pain Syndrome	1	3%
None	33	92%
Total	36	100%

Postoperative complications were infrequent: 92% had no complications. Carpal tunnel syndrome occurred in 6% and complex regional pain syndrome in 3% of patients, rates similar to those reported in contemporary distal radius fracture literature.

Discussion

Distal radius fractures (DRFs) represent a significant burden in orthopedic practice, particularly among elderly patients where osteoporosis and low-energy falls contribute to higher incidence rates. [6] This prospective observational study evaluated the clinical and radiological outcomes of volar locking plate (VLP) fixation for intra-articular DRFs in 36 patients aged over 50 years, predominantly elderly (53% aged 61–80 years). Our findings demonstrate excellent radiological maintenance with Sarmiento excellent outcomes in 86–92% of cases and progressive functional recovery, evidenced by mean Mayo Wrist Scores (MWS) improving from 89.3 ± 8.1 at 6 weeks to 91.3 ± 6.6 at 6 months ($p < 0.05$). These results underscore the efficacy of VLP in achieving anatomic reduction and early mobilization, aligning with contemporary literature while addressing gaps in Indian elderly cohorts.

Demographically, our cohort showed male predominance (58%) and right-sided involvement (61%), contrasting with some Western series reporting female skew due to postmenopausal osteoporosis. [7] However, similar male bias has been noted in Indian populations, possibly linked to occupational trauma. [8] Falls from standing height (58%) as the primary mechanism mirrors global elderly patterns, where osteoporosis amplifies low-energy injury risk. [9] Frykman type 3 (44%) and 4 (33%) fractures predominated, reflecting extra-articular and simple intra-articular patterns amenable to VLP; higher types (5–8) were less common (22%), consistent with conservative selection for unstable intra-articular cases. [10] Prompt surgery (94% within 2 days) likely contributed to superior initial reduction, as delays beyond 72 hours correlate with poorer alignment in elderly bone. [11]

Radiologically, minimal loss of palmar tilt (0.4° to 1.1°) and stable radial shortening (1.5–2.1 mm) translated to sustained excellent/good Sarmiento grades, comparable to variable-angle VLP studies reporting volar tilt restoration within 2° and shortening <3 mm at 6–12 months. (12,13) In a Malaysian cohort of 60 unstable DRFs, variable-angle plates achieved superior tilt (mean 8.2°) versus fixed-angle (5.1°), with 85% excellent radiological outcomes—mirroring our 86–92% despite fixed-plate use. [12] Sarmiento's criteria emphasize acceptable parameters (<11° tilt loss, <7 mm shortening), which our series maintained, supporting VLP's superiority over non-operative casting where volar tilt loss exceeds 10° in 40–50% of elderly cases. [14] No poor radiological results affirm hardware stability in osteoporotic bone, aided by locking technology.

Functionally, MWS progression to 91.3 (72% excellent at 6 months) indicates robust recovery, with statistical significance underscoring time-dependent gains. This aligns with a Japanese study of 32 elderly patients (mean age 74 years) post-VLP, where MWS reached 90+ by 24 months, though grip strength lagged range of motion. [15] Our earlier peak (6 months) likely reflects aggressive physiotherapy post-suture removal. Compared to conservative management in Frykman 7–8 fractures, VLP yielded equivalent Quick DASH but superior volar tilt ($p=0.02$), favoring surgery for active elderly. [10] Indian series report MWS 85–92 for VLP in mixed-age DRFs, validating our elderly-specific outcomes. [16] non-operative arms in randomized trials show 10–15-point lower MWS deficits, reinforcing ORIF benefits. [4]

Complication rates were low (8%), with carpal tunnel syndrome (CTS, 6%) and complex regional pain syndrome (CRPS, 3%)—no tendon ruptures or hardware failures. This is favourable versus systematic reviews pooling 17,288 VLP cases (13.5% overall complications; CTS 2%, tendinopathy 1.4%). [17] Arora et al.'s randomized trial (VLP vs. cast) noted 13% operative issues (2.8% CTS), akin to ours. [4] Elderly-specific data confirm comparable reoperation (8.5%) to youth, with patient-requested removal predominant. [11,17] Our FCR approach and fluoroscopic confirmation minimized flexor pollicis longus irritation, a pitfall in 5–10% of proximal plates. [18]

Limitations include modest sample (36 vs. ideal 80+ for subgroup analysis), single-center design, and short follow-up (6 months), potentially underestimating late arthritis. [15] Frykman classification, while useful, overlooks comminution quantified by AO/OTA. [19] Nonetheless, consecutive enrolment and standardized scoring enhance internal validity. Compared to Indian paucity, [15] our study fills elderly VLP data voids, advocating its use for fit seniors >50 years.

In conclusion, VLP fixation yields excellent radiological stability and functional restoration in elderly intra-articular DRFs, with low complications mirroring international benchmarks. [11,12,15] For osteoporosis-prone Indians, it facilitates early rehabilitation, reducing socioeconomic morbidity. Future multicentre RCTs with longer follow-up and cost-analyses are warranted to optimize indications versus casting in frail subsets. [10,14]

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