International Journal of Research in Orthopaedics
Rao M et al. Int J Res Orthop. 2019 Jul;5(4):645-650
http://www.ijoro.org

Original Research Article

DOI: http://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20192677

Clino-radiological and functional outcome of intra-articular distal radius fractures treated with volar locking plate system

Mohan Rao[1], Siddharth Gupta[1]*, P. V. Jayasankar[2], Vinit Yadav[3], Sudhakar Williams[2]

Department of Orthopaedics, [1]Rajawadi Hospital, Mumbai, Maharashtra, [2]Sundaram Medical Foundation, Chennai, Tamil Nadu, [3]Popular Hospital, Varanasi, Uttar Pradesh, India

Received: 18 November 2018
Revised: 14 April 2019
Accepted: 15 April 2019

***Correspondence:**
Dr. Siddharth Gupta,
E-mail: siddharthgupta777@live.com

ABSTRACT

Background: No uniform consensus exists to decide type of fixation for unstable distal radius fractures. The objective of the study is to evaluate the patients on regular follow up for radiological & functional status. We evaluated the effectiveness and outcomes of unstable distal radius fractures treated with locking plates.
Methods: The study design was prospective observational study. 36 patients with distal radius fractures deemed unsuitable for conservative management underwent ORIF with a volar locking plate. The evaluation methods were clinical examination, DASH score and PRWE score. Patients were followed up from minimum of 2 weeks to 6 months. This data was analysed in MS excel and SPSS software version 19.0 for testing the association between different variables by using the chi-square tests.
Results: The mean age of patients was 45 years with male preponderance. As per DASH score 17 patients had zero score implying no disability. In the remaining 19 patients score ranged from 4 to 24 with a mean of 11 indicating good outcome. PRWE score was best in 17 patients and worst in zero patients.
Conclusions: The fixation of unstable distal radius fractures with volarly applied locking plates without bone grafting and prolonged immobilisation is an effective method & hence has gained worldwide acceptance and is highly recommended.

Keywords: Distal radius fractures, Locking plate, DASH score

INTRODUCTION

Distal radius fractures are among the most common fractures treated, accounting for 10% to 25% of all fractures.[1] Many of these fractures are adequately treated non-operatively. However, it is estimated that 40% to 49% are unstable and may benefit from operative treatment.[2] Volar plate fixation has emerged as a popular method of treatment for internal fixation of unstable distal radius fractures.[3-5] The objective of the study is to evaluate the patients on regular follow up for radiological & functional status. We evaluated the effectiveness and outcomes of unstable distal radius fractures treated with locking plates. Volar locking plate fixation has been demonstrated to allow restoration of radiographic parameters within accepted standards.[3,4,7] This popularity is partly the result of the biomechanical advantages of volar plate fixation and associated higher rates of extensor tendon complications after dorsal plating, ease of the volar surgical approach, and increased strength and stiffness of volar locking constructs compared with other methods.[6,7] Numerous studies have confirmed the importance of restoring and maintaining anatomic alignment for optimal functional outcome and prevention of residual articular incongruence, which is associated with the development of post-traumatic arthritis.

METHODS

This is a case series study in which we have prospectively evaluated all intra-articular distal radius fractures treated by internal fixation with a LCP. The study was done in our secondary care centre Rajawadi hospital in Ghatkopar Mumbai. The study commenced from June 2016 till July 2017. Implant used was a 2.4 mm distal radius LCP (Depuy-Synthes). We used the Extra-Articular, Juxta-Articular or variable angle distal radius LCP depending on the fracture geometry.

Inclusion criteria were age >18 years; intra-articular distal radius fractures. Classified As: AO 23 B1 & above (Confirmed By CT Scan); fracture less than 2 weeks old; no associated injury (fractures or dislocations except ulna).

Exclusion criteria were pathological fracture.

A displaced distal radius fracture was defined as a fracture with any of the following criteria:[8]

- Greater than 20 degrees of dorsal angulation,
- Less than 5 mm radial height,
- Less than 10 degrees of radial inclination,
- Greater than 2 mm positive ulnar variance,
- Greaterthan 1 mm articular incongruity.

A CT scan was taken to assess the intra-articular extent of the fracture and plan for intra operative reduction. An unstable distal radius fracture was defined as possessing variables that, if present, would result in the fracture re-displacing into an unacceptable alignment even if a successful closed reduction were obtained.

Variables of instability included any of the following criteria:[8]

- Dorsal comminution greater than 50% of the width of the dorsal cortex or any volar cortical comminution,
- Initial dorsal angulation greater than 20 degrees,
- Initial fracture displacement or translation greater than 1 cm,
- Intra-articular disruption,
- Associated ulnar neck or shaft fracture.

Surgery was recommended to patients whose fractures were displaced and had associated variables of instability. The fractures were classified as A, B, or C based on the AO classification system.[9] We obtained data on wrist ROM, radiographic parameters, grip strength (measured as a percentage of the contralateral uninjured side), DASH scores, PRWE scores and VAS scores for pain at 3 and 6 months postoperatively. A physiotherapist who was blinded to the study protocol measured range of motion and grip strength. Fracture union was defined as the presence of bridging bone on orthogonal views. Surgery was done under standard preoperative antibiotic prophylaxis all fractures were exposed using modified Henry's approach. The volar aspect of the distal radius and the fracture were then identified. When the volar cortex was not comminuted, use of a small periosteal elevator combined with manual traction restored the anatomic continuity of the volar cortex in regard to the radial length, radial inclination, and articular congruency. Following this, the distal fragment was pushed down and volarly flexed to obtain an anatomic volar tilt. For this to be easily performed, a folded towel was placed beneath the dorsum of the hand (not beneath the wrist, because this makes reduction more difficult), and then the distal radius was rotated volarly with the fracture line of the volar cortex as a centre of rotation. When both volar and dorsal metaphases were comminuted continuous manual traction was necessary to maintain the longitudinal length of the radius during plate fixation. When the depressed fragments of the intra-articular comminuted fractures were identified by fluoroscopy after reduction, those fragments were elevated to sit in line with the articular surface transmedullarly through the volar fracture surface, while using a small, single blunt retractor or a K-wire. The displaced radial styloid was temporarily fixed with a 1.5 mm K-wire followed by temporary percutaneous fixations of the fragments with 1.0-mm K-wires (Figure 1).

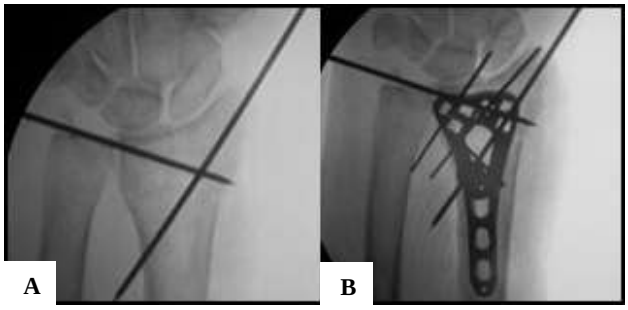

Figure 1: (A) The intra-operative fluoroscopic picture of reduction and temporary fixation with K-wires; (B) intra-operative fluoroscopic picture of volar plate and screw fixation of the fracture.

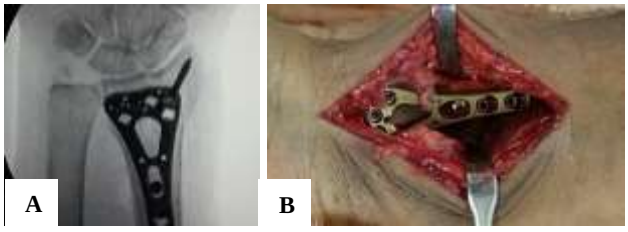

Figure 2: (A) The Intra-operative fluoroscopic picture of volar plate and screw fixation of the fracture; (B) intra operative clinical picture of placement of volar plate after exposure.

It was important for the K-wires to be placed as close as possible to the joint line. After accurate predrilling with a threaded drill guide, locking screws were inserted into the subchondral bone of the distal radius. The epiphysis of

the distal radius was usually fixed with 4 locking screws. These screws give support by acting as an internal buttress. They do not induce inter fragmentary compression but firmly maintain bony alignment. The K-wires that had temporarily fixed the plate were then removed.

Figure 3: Distraction/oblong hole on the plate used for correction of radial shortening.

In fractures with intra-articular disruption, the most radial side locking screw fixed radial styloid fragments, and the most ulnar side locking screw fixed ulnar split fragments or dorsal die-punch fragments (Figure 2). If the distal comminuted fragments were to be securely fixed, a supplemental locking screw was added. However, if dorsal marginal fragments or small radial styloid fragment could not be fixed securely by screws, the K-wires were not removed. Finally, proximal screws were inserted. At this time, if there was radial shortening that needed correcting, the distraction hole was used (Figure 3). During this procedure, there was no need for bone grafting or artificial bone packing because the plate provides sufficient stability for the fracture. The pronator quadratus was reattached to cover the plate and protect the flexor tendons and median nerve. The advantages of the locking plate included sufficient strength to prevent dorsal angulation at axial loads, carrying the load directly with the locking screws placed in the distal screw holes to hold the comminuted fracture fragments. Consequently, active range of motion exercises of the wrist could begin immediately after surgery. Post-operatively 3 doses of first generation cephalosporin were given for prophylaxis. Parenteral analgesics were given for 24 hours following surgery and then changed to oral analgesics. Intermittent active and gentle passive wrist mobilisation exercises according to pain tolerance were usually started after the first postoperative day. The full exercise program progresses to protected active and then self- assisted exercises. Postoperative physiotherapy must be carefully supervised. Activities of daily living can generally be resumed while avoiding certain stresses on the wrist. Approval from our institutional ethical committee board was taken. The statistical analysis was done from data collected. This data was analysed in MS excel and SPSS software version 19.0 for testing the association between different variables by using the chi-square tests. P≤0.05 will be taken as highly significant for the statistical tests used. All patients were followed up at 2 weeks for suture removal and then at 6 weeks, 3 months and 6 months. During follow up patients were assessed functionally by DASH and PRWE scores and radiologically by X-rays. Grip strength was measured by dynamometer. Range of movements measured by hand held goniometer.

RESULTS

In our study with 36 patients of which 25 were males and 11 were females. The patient's ages ranged from 23 to 67 years with a mean age of 45 years. 24 fractures involved the left side and 12 involved the right side. All fractures were post-traumatic with 24 due to road traffic accident, 10 due to domestic fall and 2 due to sports injuries. All fractures were intra articular, 10 were 23B1, 11 were 23B3, 7 were 23C1, 3 were 23C2 and 5 were 23C3. Majority of fractures belonged to 23B3 category.

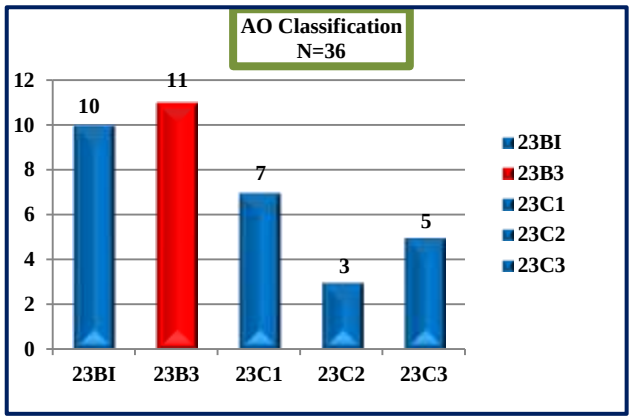

Figure 4: Distribution according to AO/OTA classification.

Table 1: Distribution according To AO/OTA classification.

AO classification	DASH score (%)		P value
	0	0-40	
23BI	41.2	15.8	0.162 (NS)
23B3	29.4	31.6	
23C1	23.5	15.8	
23C2	0.0	15.8	
23C3	5.9	21.1	
Total	100.0	100.0	

The time between injury and surgery ranged between 8 hours to 60 hours with an average of 27 hours. Patient's minimum follow up was 3 months and maximum was 6 months. Average time for radiological union was 7 weeks. At the final follow up visit 22 patients had no pain, 6 patients had mild pain, 7 patients had moderate pain and 1 patient had severe pain necessitating implant removal. Of 36, 22 patients had equal grip strength, 4 patients had 10% less compared to contralateral wrist, 9 patients had 20% less and only one patient had 50% less grip strength compared to contralateral side. No superficial or deep surgical site infections were reported.

There was no incidence of malunion or non-union or persistence of deformity. One patient developed reflex sympathetic dystrophy and severe pain and underwent implant removal for the same after 6 months from surgery. No patients had any implant failure or median nerve dysfunction. At the final follow up visits, radial height ranged from 10 mm to 14 mm with a mean of 11.8 mm. Radial inclination varied from 18degree to 25 degree with a mean of 22 degree. Volar tilt ranged from 8 degree to 13 degree with a mean of 11.6 degrees. Ulnar variance was neutral (0 mm) in 25 patients and positive (1 mm) in 11 patients.

On DASH score assessment, 17 patients had zero score reflecting best outcome. In the remaining 19 patients score ranged from 4 to 24 with a mean of 11 indicating good outcome. PRWE score was best in 17 patients & worst in zero patients. There was a statistically significant association between age and DASH Scores (p=0.041) with patients above 60 years of age having higher DASH Scores at final follow up. There was a statistically significant association between gender and DASH Scores (p=0.021) with females having higher DASH Scores at final follow up. There was a statistically significant correlation between the DASH Scores and duration of follow up (p=0.012). Patients had higher DASH Scores at 3 months and average functional outcomes compared to 6 months follow up where patients had better DASH scores and excellent outcome.

Table 2: Distribution according to duration of follow up.

Total duration of follow-up	DASH score (%)		P value
	0	0-40	
3 months	5.9	42.1	0.012(s)
6 months	94.1	57.9	
Total	100.0	100.0	

Table 3: Distribution according to presence of pain.

Duration of follow up	Pain				P value
	Mild (%)	Moderate (%)	No pain (%)	Severe (%)	
3 months	50.0	71.4	4.5	0.0	0.002(S)
6 months	50.0	28.6	95.5	100.0	
Total	100.0	100.0	100.0	100.0	

There was a statistically significant correlation between the pain and duration of follow up (p=0.002) with most patients having mild to moderate pain at 3 months follow up which gradually improved at the 6 months follow up visit.

Table 4: Distribution according to time taken for radiological union in relation to DASH score.

Radiological union	DASH score (%)		P value
	0	0-40	
6 weeks	94.1	21.1	0.000(S)
8 weeks	5.9	78.9	
Total	100.0	100.0	

There was a statistically significant correlation between the time taken for radiological union and DASH and PRWE scores (p=0.000). Patients with radiological fracture union by 6 weeks had improved functional outcomes compared to patients with union by 8 weeks.

Table 5: Distribution according to time taken for radiological union in relation to PRWE score.

Radiological union	PRWE score (%)				P value
	0	0-10	10-20	20-30	
6 weeks	94.1	11.1	25.0	50.0	0.000 (S)
8 weeks	5.9	88.9	75.0	50.0	
Total	100.0	100.0	100.0	100.0	

There was a statistically significant correlation between grip strength and DASH scores (p=0.000). Patients with equal grip strength compared to the contralateral wrist had better DASH Scores at final follow up. There is no statistically significant association between comorbidities and DASH Scores (p=0.059), mechanism of injury and DASH Scores (p=0.174), type of fracture and DASH Scores (p=0.162), complications and DASH Scores (p=0.337) at final follow up.

Table 6: Distribution of grip strength.

Grip Strength	DASH score (%)		P value
	0	0-40	
10% less	13.3	0.0	0.000 (S)
20% less	30.0	0.0	
50% less	0.0	16.7	
Equal	56.7	83.3	
Total	100.0	100.0	

DISCUSSION

Volar plating has several advantages over dorsal plating. It's technically easier, preserves vascular supply to dorsal metaphyseal fragments and does not cause extensor tendon problems.

Volarly placed plates are almost covered with the pronator quadratus except at the distal edge & therefore do not disturb the flexor tendons. Volar Locking Plate

had advantages in functional recovery in the early period after surgery.[14] In addition, fixed-angle plate system confers increased rigidity to the volar plate construct. Our overall results were compared with other reported series using locking or non-locking volar plates for dorsally displaced, unstable fractures of the distal radius. Chung et al[3] treated the distal radius fractures with the DVR plate and started wrist joint mobilization within a week after operation. However, they did not use bone grafting and protected the wrist in a volar splint for 6 weeks. Orbay and Kamano et al evaluated clinical results only using the Gartland and Werley score, which has been used frequently in such studies.[4,5] However, this scoring system is much less strict, and it gives no demerits. Constantine et al used locking plates, but they used non-locking screws to fix the distal radius, so that they did not use a locking mechanism of the plate.[10] Arora et al did not use bone graft or artificial bone because the good mechanical stiffness of the 2.4 mm AO LCP (Synthes).[11] We think that postoperative splinting of the wrist has little effect on preventing a re-displacement of the fracture fragment as long as active digit movement exercise is started immediately after the operation. Physiologically, active wrist joint motion during daily activities have been estimated to cause 100 N axial load across the wrist joint, whereas active digit flexion has been estimated to produce 250 N axial load across the wrist joint.[6] Therefore, a splint at the wrist does not make sense in terms of neutralizing the axial load generated by digit movements. Because the 2.4 mm distal radius LCP is sufficiently strong, there were no fractures that needed either bone grafting or postoperative immobilization in our series. This plate enabled us to start active range of motion exercises of the wrist and the forearm in the immediate postoperative period. Even after vigorous early motion exercises in our protocol, the reduction of the distal radius fracture was maintained during the follow-up periods in almost all the cases.

All movements of the wrist and forearm at 3 months after surgery reached an excellent level according to the DASH and PRWE Score. Recovery of grip strength was also rapid. The functional recoveries at 3 months or 6 months in this study were much better than those of the previous reports of dorsal plating followed by 1 to 2 weeks of immobilization. Furthermore, the functional recoveries in this study were more rapid than those of Chung et al.[3] The 1-year DASH scores suggest a high degree of patient satisfaction. We believe the good results in terms of range of motion, grip strength, and pain were due to the restoration of the joints and the extra-articular anatomy. There was no later loss of radial inclination or volar tilt in our series. Orbay reported 1 case of dorsal tendon irritation from a locking pin of incorrect length.[5] Drobetz and Kutscha-Lissberg reported a high rate of complications (30%) using a Mathys Plate.[8]

Constantine et al reported 2 cases of neuropraxia of the median and ulnar nerves and 1 complex regional pain syndrome.[10] Arora et al reported 2 instances of complex regional pain syndrome and 1 carpal tunnel syndrome.[11] Wright et al reported 3 cases of complex regional pain syndrome using a SCS/V plate.[12] In our series, 1 patient had reflex sympathetic dystrophy requiring implant removal, but the rate of complications (3%) was least among volar plating series. The volar tilting angle of plate group was significantly larger than that of external fixation group.[13]

CONCLUSION

Based on the satisfactory clinical and radiographic outcomes we report here, we conclude that volar locking plate fixation without bone grafting and early mobilization is a safe and effective treatment for displaced, unstable fractures of the distal radius. The surgeon must be familiar with the appropriate indications and with the surgical technique, especially if managing complex fractures. It is an easy to learn, simple, and reproducible procedure that has improved the outcome of this common injury. Complications encountered are few and frequently are related to surgical technique. Stiffness and reflex sympathetic dystrophy are uncommon with this technique but must be watched for and treated aggressively in their early stages. Allowing the patient to perform early functional use of the hand is preventive. In general, vigilance and attention to detail is essential to avoid most complications. Contraindications include those patients with dorsal Barton's fracture, skelet ally immature bone and open epiphysis, patients with severe medical illness that do not justify this procedure.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the institutional ethics committee

REFERENCES

1. Singer BR, Mc Lauchlan GJ, Robinson CM, Christie J. Epidemiology of fractures in 15,000 adults: the influence of age and gender. J Bone Joint Surg Br. 1998;80(2):243-8.
2. Mac Dermid JC, Roth JH, Richards RS. Pain and disability reported in the year following a distal radius fracture: a cohort study. BMC Musculoskelet Disord. 2003;4:24.
3. Chung KC, Watt AJ, Kotsis SV, Margaliot Z, Haase SC, Kim HM. Treatment of unstable distal radial fractures with the volar locking plating system. J Bone Joint Surg Am. 2006;88(12):2687-94.
4. Kamano M, Honda Y, Kazuki K, Yasuda M. Palmar plating for dorsally displaced fractures of the Distal radius. Clin Orthop Relat Res. 2002;(397):403-8.
5. Orbay JL, Fernandez DL. Volar fixed-angle plate fixation for unstable distal radius fractures in the elderly patient. J Hand Surg Am. 2004;29(1):96-102.
6. Osada D, Viegas SF, Shah MA, Morris RP, Patterson RM. Comparison of different distal radius

dorsal and volar fracture fixation plates: a biomechanical study. J Hand Surg Am. 2003;28(1):94-104.
7. Drobetz H, Kutscha-Lissberg E. Osteosynthesis of distal radial fractures with a volar locking screw plate system. Int Orthop. 2003;27(1):1e6.
8. Porter M, Stockley I. Fractures of the distal radius: intermediate and end results in relation to radiologic parameters. Clin Orthop Relat Res. 1987;(220):241-52.
9. Müller ME, Nazarian S, Koch P, Schatzer J. The comprehensive classification of fractures of long bones. Berlin: Springer-Verlag, 1990: 106–115.
10. Constantine KJ, Clawson MC, Stern PJ. Volar neutralization plate fixation of dorsally Displaced distal radius fractures. Orthopedics 2002;25:125–8.
11. Arora R, Lutz M, Fritz D, Zimmermann R, Oberladstatter J, Gabl M. Palmar locking plate for treatment of unstable dorsal dislocated distal radius fractures. Arch Orthop Trauma Surg. 2005;125:399–404.
12. Wright TW, Horodyski M, Smith DW. Functional outcome of unstable distal radius fractures: ORIF with a volar fixed-angle tine plate versus external fixation. J Hand Surg. 2005;30:289–99.
13. Sha L, Chen Q, Sun L. Effectiveness comparison of external fixation and volar locking compression plate in treatment of distal radius fractures of type C. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2015; 29(6):683-7.
14. Li-hai Z, Ya-nan W, Zhi M, Li-cheng Z, Hong-da L, Huan Y, et al. Volar locking plate versus external fixation for the treatment of unstable distal radial fractures: a meta-analysis of randomized controlled trials. J Surg Res. 2015;193:324-33.

Cite this article as: Rao M, Gupta S, Jayasankar PV, Yadav V, Williams S. Clino-radiological and functional outcome of intra-articular distal radius fractures treated with volar locking plate system. Int J Res Orthop 2019;5:645-50.