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Original Research Article

A PROSPECTIVE OBSERVATIONAL STUDY TO ASSESS THE FUNCTIONAL OUTCOME OF INTRA-ARTICULAR DISTAL RADIUS FRACTURES TREATED WITH VOLAR LOCKING COMPRESSION PLATE

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ABSTRACT

Background: Distal radius fractures are best managed with volar locking plates, which provide stable fixation and allow early mobilisation. Locking plates offer superior stability, especially in osteoporotic or comminuted fractures, by minimising screw toggle. This study assessed functional and radiological outcomes of intra-articular distal radius fractures treated with volar LCP, using Sarmiento's and Gartland-Werley criteria. **Materials and Methods:** This prospective observational study was conducted on 28 patients at the Southern Railways Headquarters Hospital, Chennai. All surgeries were performed using the Modified Henry approach for volar access, with fracture reduction and fixation achieved using a volar locking plate under C-arm guidance. Postoperatively, early finger mobilisation, short-term immobilisation, and progressive wrist exercises were implemented, with follow-ups up to 12 months. **Result:** Males (19; 68%) and right-sided fractures (19; 68%) predominated, with falls being the most common injury mechanism (16; 57%). The majority of fractures were AO type 2R3C2 (11; 39.2%). Most patients (23; 82.14%) underwent surgery within 1–5 days, with fracture union achieved within 2–3 months in 24 (85.71%) cases. Complications were minimal, with one case each of CRPS (1; 3.57%) and reduced range of motion (1; 3.57%). Over 89% (25–27 patients) regained near-normal wrist movements, and 26 (92.85%) maintained grip strength above 60% of the opposite side. Functional outcomes were predominantly good to excellent, with 26 (92.85%) by Gartland and Werley scoring and 27 (96.43%) by Sarmiento's criteria. **Conclusion:** Volar LCP ensure stable fixation, accurate alignment, and early mobilisation in distal radius fractures, offering excellent outcomes, faster recovery, improved function, and reliable rehabilitation.

INTRODUCTION

Distal radius fractures account for 14% of all extremity fractures and 17% of all fractures treated in the emergency department.[1] They can significantly affect wrist function, grip strength, and overall quality of life, leading to prolonged disability and loss of productivity. Hence, achieving anatomical reduction and early mobilisation is essential for restoring function and preventing long-term complications.[2] Previously, distal radius fractures were managed with closed reduction and casting, although malunion was frequent. Techniques such as pin and plaster, external fixation, and conventional plating have improved outcomes but have lacked precise reduction. Volar locking plate fixation is now preferred, offering stable fixation, maintained alignment, and early wrist motion.[3,4]

Conventional plates rely on bone compression using bicortical screws, making fixation dependent on bone quality. In contrast, fixed-angle locking plates provide stable support to the subchondral bone and resist axial forces, even in osteoporotic or comminuted fractures. They do not require full bone contact, preserving periosteal blood flow.[5] The Locking Compression Plate (LCP) with combi holes allows both axial compression and locking fixation,

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functioning as a compression plate, a locked internal fixator, or a combination, depending on clinical needs.[6]

Locked volar plates are increasingly used for distal radius fractures because of their strong fixation, especially in osteoporotic bones. The volar approach avoids extensive dorsal dissection, and placing the plate beneath the pronator quadratus minimises flexor tendon irritation. Volar scars are better tolerated than dorsal scars. The use of 3.5 mm cortical screws with locking screws enhances stability, reduces screw toggling and loss of reduction, and promotes better bone healing. The rigid fixation achieved with locking plates is considered crucial for successful fracture management.[7,8]

Several studies have shown favourable short-term outcomes with volar locking compression plates, data on long-term radiological and functional correlations remain limited, particularly in the Indian population. Variations in fracture patterns, bone quality, and postoperative rehabilitation may influence the recovery process. Therefore, further research is needed to evaluate the effectiveness of volar LCP fixation over a longer follow-up period.

The present study aimed to evaluate the functional, radiological, and patient-reported outcomes of intra-articular distal radius fractures treated with volar locking compression plates (LCP) 12 months post-surgery. Functional recovery was assessed through range of motion (ROM) and grip strength, radiographic healing using Sarmiento's modification of Lindstrom's criteria, and patient-reported outcomes using the Gartland and Werley scoring system.

MATERIALS AND METHODS

This prospective observational study was conducted on 28 patients who presented with Distal Radius Intra-articular fractures at the Department of Orthopaedics, Southern Railways Headquarters Hospital, Perambur, Chennai-23. The study was approved by the Institutional Ethics Committee (HQ/MD/156/1/EC/PAT). Written informed consent was obtained from all patients before inclusion.

Inclusion Criteria

Patients aged > 18 years and admitted with an intra-articular distal radius fracture were included.

Exclusion Criteria

Patients with open fractures, associated fractures or dislocations in the ipsilateral limb, fractures accompanied by neurovascular injury, pathological fractures, and extra-articular fractures of the lower end of the radius were excluded.

Methods: All surgeries were performed under aseptic conditions. The wrist was prepared using Betadine and draped. The patients were positioned supine, with the wrist in a neutral position on a rolled towel to facilitate exposure. A Modified Henry approach was used, utilising the interval between the flexor carpi radialis (FCR) tendon and the radial artery. A longitudinal incision was made along the radial border of the FCR tendon, avoiding a perpendicular crossing of the wrist crease. The FCR sheath was opened, and the tendon was retracted to the ulnar side. Dissection was performed between the flexor pollicis longus (FPL) tendon and the radial artery, with the FPL belly swept to the ulnar side.

An L-shaped incision was made over the pronator quadratus to expose the distal radius, taking care to protect the sensory branches of the median nerve and radial artery. The pronator quadratus was elevated and retracted to visualise the fracture site. Fracture fragments were anatomically reduced under direct vision, and depressed lunate fragments were elevated using a small osteotome. A volar locking plate was placed proximal to the watershed line (approximately 2 mm from the radiocarpal joint surface) and temporarily fixed with K-wires under C-arm guidance to the distal fragment. Once satisfactory alignment was confirmed on the AP, lateral, and oblique views, screws were inserted, keeping the distal screws 2 mm below the joint line and short of the dorsal cortex to avoid tendon irritation. After achieving haemostasis, the wound was closed in layers, with the pronator quadratus reattached, where possible, to cover the plate. A sterile dressing was then applied.

Postoperative care: The limb was elevated postoperatively, and active finger movement was encouraged. Intravenous antibiotics were administered for two days. The wrist was immobilised in a short arm plaster cast until suture removal, after which gentle wrist mobilisation was initiated. Resistance exercises were initiated at six weeks. Patients were reviewed at 4, 8, and 12 weeks, and subsequently at 3, 6, and 12 months postoperatively. Radiographs were obtained at each visit to assess the healing process. Six-pack exercises (Dobyns and Linscheid) were initiated early to maintain muscle strength. Clinical and radiological outcomes were assessed at 12 months using Sarmiento's modification of Lindstrom's criteria, and functional evaluation was performed using the Gartland and Werley Demerit Point System. Data are presented as frequency and percentage.

RESULTS

Males (68%) were more commonly affected than females (32%). The right side was more frequently involved (68%) than the left side (32%). The most common mode of injury was a fall (57%), followed by road traffic accidents (43%). According to the AO classification, type 2R3C2 fractures were the most prevalent (39.2%), followed by 2R3C1 (21.42%), while 2R3B3 fractures were the least common (3.57%) [Table 1].

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Table 1: Demographic and injury profile

Parameter	Variable	N (%)
Gender	Male	19 (68%)
	Female	9 (32%)
Involved side	Right	19 (68%)
	Left	9 (32%)
Mode of injury	Road Traffic Accident (RTA)	12 (43%)
	Fall	16 (57%)
Fracture type (AO classification)	2R3B1	4 (14.28%)
	2R3B2	3 (10.71%)
	2R3B3	1 (3.57%)
	2R3C1	6 (21.42%)
	2R3C2	11 (39.2%)
	2R3C3	3 (10.71%)

Most patients (82.14%) underwent surgery within 1-5 days of injury, while 17.85% had a waiting period of 6-15 days. Associated injuries were uncommon, with contralateral proximal humerus fractures observed in 7.14% of patients and head and intertrochanteric fractures observed in 3.57% of patients. Most patients achieved fracture union within 2-3 months (85.71%), and a smaller proportion within 3-4 months (14.28%). Complications were minimal, with one case each of Complex Regional Pain Syndrome (CRPS) (3.57%) and reduced ROM (3.57%) [Table 2].

Table 2: Surgical timing, associated injuries, union, and complications

Parameter	Variable	N (%)
Surgical waiting period	1–5 days	23 (82.14%)
	6–15 days	5 (17.85%)
Associated injuries	Contralateral proximal humerus fracture	2 (7.14%)
	Head injury	1 (3.57%)
	Intertrochanteric fracture	1 (3.57%)
Time to union	2–3 months	24 (85.71%)
	3–4 months	4 (14.28%)
Complications	Complex Regional Pain Syndrome (CRPS)	1 (3.57%)
	Reduced range of motion	1 (3.57%)

Most patients regained near-normal wrist function, with over 89% achieving satisfactory ranges of dorsiflexion, palmar flexion, pronation, supination, radial deviation, and ulnar deviation. A few patients reported pain in the distal radioulnar joint (10.71%) or reduced grip strength (7.14%), whereas 92.85% maintained grip strength exceeding 60% of the contralateral side. Based on the Gartland and Werley scoring, outcomes were predominantly good (64.28%) or excellent (28.57%), with only 7% rated as fair. In Sarmiento's Modification of the Lindstrom Criteria, 78.57% had excellent, 17.86% good, and 3.57% fair results [Table 3].

Table 3: Range of motion, symptoms, and functional outcomes

Parameter	Variable	N (%)
Range of movements (within normal functional range)	Dorsiflexion	26 (92.85%)
	Palmar flexion	26 (92.85%)
	Pronation	25 (89.28%)
	Supination	27 (96.42%)
	Radial deviation	26 (92.85%)
	Ulnar deviation	25 (89.28%)
Symptoms and strength	Pain in the distal radioulnar joint	3 (10.71%)
	Decreased grip strength	2 (7.14%)
	Grip strength > 60% of the opposite side	26 (92.85%)
Gartland and Werley Scoring	Good	18 (64.28%)
	Excellent	8 (28.57%)
	Fair	2 (7%)
Sarmiento's modification of the Lindstrom criteria	Excellent	22 (78.57%)
	Good	5 (17.86%)
	Fair	1 (3.57%)

DISCUSSION

This study aimed to evaluate the functional and radiological outcomes of intra-articular distal radius fractures treated with volar locking compression plates 12 months post-surgery. Among the patients, the majority achieved fracture union within 2–3 months and showed excellent functional recovery, with most regaining near-normal wrist motion and grip strength. Complications were minimal, with only isolated cases of reduced ROM and CRPS observed. In our study, the functional outcomes were the same as reports showing that volar LCP are effective in treating intra-articular distal radius fractures. Fowler

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and Ilyas observed around 92% recovery of forearm rotation within three months, while wrist flexion and extension improved up to one year.[9] Dillingham et al. also noted that most ROM recovery occurred during the first three months, followed by minimal change after one year.[10] In our series, one patient showed limited wrist motion, highlighting the importance of initial mobilisation, which was similarly in Lozano-Calderon et al. study.[11]

In the present study, 2 (7.14%) had reduced grip strength, and 1 (3.57%) showed a restricted ROM after surgery. Grip strength remains an important marker of recovery following volar locking plate fixation. Chung et al. reported grip strength recovery reaching 86% of the opposite side at 12 months, while Shimura et al. noted improvement to 84% within a year.[12,13] Our results are consistent with these observations, indicating that although VLP fixation gives good stability, complete repair of grip strength often requires time and structured rehabilitation.

The functional outcomes evaluated using the Gartland and Werley Scoring System showed that 64.28% of cases were excellent, 28.57% were good, and 7.14% were fair. Similarly, Arora et al. reported 31% excellent and 54% good outcomes, while Kilic et al. found 44.4% excellent and 44.4% good results.[14,15] Agarwala et al. observed 100% excellent outcomes.[16] In our study, patients with results had a near-normal range of motion and returned to daily activities early, whereas fair results were associated with mild pain and residual deformity, particularly during ulnar deviation.

In the present study, based on Sarmiento's Modification of the Lindstrom Criteria, 78.57% of patients had excellent, 17.86% had good, and 3.57% had fair radiological outcomes, indicating good success with volar LCP fixation. Kotian et al. reported good-to-excellent outcomes in 75% of patients.[17] Similarly, Pradeep et al. observed 70% excellent and 20% good outcomes in AO Type 23B3 fractures treated with VLPs.[18]

In our study, the right wrist was involved in 68% of cases, which is similar to the findings of Arora et al. and Agarwala et al., who reported right-sided involvement in 61% and 60% of patients, respectively.[14,16] Meena et al. also observed right-sided predominance in 60% of cases.[19] The frequent involvement of the dominant wrist may be related to its greater use in daily activities and higher contact to injury during falls.

In our study, 57% of fractures were caused by household falls and 43% by RTA. This is comparable to the findings of Arora et al., who reported 65% of fractures resulting from falls and 35% from RTA, and Agarwala et al., who observed 71% and 29%.[14,16] The higher occurrence of low-energy falls, especially in old patients, underlines the importance of fall prevention and maintaining good bone health.

According to the AO Classification, the majority of fractures in our study were C2 type (39.21%), representing complete articular multi-fragmentary fractures. In comparison, Arora et al. reported 39 cases of A2 fractures, 16 of A3, 24 of C1, 30 of C2, and 5 of C3.14 Similarly, Kilic et al. documented 3 cases of B2 fractures, 2 of B3, 2 of C1, 14 of C2, and 6 of C3.15 Anakwe et al. observed 4 cases of C1 fractures, 8 of C2, and 9 of C3.20 Agarwala et al. reported 2 cases of A1 fractures, 7 of A2, 10 of A3, 9 of B2, 4 of B3, and 2 cases each of C2 and C3 fractures.[16] Meena et al. identified 5 cases of A1 fractures, and 1 case each of A3, B2, B3, C1, and C2.19 Our profile is the same as these patterns, reflecting the predominance of complete articular multi-fragmentary fractures typically managed with volar plates.

In our study, fracture union occurred within 2–3 months in 85.71% of patients, while the remaining 14.28% achieved union within 3–4 months. Lal et al. reported a median union time of three months in patients treated with variable-angle volar LCP.[21] Agrawal et al. also documented union within 12 weeks in 90% of cases.[22] The similarity of these results indicates that VLP fixation provides stable fixation and promotes early fracture healing.

In our study, the complications were 7.14%, which included one case each of complex regional pain syndrome and reduced ROM. This rate was lower than Arora et al. reported (57%) and Kilic et al. (11.1%).[14,15] Anakwe et al. recorded a complication rate of 4.8%,20 while Agarwala et al. and Meena et al. reported 4% and 20%.[16,19] The lower rate observed in our study may be related to careful surgical method, stable fixation, and early rehabilitation, together help reduce postoperative stiffness and neurovascular issues.

Limitations

This single-centre study with a small sample size and short follow-up may limit the generalisability of its findings. The use of self-reported functional scores may have introduced subjective bias.

CONCLUSION

Volar LCP provides stable fixation, accurate anatomical restoration, and early mobilisation in intra-articular distal radius fractures. Most patients achieved excellent functional and radiological outcomes with minimal complications, supporting VLP fixation as an effective method for achieving early union, good wrist motion, and improved grip strength. This technique enables early rehabilitation and a quicker return to daily activities, making it a reliable option for complex distal radius fractures. Future studies with larger sample sizes and longer follow-ups are recommended to evaluate long-term functional recovery, the incidence of posttraumatic arthritis, and the cost-effectiveness of this fixation method compared with other fixation methods.

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