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Functional and radiological outcome of intra articular distal radius fractures treated with variable-angle locking plate

Ananthabalaram B.*, Aswinlal K. S., Asgar Ali Usman, Abdul Asraf V.

Department of Orthopaedics, MES Medical College, Perinthalmanna, Malappuram, Kerala, India

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***Correspondence:**
Dr. Ananthabalaram B.,
E-mail: anlalaswinlalks@gmail.com

ABSTRACT

Background: Intra-articular distal radius fractures are common injuries that require precise anatomical reduction to achieve optimal functional recovery. Variable-angle locking plates (VA-LCP) have been increasingly used due to their ability to stabilize periarticular fragments through polyaxial screw placement, potentially enhancing both radiological and clinical outcomes.
Methods: A prospective observational study was conducted among 85 patients with intra-articular distal radius fractures who underwent open reduction and internal fixation with VA-LCP at a tertiary care centre. Clinical and radiological assessments were performed at discharge, 4 weeks, and 6 months. Data were analysed using SPSS, with quantitative variables expressed as mean±SD and repeated-measures ANOVA applied for change over time.
Results: The mean age was 35.8 years, with males forming 72.9% of the cohort. Significant improvement was observed across all wrist movements ($p<0.001$), with ≥90% of normal range regained by 6 months. Mean Quick DASH score improved to 5.73, and MMWS increased to 92.59, with 76.5% achieving excellent functional outcomes. Radiological parameters were well maintained, and only 8.2% experienced minor complications.
Conclusions: VA-LCP provides stable fixation and results in excellent functional and radiological recovery for intra-articular distal radius fractures, with minimal complications.

Keywords: Distal radius fractures, Variable-angle locking plate, Functional outcome, Radiological outcome, Quick DASH, Modified mayo wrist score

INTRODUCTION

Distal radius fractures are the most common fractures in the whole body and constitute up to 15% of all fractures, out of which the intra-articular fractures account for approximately 25%. These fractures are the commonly seen in the elderly population, and the mode of injury may be low energy trauma. In young adults, high energy trauma such as the resulting from road traffic accidents accounts for a major number of the cases, the most of which are unstable. The most complicated fractures of the distal radius are the high energy, comminuted, intra-articular, and the unstable fractures. Treatment modalities for these fractures includes-plaster cast application, Kirschner wire fixation, external fixation, dorsal and volar plates. The main goals of treatment are maintaining normal anatomy and obtaining a functional joint. Maintenance of articular congruity, restoration of volar angulation, radial length, and radial inclination are essential for good functional outcomes at the wrist joint. There are many surgical procedures in the management of unstable distal radius fractures, but there is no gold standard treatment established in the literature so far.[1] As per Arbeitsgemeinschaftfür Osteosynthesefragen (AO) classification distal radius fractures classified as 2R3A1, 2R3A2, 2R3A3, 2R3B1, 2R3B2, 2R3B3, 2R3C1, 2R3C2

and 2R3C3. This study focuses on fixation of intra articular distal radius fractures classified under 2R3B1, 2R3B2, 2R3B3, 2R3C1 ,2R3C2 and 2R3C3 using a variable angle locking compression plate (VA-LCP). Locking volar plates bridge the bone mechanically and bear the load through the locking construct. But in comminuted distal end radius fractures the fracture line may extend distal to the volar rim. This type of fractures is often treated with volar fixed-angle locking compression plates (FA-LCP) but will require additional fixation methods. This is because the screws in the FA-LCP can be inserted only in a predefined direction and will not allow capturing of fracture segments in a comminuted intra-articular fracture. The FA-LCP does not allow any variability in the positioning of the plate also. So, this type of complex fractures can be managed in a better way with the use of a VA-LCP, which allows insertion of screws in many directions and thus captures the periarticular fragments.[1,2] The use of VA-LCP also helps in early rehabilitation and thus good functional outcome with low complication rates.[2,3] There is still controversy on the most optimal treatment method. Studies on operative management of distal end radius fractures treated with FA-LCP are already done by many, but the studies regarding the functional and radiological outcomes in patients treated with VA-LCP is very low in number. Khatri et al department of orthopedics, GGS Medical college, Faridkot, India conducted a study in 2019 to evaluate the functional and radiological outcomes in unstable distal radial fractures treated with VA-LCP. 23 unstable distal end radius fractures treated at their institution with volar variable angle locking plates were reviewed. Radiological parameters such as radial inclination, length, tilt, and ulnar variance were measured at six weeks and at the final follow-up. The functional evaluation was conducted by measuring the range of motion at the wrist joint as well as the grip strength. Gartland and Werley's demerit scoring system was used to assess the outcome.

They concluded that the use of VA-LCP is associated with excellent to good functional outcome with minimal complications.[4-7] With this study, we assessed the functional and radiological outcome of intra-articular distal radius fractures treated with VA-LCP to find whether the technique is relevant to the outcome. The main objective of the study is to measure the functional outcome and wrist range of motion in patients with intra-articular distal radius fractures managed by ORIF with variable-angle locking plate. The secondary objective is to measure the radiological outcome by measuring joint surface step-off, radial inclination, radial height, volar tilt angle and Sarmiento radiological score in patients with intra-articular distal radius fractures managed by ORIF with variable-angle locking plate.

METHODS

This prospective observational study was conducted in the department of orthopaedics, MES medical college, Perinthalmanna, between December 1st 2020 and November 31st 2021. The study population comprised patients above 18 years with closed intra-articular distal radius fractures, managed by open reduction and internal fixation (ORIF) using variable-angle locking compression plates (VALCP). Intra-articular fractures were defined as those extending to the articular surface, while VALCP allowed screw insertion at multiple angles. Patients with open or pathological fractures, neurovascular deficits, delayed presentation, or associated injuries preventing rehabilitation were excluded. Convenience sampling was used, and 85 patients were enrolled.

The sample size was calculated based on prior literature, assuming 66.67% favourable outcomes, with a 10% margin of error and 95% confidence interval. Functional outcomes were assessed using wrist range of motion, Modified Mayo Wrist Score, Quick DASH score, and complication rates. Radiological evaluation included joint surface step-off, radial inclination, radial height, volar tilt angle, and Sarmiento radiological score. The research question focused on whether VALCP fixation provides superior functional and radiological outcomes in intra-articular distal radius fractures.

Eligible patients underwent detailed clinical and radiological evaluation, with demographic and fracture characteristics recorded in a structured proforma. Surgery was performed within 2-3 days under general or regional anaesthesia using the modified Henry's approach. Fracture fragments were reduced, sometimes aided by K-wires, and stabilized with VALCP. Fixation was confirmed fluoroscopically, wounds closed in layers, and immobilization provided with a below-elbow plaster slab. Early finger mobilization began on day one, with suture removal on day ten and slab retention for four weeks. Wrist mobilization commenced after slab removal. Follow-up included radiographs in anteroposterior and lateral views immediately postoperatively, at four weeks, and at six months. Reduction quality was measured with a goniometer and classified using the Sarmiento score. Functional outcomes were recorded at discharge, four weeks, and final follow-up using MMWS, Quick DASH, and wrist ROM. This systematic approach allowed comprehensive evaluation of both functional recovery and radiological alignment following VALCP fixation. Data entered in Microsoft Excel and analysis done using SPSS software V26. Qualitative variables are expressed as proportions and associations checked by chi square test.

RESULTS

The study evaluated 85 patients with intra-articular distal radius fractures managed using a variable-angle locking plate. The baseline characteristics is provided in table 1. The mean age of study participants is 35.80±12.56 years (range: 19-65), with a clear male predominance (72.95%), reflecting the typical demographic exposed to high-energy trauma. Road traffic accidents accounted for 80% of injuries, while falls contributed to the remaining 20%. Left-sided involvement was slightly more frequent

(54.1%) than right-sided fractures (45.9%). Associated injuries were relatively uncommon, with DRUJ instability observed in 3.5% and ulnar styloid fractures in 8.2% of cases.

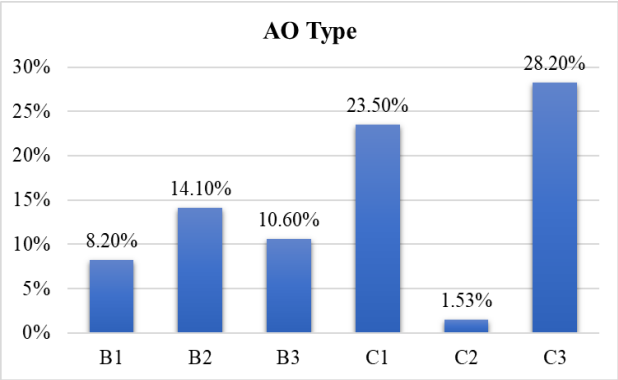

Figure 1: Distribution of type of fracture according to AO classification.

Fracture morphology based on the AO classification (Figure 1) revealed that complete articular fractures were most prevalent, with C3 fractures constituting 28.2%, followed by C1 (23.5%) and C2 (15.3%) patterns. Partial articular fractures (B1, B2, B3) comprised the remainder of the cohort. This distribution highlights that most patients presented with high-grade intra-articular injuries, justifying the use of open reduction and internal fixation with a variable-angle locking compression plate to achieve optimal anatomical restoration and stability.

Functional outcomes (Table 2) showed a consistent and statistically significant improvement across all assessment intervals. Wrist range of motion demonstrated marked recovery in every plane, with palmar flexion improving from 52.59% immediately postoperative to 94.24% at six months ($p<0.001$), and dorsiflexion increasing from 52.94% to 95.16% ($p<0.001$).

Ulnar deviation and radial deviation also showed significant gains, rising from 52.59% to 93.88% and 52.82% to 93.41%, respectively (both $p<0.001$). Forearm rotational movements followed a similar trend, with pronation increasing from 40.59% to 95.12% and supination from 40.24% to 93.65%, both showing highly significant improvement ($p<0.001$).

In addition to ROM recovery, the Modified Mayo Wrist Score improved substantially from 44.53±6.75 in the immediate postoperative period to 92.59±8.82 at six months ($p<0.001$), with 76.5% of patients achieving excellent and 17.6% achieving good outcomes. The Quick DASH score further supported superior functional restoration, declining to 5.73±4.90 at six months, indicating minimal residual disability. Overall, these findings demonstrate that variable-angle locking plate fixation facilitates rapid and effective functional recovery, with most patients regaining near-normal wrist mobility and strength within six months postoperatively.

When assessed at the immediate postoperative period and at 4 weeks immediately after slab removal the QUICK DASH score was more than 35 in all patients. At 6 months follow up 57 patients had excellent outcome (67.1%), 25 patients had good outcome (29.4%), 3 patients had satisfactory outcome (3.5%) and no patient with poor outcome. The mean QUICK DASH score at 6 months is 5.73 with a standard deviation of 4.902.

Table 1: Baseline characteristic of the study participants.

Baseline parameter	Frequency (n=85)	Percentage (%)
Male	62	72.95
Female	23	27.05
Left side involved	46	54.1
Right side involved	39	45.9
Road traffic accident (RTA)	68	80
Fall	17	20
Ulnar styloid fracture	7	8.2
DRUJ instability	3	3.5
AO type C3	24	28.2
AO type C1	20	23.5
AO type C2	13	15.3
AO type B1	10	11.8
AO type B2	8	9.4
AO type B3	10	11.8

The radiological assessment (Table 3) shows the loss of volar tilt increased significantly across intervals, from 4.51° immediately postoperative to 4.73° at 6 months, with ANOVA showing $p=0.001$, indicating statistically significant variation. Despite this, values remained within acceptable functional limits.

The loss of radial height showed no statistically significant change ($p=0.424$), with means of 3.94 mm immediately postoperative and 4.04 mm at 6 months, suggesting that VA-LCP fixation effectively maintained radial height during healing. The loss of radial inclination increased from 5.40° to 5.58°, with ANOVA suggesting significance, but clinically reported as not significant, likely because the absolute change was minimal and functionally acceptable. Intra-articular step-off remained < 2 mm in all patients at all time points, confirming excellent articular surface restoration.

According to the Sarmiento scoring system, 85.9% of patients demonstrated excellent to good radiological outcomes, reflecting stable and satisfactory alignment after fixation. In our study only 7 patients (8.2%) out of 85 had complications. The complications observed include joint stiffness in 2 patients, hypertrophied scar in 1 patient and persisting pain in 4 patients. None of the patients had post operative infection and neurovascular injuries.

Table 2: Functional outcome of the study participants.

Functional parameter	Immediate mean±SD	4 weeks mean±SD	6 months mean±SD	f-value	P value
Palmar flexion (%)	52.59±7.263	75.06±7.657	94.24±8.504	f=557.453	<0.001
Dorsiflexion (%)	52.94±7.208	74.94±7.657	95.16±6.746	f=891.988	<0.001
Ulnar deviation (%)	52.59±7.263	75.18±7.771	93.88±9.141	f=573.362	<0.001
Radial deviation (%)	52.82±7.730	74.94±7.657	93.41±9.233	f=578.321	<0.001
Pronation (%)	40.59±7.615	65.06 ±10.074	95.12±6.856	f=1094	<0.001
Supination (%)	40.24±7.556	65.06 ±10.074	93.65±9.174	f=756.342	<0.001
Modified mayo wrist score	44.53±6.753	56.53±5.671	92.59±8.817	f=1463	<0.001

Table 3: The radiological outcome of the study participants.

Radiological parameter	Immediate mean±SD	4 weeks mean±SD	6 months mean±SD	P value
Loss of volar tilt (°)	4.51±4.58	4.73±4.76	4.73±4.76	0.001
Loss of radial height (mm)	3.94±2.42	4.04±2.47	4.04±2.47	0.424
Loss of radial inclination (°)	5.40±2.77	5.58±2.93	5.58±2.93	0.001

DISCUSSION

The present study evaluated the functional and radiological outcomes of intra-articular distal radius fractures treated with variable-angle locking plates (VA-LCP). Intra-articular fractures are known to require precise restoration of articular congruity and stable fixation to prevent subsequent disability. Previous studies have emphasized that restoration of parameters such as volar tilt, radial height, inclination, and articular congruity is essential for achieving good functional outcomes.[1] In our study, most patients were young males injured in high-energy trauma, which is consistent with the demographic pattern described in earlier literature.[8,9] The high proportion of AO type C fractures also reflects the complexity and instability typically associated with intra-articular distal radius injuries.

The functional results obtained in the present study showed progressive and statistically significant improvement in all wrist movements from immediate postoperative period to 6-month follow-up. Most patients achieved more than 90% of normal wrist motion by six months, which is comparable to the outcomes reported by Khatri et al, who observed excellent recovery of wrist mobility and grip strength with VA-LCP fixation.[9] Similarly, MMWS and Quick DASH scores in our cohort indicate excellent to good outcomes in more than 90% of patients, aligning with findings by Spiteri et al, who reported favorable functional recovery and low complication rates when VA-LCP was used for complex distal radius fractures.[10] These parallels demonstrate that VA-LCP promotes early rehabilitation and functional restoration by allowing stable fixation even in Mult fragmentary fractures. Radiologically, our study showed satisfactory maintenance of volar tilt, radial height, and inclination throughout follow-up, with minimal articular step-off in all patients. This outcome supports earlier observations by Trumble et al, who noted that anatomical reduction of the articular surface strongly correlates with better long-term functional results.[11] The high percentage of excellent and good radiological scores in our study further supports the advantage of VA-LCP in achieving stable fixation, particularly when fracture lines extend distally beyond the typical purchase zone of fixed-angle plates. Prior comparative studies, including those by Chen et al, have demonstrated that VA-LCP provides superior articular reduction and decreases hardware-related complications compared to fixed-angle plates, which is consistent with the favorable radiological outcomes observed in our patients.[12]

The complication rate in this study was low (8.2%), comparable to previously published studies reporting complication rates between 6% and 20% after volar plating.[13] No patient had loss of reduction, significant malunion, or tendon irritation findings that reinforce the biomechanical advantages of VA-LCP, particularly its ability to capture periarticular fragments through polyaxial screw placement. Overall, both functional and radiological outcomes from this study support the conclusion that variable-angle locking plates provide a reliable and effective method for treating complex intra-articular distal radius fractures, offering stable fixation, early mobilization, and excellent clinical outcomes.[12]

This study does have strength and limitations. The strength of this study is its prospective design with a uniform surgical technique performed using variable-angle locking plates, allowing reliable comparison of functional and radiological outcomes over clearly defined follow-up intervals. The use of standardized scoring systems (MMWS, Quick DASH) and objective radiological measurements enhances internal validity. Additionally, the inclusion of a substantial proportion of complex AO type C fractures provides strong evidence for the effectiveness of VA-LCP in challenging fracture patterns. However, the study has certain the limitations of the study include the absence of a control group treated with alternative fixation methods, which restricts direct comparative evaluation.

The follow-up period of six months, though adequate for assessing early functional and radiological recovery, may not capture long-term complications such as post-traumatic arthritis. Finally, variations in rehabilitation compliance among patients may have influenced functional outcomes.

CONCLUSION

The present study demonstrates that variable-angle locking compression plates provide excellent functional and radiological outcomes in the management of complex intra-articular distal radius fractures. Significant improvements were observed across all wrist range of motion parameters, Modified Mayo Wrist Scores, and Quick DASH scores by six months, with most patients achieving excellent to good functional results. Radiological parameters, including volar tilt, radial height, inclination, and articular congruity, were well maintained throughout follow-up, reflecting stable anatomical restoration. The low complication rate further supports the safety and reliability of VA-LCP fixation. Overall, the findings affirm that variable-angle locking plates are an effective and superior fixation method for achieving stable reduction, early mobilization, and rapid functional recovery in intra-articular distal radius fractures.

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