

Analysis of the Variables Affecting the Outcome of Management of Distal Radius Fractures with a Variable-Angle Volar Locking Plate

Ahmed Mohamed Abdel Wahed*, Mohamed Safwat Mostafa Shalaby,
Mohamed Elsadek Attia, Reda Hussien Elkady

Department of Orthopedic Surgery, Faculty of Medicine, Zagazig University, Sharkia, Egypt.

*Correspondence: Ahmed Mohamed Abdel Wahed, Mobile: (+20) 01097888228

Email: ahmedabdelwahed126@gmail.com

ABSTRACT

Background: The new low-profile plates and locking systems have popularized surgical options. Treatment modalities exist for surgical management of distal radius fractures, including open reduction and internal fixation (ORIF) with volar or dorsal plates and screws.

Objectives: This study aimed to find a possible correlation between various parameters, either patient-related (age, bone quality) or fracture-related (type, reduction), and to analyze the impact of these factors on the radiological and clinical outcome of distal radius fractures treated by a variable-angle volar locking plate.

Patients and Methods: The study included 18 patients suffering from fractures of the distal radius admitted to the Orthopedic Department in Zagazig University Hospital. All patients were operated from January 2019 to June 2019. A total of 18 patients complete at least 6 months follow up period.

Results: The results were assessed according to the disabilities of arm, shoulder, and hand scoring system (DASH score), eight patients had excellent results with average 3.54 ± 1.23 , eight patients had good results with average 9.71 ± 1.97 .

Conclusions: There was a negative correlation between patients' age, sex, type of fracture, or presence of an associated ulnar styloid fracture and the final score. This correlation was statistically insignificant. A correlation was found between the affected dominant hand or number of rows of distal screws and the final functional score. this was found to be statistically significant.

Keyword: Distal Radius, variable angle, locking plates

INTRODUCTION

The distal radius fractures commonly occur and represent 10 % of all broken bones ⁽¹⁾. A fracture of the distal radius is considered unstable by the inability to resist displacement following anatomic reduction. Some of the more redundant factors of instability in the literature include fracture prereduction with the following radiographic features: Dorsal tilt greater than 20° , radial inclination less than 15° , radial shortening greater than 5 mm (or resultant ulnar positive variance). Extension into the radiocarpal joint. Concomitant fracture of the ulna. Patients more than 60 years old or the presence of osteoporosis ^(4,5). Whereas a large number of these fractures are managed non-operatively, the number of patients who undergo surgical management is considerable ^(2,3).

A few randomized control trials have shown that open reduction and internal fixation with locking implants were usually superior to both external fixation and percutaneous pinning, concerning radiological results, early functional results, and complication rates ⁽⁶⁾.

PATIENTS AND METHODS

A prospective cohort study on eighteen patients with unstable distal end radius fractures admitted to Orthopedic Department in Zagazig University Hospital. All patients were operated from

January 2019 to June 2019. A total of eighteen patients who fulfilled the inclusion criteria complete at least 6 months follow up period.

Ethical Approval:

Approval for performing the study was obtained from Orthopedic Surgery Departments, Zagazig University Hospitals after taking Institutional Review Board (IRB) approval.

The work has been carried out following the code of ethics of the world medical association (Declaration of Helsinki) for studies involving humans.

The inclusion criteria for the study were as follows:

- Age: Skeletally mature patients' group (>18) years old.
- Unstable extra-articular fractures.
- Intra-articular fractures.

The exclusion criteria for the study were:

- Open fractures Gustilo and Anderson type II and III.
 - Pathological fractures.
 - Patients who are unfit for surgery.

There were twelve males and six females. There were eleven patients with dominant hand fractures and seven with non-dominant hands fracture.



This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY-SA) license (<http://creativecommons.org/licenses/by/4.0/>)

METHODS

Preoperative diagnosis and assessment:

- History.
- Clinical examination.
- Radiological evaluation. For preoperative assessment of fracture type and degree of displacement of the fragments, the anteroposterior and lateral views of the wrist and CT scan were obtained

Methods of treatment: All patients were treated by open reduction and internal fixation (ORIF) by using the variable-angle 2.4-mm distal radius locking plate.

First aid treatment: The fractured limb was splinted until the time of surgery. Analgesic and anti-edematous drugs were given as required. Patients then were admitted and scheduled for surgery.

Anesthesia: Under general or local IV anesthesia and after prophylactic IV antibiotics were given a tourniquet was inflated. The surgical field was disinfected and prepared formally.

Basic procedures: All fractures were fixed using a volar approach to the distal radius as described by Orbay over flexor carpi radialis tendon ⁽⁷⁾. The skin incision is made directly throughout the FCR tendon and is 8 to 10 cm long (Figure 1).

The dissection is taken down to the surface of the distal radius by developing the space between the flexor pollicis longus and the radial septum. The radial origins of the most distal fibers of the flexor pollicis longus muscle are released for greater exposure.

The pronator quadratus muscle and the anterior wrist capsule are then exposed after blunt dissection and then are mobilized by releasing its distal and lateral borders with an L-shaped incision (Figure 2). It is then lifted from its bed by subperiosteal dissection, exposing the fracture site.



Figure (1): Flexor carpi radialis tendon after sheath release



Figure (2): Pronator quadratus exposed and an L-shaped incision is made to elevate it.

After exposure and debridement of the fracture site, the fracture was reduced and provisionally fixed under C-Arm using k-wires. Extra-articular fractures were reduced by simple traction and slight palmar flexion of the wrist and manual manipulation. In intraarticular fractures, large fragments were being manipulated, reduced and preliminary fixed by wires (Figure 3).



Figure (3): preliminary fixation of large articular fragments.

Plate position:

The plate should be positioned on the distal radius proximal to the Watershed line. If placed properly, K-wires inserted in it to ensure the position. The plate is designed to be elongated in its ulnar side as the volar surface of the ulnar column is more distal than the radial column. The position of the plate is confirmed by C-arm (Figure 4a). The plate may be positioned more distally to cover the volar fracture line or more ulnar if there was a sagittal plane fracture line in the ulnar portion of the distal radius. A screw is inserted in the oval non-locking hole of the plate which permits fine adjustment of the plate position either proximally or distally. At this point, the plate is used as a buttress for the lunate facet fragment (Figure 4b).

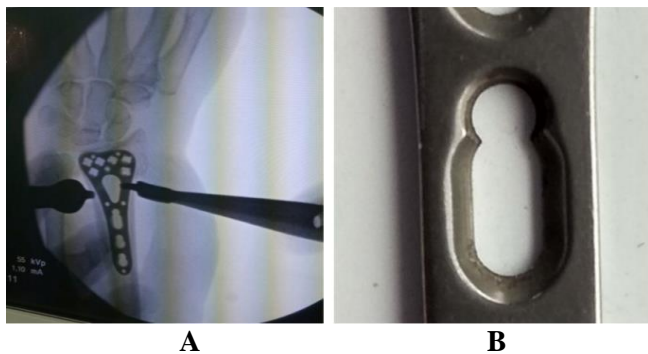


Figure (4): A: Plate adjustment on the volar surface of lunate facet, B: Oblong combi-hole Allows accurate plate positioning on the bone.

The plate was fixed to bone distally beginning with the most ulnar screw using the funnel-shaped end of the VA-LCP drill sleeve at the desired angle. This funnel-shaped sleeve allows the drill bit up to a 15° angulation around the central axis of the locking hole. The more ulnar screws may be directed perpendicular or even angled slightly proximal relative to the plate to ensure that articular perforation does not occur and for proper screw length. After each screw insertion, the screw position was confirmed by C-arm to ensure that there is no articular perforation. 20° tilted lateral view was done intra-operative rather than regular lateral view.

The distal fixation of the plate was finished by the insertion of lateral screws. If sufficient angulation of the screws relative to the longitudinal axis of the plate can be achieved, one or two screws were directed from the volar radial aspect of the plate in a dorsal and radial direction. This stabilizes the radial column. The direction and the size of 2.4 of the screws allow catching small radial styloid fragment (Figure 5).



Figure (5): Distal screws catch small radial styloid fragment.

Definitive Plate Fixation:

Proximal screws were inserted once distal screws positioning were completed. In the case of articular fragments, the net result is that the distal articular surface can then be manipulated as one fragment utilizing the plate as a reduction device for final fine-tuning of the relation between the articular surface and the diaphysis.

Wound closure: The pronator quadratus was repaired over the plate if it was repairable. The subcutaneous layer is closed, and the skin is closed with simple interrupted sutures starting at the zigzag portion of the incision. And the patient is put in a splint making sure that the MPJ and the fingers are free.

Post-operative and rehabilitation Post-operative treatment was described for patients with anti-edematous, NSAID, and antibiotic. Early active fingers and MP exercises were encouraged. The splint was removed at one week and patients could wear a wrist brace. Patients were instructed to remove the brace and start gentle active wrist and finger exercises.

RESULTS

The results were assessed according to the disabilities of arm, shoulder, and hand scoring system (DASH score), eight patients had excellent results with average 3.54 ± 1.23 , eight patients had good results with average 9.71 ± 1.97 and two patients had fair results (scores between 20-24.2) with average 22.10 ± 2.97 , no patients had poor results. The score ranged from 1.7 to 24.2 in the studied patients' group with a mean of (8.3 ± 6.06) .

All affected dominant hand patients achieved excellent and good results while the non-dominant there were seven patients (38.88%), 6 of them achieved good and fair results and this was found to be significant ($P < 0.05$) **Table 1**.

There was a statistically insignificant correlation fracture type according to Frykman's classification system and the final clinical and radiological score ($P=0.327$), ($P=0.189$) (p-value > 0.05).

Six patients had an associated ulnar styloid fracture, their mean score was 4.68 ± 2.81 . Twelve patients did not have an associated ulnar styloid fracture and their mean score was 4.06 ± 2.35 . There was no statistically significant difference between the two groups **Table 2**.

There were eleven Patients in whom 2 rows of screws were placed in the distal part of Radius there results were Excellent and good, on the other hand, there were seven Patients in whom 1 rows of screws were placed in the distal part of Radius, their results were good and fair. This was found to be statistically significant ($P < 0.05$) **Table 3**.

One patient had a tourniquet palsy which was resolved after one month of physiotherapy (5.56%). One patient suffered from delayed wound healing (5.56%). This resolved completely after one month. One patient had screw misplacement in the radio-ulnar joint that remains asymptomatic at the final follow up period (5.56%) **Table 4**.

Table 1: Relation between dominant hand and final functional score

Side	DASH score							
	Fair		Good		Excellent		Total	
	N	%	N	%	N	%	N	%
Non-dominant	2	100.0	4	50.0	1	12.5	7	44.0
Dominant	0	0.0	4	50.0	7	87.5	11	56.0
Total	2	100.0	8	100.0	8	100.0	18	100.0
Chi-square	X ²	9.510						
	P-value	0.009*						

Table 2: Relation between the presence of an ulnar styloid fracture and final clinical score

Associated injuries	DASH score							
	Fair		Good		Excellent		Total	
	N	%	N	%	N	%	N	%
Ulnar styloid	1	50.0	2	25	3	37.5	6	33.33
Others	1	50.0	6	75	5	62.5	12	66.66
Total	2	100.0	8	100.0	8	100.0	18	100.0
Chi-square	X ²	0.562						
	P-value	0.755						

Table 3: Relation between the number of rows of distal screws and Final functional score.

Side	DASH score							
	Fair		Good		Excellent		Total	
	N	%	N	%	N	%	N	%
One row	2	100.0	4	50.0	1	12.5	7	44.0
Two rows	0	0.0	4	50.0	7	87.5	11	56.0
Total	2	100.0	8	100.0	8	100.0	18	100.0
Chi-square	X ²	9.510						
	P-value	0.009*						

Table 4: Distribution of the studied patient's group according to complications

Complication	N	%
No	14	77.78
Delayed wound healing	1	5.56
Radiocarpal screw penetration	1	5.56
Radioulnar screw penetration	1	5.56
Tourniquet palsy	1	5.56
Total	18	100.00

DISCUSSION

In our study, there was a negative correlation between patients' age, sex, type of fracture, or presence of associated ulnar styloid fracture and the final score. This correlation was statistically insignificant. A correlation was found between the affected dominant hand or number of rows of distal screws and the final functional score was found to be statistically significant.

Hand dominance: Injured dominant hands achieved more excellent functional results than injured non-dominant hands. This may due to muscle power and grip strength in the dominant hand is more than non-dominant. There is no evidence in the literature that the dominant hand had good functional

results than non-dominant after the management of distal radius fractures.

Fracture type: Statistical analysis of the results showed no change in results with the type of fracture. These results are similar to the results of Karnezis et al, as they found that no demonstrable correlation between fracture type and outcome in their study. Ng and McQueen had similar results (8,9).

In contrast, **Braziulis et al.** (11), found that there was a strong correlation between fracture type and functional result. According to the AO classification system (10), patients with type C fractures treated with a volar locking plate had a worse wrist function as compared with the patients type A and B fractures at

the 6-month follow-up. The postoperative hand function was significantly associated only with the type C fracture, while age and gender had no significant impact. But they used a different plate system with fixed angle screws.

Ulnar styloid fractures: Six patients had an associated ulnar styloid fracture; their mean score was 4.68 ± 2.81 . Thirteen patients did not have an associated ulnar styloid fracture and their mean score was 4.06 ± 2.35 . There was no statistically significant difference between the 2 groups. These results are comparable with the study made by **Mulders et al.** ⁽¹²⁾ they performed a meta-analysis to compare the functional outcomes of 1196 patients with a distal radius fracture with and 1047 without a concomitant fracture of the ulnar styloid process. They found that no significant difference was found in Patient-Rated Wrist Evaluation scores, range of motion, grip strength, visual analog scale pain scores, ulnar-sided wrist pain, and distal radio-ulnar joint instability between patients with and without an ulnar styloid process fracture after 1 year of follow-up. Moreover, no significant differences were found between the ulnar styloid base and non-base fractures ⁽¹²⁾.

The relation between radiological and functional results: In our study, there was a highly significant correlation between radiological and functional results. Patients with excellent radiological results achieved excellent functional results, patients with good radiological results achieved excellent and good functional results, and none of the patients with poor radiological results achieved excellent functional result.

Many studies support our results as in **Kale et al.** ⁽¹³⁾ they found that radiological parameters affect the functional outcome in their study at six months of follow up. The more the number of radiological parameters affected the poorer is the functional outcome.

It is also shown that permanent radial shortening and loss of the palmar angle were associated with prolonged wrist pain as in **Karnezis et al.** ⁽¹⁴⁾ study. They found that residual articular incongruity correlates with persisting loss of wrist dorsiflexion and wrist dysfunction contradicts the view that loss of articular congruity is associated with late development of articular degeneration but not with early wrist dysfunction.

Correlation between the functional outcome and the radiographic appearance of the wrist after a fracture of the distal radius remains debated. Also, many studies are reporting that there is no correlation between radiological and functional outcomes ^(9, 15).

This controversy may be due to the wide spectrum of injury patterns, different methodologies used by different investigators, and the number of possible parameters studied. Also, the patient's

demand and age play an important role in the difference in these results. This is following **Grewal and MacDermid** ⁽¹⁶⁾, who reported that isolated measures of mal alignment of the distal radius do not have a statistically significant effect on self-reported pain and disabilities.

One row Vs two rows strategy:

In this study, we performed a comparison between the numbers of distal screws as it may have as significant value. Using screws in only one or two rows of the distal portion of the plate is debatable.

Mehling et al. ⁽¹⁷⁾, recommend using at least 4 locking distal screws at least 2 in the distal row and 2 in the proximal row in the distal fragment gives enough stability to the implant-bone construct.

Moss et al. ⁽¹⁸⁾, made a biomechanical study which is confirmed that initial stiffness and higher failure load in fractures fixed distally with 7 locking screws, the results were not statistically significant compared with fractures fixed with only 4 screws.

In contrast, **Neuhaus et al.** ⁽¹⁹⁾, found that no advantage of 2 rows of distal screws over a single row of screws. Also, **Kawasaki et al.** ⁽²⁰⁾ concluded the same.

In our study, among 18 patients were operated, there were 11 patients in whom 2 rows of screws were placed in the distal part of Radius there results were Excellent and good, on the other hand, there were 7 Patients in whom 1 rows of screws were placed in the distal part of the radius, their results were good and fair. This was found to be statistically significant.

Complications:

In our study, the complication rate was 22.22 %. One patient had a tourniquet palsy which was resolved after one month of physiotherapy. One patient suffered from delayed wound healing. This resolved completely after one month. One patient had screw misplacement in the radio-ulnar joint that remains asymptomatic at the final follow up period.

Comparing our results with the results of **Khatri et al.** ⁽²¹⁾ the complication rate was 21.7% in the form of hardware prominence, loss of reduction, and tendon irritation. In their results, similarly, one patient had a screw malposition also.

Mehrzad and Kim ⁽¹⁷⁾ results are comparable to ours in their variable angle study group regarding nerve affection, tendon injuries, and hardware complications such as screw loosening, pain related to hardware, and tendon rupture.

In our study, there is no patient developed a tendon irritation or rupture. This may due to the low profile of the plate compared to the old 3.5 mm system. **Kwan et al.** ⁽¹⁸⁾, reported that the plates are much smaller, they can be placed more distally

allowing sub-chondral fixation and reduced tendon and soft tissue irritation.

Comparing between fixed angle and variable angled plates, **Mehrzad and Kim** ⁽¹⁷⁾ reported that a fixed-angle plate is positioned in a single location to provide optimal support of the subchondral bone across the articular surface. If the plates are positioned too proximal or angled to one side, subchondral support may be compromised, leading to dorsal migration of the distal fragment and prominent hardware, loosening, and/or tendinitis.

The position of variable angle plates proximal to watershed line permits giving subchondral support by using the screws with the desired angle this limits irritation of tendons.

CONCLUSIONS

There was a negative correlation between patients' age, sex, type of fracture, or presence of associated ulnar styloid fracture and the final score. This correlation was statistically insignificant. A correlation was found between the affected dominant hand or number of rows of distal screws and the final functional score. This was found to be statistically significant.

The newest concept the volar locking plates with angle stable screws are becoming widely used. Treatment of unstable distal radius fractures with a volar variable angle plate fixation is safe and effective. Using these plates is associated with excellent and good functional outcomes with a significant reduction of hardware complications.

REFERENCES

1. **Oc Y, Kilinc B, Armagan R et al. (2016):** Volar locking plating treatment results in fragmented intraarticular distal radius fractures. *Ser J Exp Clin Res.*, 17(1): 27-33.
2. **Hozack B, Tosti R (2019):** Fragment-Specific Fixation in Distal Radius Fractures. *Current Reviews in Musculoskeletal Medicine*, 12(2): 190-197.
3. **Raittio L, Launonen A, Hevonkorpi T et al. (2017):** Comparison of volar-flexion, ulnar-deviation, and functional position cast immobilization in the non-operative treatment of distal radius fracture in elderly patients. *BMC Musculoskeletal Disorders*, 18(1): 401.
4. **Arora R, Gabl M, Gschwentner M et al. (2009):** A comparative study of clinical and radiologic outcomes of unstable colles type distal radius fractures in patients older than 70 years: nonoperative treatment versus volar locking plating. *J Orthop Trauma*, 23(4):237-42.
5. **Meena S, Sharma P, Sambharia A et al. (2014):** Fractures of the distal radius: an overview. *Journal of Family Medicine and Primary Care*, 3(4): 325.
6. **Clutton J, Lewis J (2018):** Trauma. In *Radiology of Orthopedic Implants*. Springer, Cham. Pp. 117-147.
7. **MacDermid J, Roth J, Richards R (2003):** Pain and disability reported in the year following a distal radius fracture: a cohort study. *BMC Musculoskelet Disord.*, 4:24-27.
8. **Karnezis I, Panagiotopoulos E, Tyllianakis M et al. (2005):** Correlation between radiological parameters and patient-rated wrist dysfunction following fractures of the distal radius. *Injury*, 36(12): 1435-9.
9. **Ng C, McQueen M (2011):** What are the radiological predictors of functional outcome following fractures of the distal radius? *J Bone Joint Surg.*, 93: 145-150.
10. **Fleury T, Stern R (2014):** Classification of Long Bone Fractures. *European Surgical Orthopaedics and Traumatology: The EFORT Textbook*, Pp. 115-137.
11. **Braziulis K, Rimdeika R, Kregždutė R et al. (2014):** Associations Between the Fracture Type and Functional Outcomes After Distal Radial Fractures Treated with a Volar Locking Plate. *Medicina (Kaunas)*, 49(9): 399-402.
12. **Mulders M, Fuhri S, Sneathlaga L et al. (2018):** Functional outcomes of distal radius fractures with and without ulnar styloid fractures: a meta-analysis. *J Hand Surg Eur.*, 43(2):150-157.
13. **Kale S, Bhor P, Salunkhe R et al. (2016):** Correlation between the radiological and functional outcome of post-operative intra articular distal end radius fracture. *Ind J Appl Basic Med Res.*, 5(3): 906-909.
14. **Karnezis I, Panagiotopoulos E, Tyllianakis M et al. (2005):** Correlation between radiological parameters and patient-rated wrist dysfunction following fractures of the distal radius. *Injury*, 36: 1435-1439.
15. **Plant C, Parsons N, Costa M (2017):** Do radiological and functional outcomes correlate for fractures of the distal radius?. *Bone Joint J.*, 99(3): 376-382.
16. **Grewal R, MacDermid J (2007):** The risk of adverse outcomes in extra-articular distal radius fractures is increased with malalignment in patients of all ages but mitigated in older patients. *J Hand Surg Am.*, 32:962-970.
17. **Mehrzad R, Kim D (2016):** Complication Rate Comparing Variable Angle Distal Locking Plate to Fixed Angle Plate Fixation of Distal Radius Fractures. *Ann Plast Surg.*, 77: 623-625.
18. **Kwan K, Lau T, Leung F (2011):** Operative treatment of distal radial fractures with locking plate system a prospective study. *International Orthopaedics*, 35(3): 389-394.
19. **Mehling I, Müller L, Delinsky K et al. (2010):** Number and locations of screw fixation for volar fixed-angle plating of distal radius fractures: biomechanical study. *The Journal of Hand Surgery*, 35(6): 885-891.
20. **Moss D, Means K, Parks B et al. (2011):** A Biomechanical Comparison of Volar Locked Plating of Intra-Articular Distal Radius Fractures: Use of 4 Versus 7 Screws for Distal Fixation. *J Hand Surg.*, 36: 1907-1911.
- Khatri K, Sharma V, Farooque K et al. (2016):** Surgical Treatment of Unstable Distal Radius Fractures with a Volar Variable-Angle Locking Plate: Clinical and Radiological Outcomes. *Arch Trauma Res.*, 5(2): e25174.