

## Research Article

# Functional and Radiological Outcome of Volar Locking Plate Versus Percutaneous K-Wiring for Distal Radius Fractures: A Prospective Comparative Study

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**Abstract: Introduction:** Distal radius holds the most incidence of fractures in adults. Though the management is guided by fracture pattern and patient characteristics, volar locking plate (VLP) and percutaneous K-wire are most frequently used for surgically treating displaced distal radius fractures. There remains uncertainty pertaining the superiority of either method, making implant choice ambiguous for the treating surgeon. Hence, the objective of this study was to compare the outcome of volar locking plate and percutaneous K-wire fixation of displaced distal radial fractures based on assessment of functional and radiological outcome. **Materials and methods:** This prospective observational and comparative study conducted over a period of one year includes 80 adults presenting at a teaching tertiary care centre with a distal radius fracture following trauma. On fulfilling the inclusion criteria, they were included for the purpose of this study and were divided in two groups comprising 40 patients each – ORIF with volar locking plate (Group A) and percutaneous K wiring (Group B). They were subject to pre-operative clinical and radiological investigation, following which they were operated for either ORIF with volar locking plate or CRIF percutaneous K-wiring by a single senior Orthopaedic surgeon, ORIF volar plating under tourniquet and CRIF K-wiring without tourniquet, under fluoroscopy guidance. All patients were examined at 1 month and 6 months for functional assessment (range of motion, grip strength, modified Mayo wrist score and complications) and radiographic analysis (radial height, radial inclination, ulnar variance, volar tilt, articular step-off and RUSS – Radius Union Scoring System). Statistical analysis was performed for group comparison of functional outcome based on each functional and radiological assessment criteria using the chi square test with p value < 0.05 considered statistically significant. **Results:** The study cohort included 32 males (40%) and 48 females (60%) with age (19-76 years) mean of 54.5 years of which 54 fractures (67.5%) occurred on the dominant side whereas 26 fractures (32.5%) occurred on the non-dominant side. 36 cases (45%) were extra-articular whereas 44 cases (55%) were intra-articular with AO/OTA classification distribution of 36 type A, 38 type B and 6 type C cases. The mean range of motion was restricted for both groups at the early 1-month assessment for group B while it was comparable but better with volar locking plate at 6-months, with no statistical difference. However, the mean key pinch and total grip strength were significantly different (p < 0.05) at 1-month for both the groups with volar locking plate faring better; but the difference between two groups was insignificant at the 6-month assessment. The modified Mayo wrist score was comparable at the 1-month assessment, but there was a statistically significant difference (p < 0.05) at the 6-months assessment with group A (55-100 {85}) faring better over group B (55-100 {85}). At the 1-month assessment, superficial infection developed in one case of group A and two cases of group B, which were resolved conservatively with and one case of tendon (EPL) injury in group B. At the 6-months assessment, group A had one case each of CRPS (Complex Regional Pain Syndrome) and tendonitis; whereas, group B had three cases of CRPS and one case of malunion. The radiological assessment showed restored parameters for both fixation modalities with volar locking plate sustaining the achieved parameters to 6-months assessment whereas there was a loss in radial height, ulnar variance and volar tilt in those operated with K wire fixation. The 6-month assessment for difference in radial height and volar tilt of group A and group B was statistically significant (p < 0.05), depicting better radiological results with volar locking plate over 6 months. The union of fracture assessed using RUSS showed no significant difference in union rate between both groups over 1-month and 6-month assessment. Two cases (5%) of those operated with K-wiring had a residual articular step-off >2mm and one case had malunion. **Discussion:** Though there is no statistically significant difference in the functional results at both 1 and 6 months, cases with volar locking plate had a higher mean range of motion with a better and significantly greater modified Mayo wrist score after 6-months owing to sustained corrected radiological parameters and early initiated range of motion. Grip strength fared better for plating owing to early training and rehabilitation of muscles. Evidently, on account of higher rate

of CRPS with K-wiring, early initiation of range of motion and prophylaxis is mandated and iatrogenic injury to tendons during insertion must be prevented. The radiological parameters were restored better and the sustenance of this correction was superior with volar locking plate owing to a lesser risk of rotational displacement and improved fracture site stability with a hold on the restored articular margin for intra-articular (AO/OTA type B and C) distal radius fractures. **Conclusion:** Outcomes with both volar locking plate and percutaneous K-wiring have comparable range of motion, but the former ensures adequate restoration of radiographic characteristics, achieving the sustenance of reduction parameters over time, allows early range of motion, hence resulting in a better and optimal long term functional outcome. However, no overall statistically significant difference was found in functional and radiological outcome on fixation of distal radius fractures by the two modalities.

**Keywords:** distal radius, wrist fracture, plating, K wiring

## INTRODUCTION

Distal radius accounts for the most incidence of fractures in adult population, especially in young males following trauma or elderly osteoporotic females<sup>1</sup>. In recent years, management of displaced distal radius fractures has been subject to a debate comparing outcomes of different surgical modalities, pertaining early and satisfactory functional results<sup>2</sup>. Though the management is guided by fracture pattern and patient characteristics, volar locking plate and percutaneous K-wire remain the most frequently adopted implants for surgically managing displaced distal radius fractures and there exists lack of concrete evidence regarding the best surgical treatment; as reported by a Cochrane Collaboration summary. This uncertainty pertaining the superiority of either method makes implant choice ambiguous for the treating surgeon. Hence, the objective of this study is to compare the outcome of volar locking plate (VLP) versus percutaneous K-wire fixation of displaced distal radial fractures based on assessment of functional and radiological outcome, according to established criteria.

## MATERIALS AND METHODS

Institutional Ethics Committee (IEC) approval was obtained for conducting this study and no patient identity has been revealed. This is a prospective observational and comparative study which was conducted over a period of one year and includes 80 adults (n=80), presenting at a teaching tertiary care health facility with a distal radius fracture following trauma. They were managed by a single senior Orthopaedic surgeon and subject to pre-operative clinical and radiological investigation. Cases were included for the purpose of this study based on definitive criteria, framed as follows – Inclusion criteria: 1. Age > 18 years, 2. Unilateral distal radius fractures (both extra-articular and intra-articular), 3. Fit for surgery, 4. Consenting patients and 5. Follow-up available. Exclusion criteria: 1. Open fractures, 2. Associated ulnar (also ulnar styloid) fracture, 3. Ipsilateral upper limb bony or soft tissue injury, 4. Bilateral distal radius fractures, 5. Unfit for surgery, 6. Non consenting patients and 7. Lost follow-up.

The operative modality selected was based on the fracture type and patient characteristics. On fulfilling the inclusion criteria, cases were divided in two groups pre-

operatively, comprising 40 patients each – ORIF with volar locking plate (Group A) and percutaneous K wiring (Group B). Following the distribution and on availing pre-operative fitness and consent, patients were operated by a single senior surgeon with ORIF volar plating (n=40) under tourniquet and CRIF K-wiring (n=40) without tourniquet, under fluoroscopy guidance. All K-wires were removed at 45 days subject to radiological assessment. Post-operative PoP slab was given to all cases operated for percutaneous K-wiring while it differed on case basis for those operated with volar locking plate. Rehabilitation and physiotherapy were case tailored. All patients were examined at 1 month and 6 months for functional assessment (range of motion, grip strength using Jamar dynamometer, modified Mayo wrist score and complications) and radiographic analysis (radial height, radial inclination, ulnar variance, volar tilt, articular step-off and RUSS – Radius Union Scoring System). Statistical analysis and comparative assessment were performed for group comparison of functional outcome based on each functional and radiological assessment criteria using the chi square test with *p value* < 0.05 considered statistically significant.

**Table 1**

STUDY VARIABLES	
<b>AGE GROUP (YEARS)</b>	
19-30	6
30-40	14
40-50	19
50-60	16
60-70	18
>70	7
<b>TOTAL</b>	80
<b>GENDER</b>	
MALES	32
FEMALES	48
<b>SIDE</b>	
RIGHT	37
LEFT	43
DOMINANT	54
NON-DOMINANT	26
<b>CLASSIFICATION (AO/OTA)</b>	
TYPE A	36
TYPE B	38
TYPE C	6

## RESULTS

The study cohort included 32 males (40%) and 48 females (60%) with a mean age of 54.5 years and range 19-76 years. Of the 80 cases, 37 were right sided and 43 were left sided with majority of them, 54 fractures (67.5%) occurred on the dominant side whereas 26 fractures (32.5%) occurred on the non-dominant side. The AO/OTA classification distribution included 36 type A, 38 type B and 6 type C cases, i.e. 36 cases (45%) were extra-articular whereas 44 cases (55%) were intra-articular.

On functional assessment, the mean range of motion was restricted for both groups at the early 1-month assessment but group A fared better without any statistically significant difference, presumably on account of a stable fixation and early onset range of motion. However, the functional range of motion improved and was comparable for both groups but still better with volar locking plate at 6-months, though without any statistically significant difference. The mean key pinch and total grip strength were significantly different ( $p < 0.05$ ) at 1-month for both the groups with volar locking plate faring better; but the difference between two groups was insignificant at 6-months assessment. The modified Mayo wrist score was comparable for both the groups at the 1-month assessment, but there was a statistically significant difference ( $p < 0.05$ ) at the 6-months assessment with group A (55-100 {85}) faring better over group B (55-100 {85}). At the 1-month assessment, superficial infection developed in one case of group A and two cases of group B, which resolved with conservative management; however, one case in Group B developed EPL tendon weakness which had to be managed by revising the dorsal K-wire insertion. At the 6-months assessment, group A had one case each of CRPS (Complex Regional Pain Syndrome) and tendonitis; whereas, group B had three cases of CRPS, all managed conservatively with medication and physiotherapy. One case in group B had severe wrist deformity, which was diagnosed as malunion on radiographs and was subject to revision with bone grafting and plating.

**Table 2**

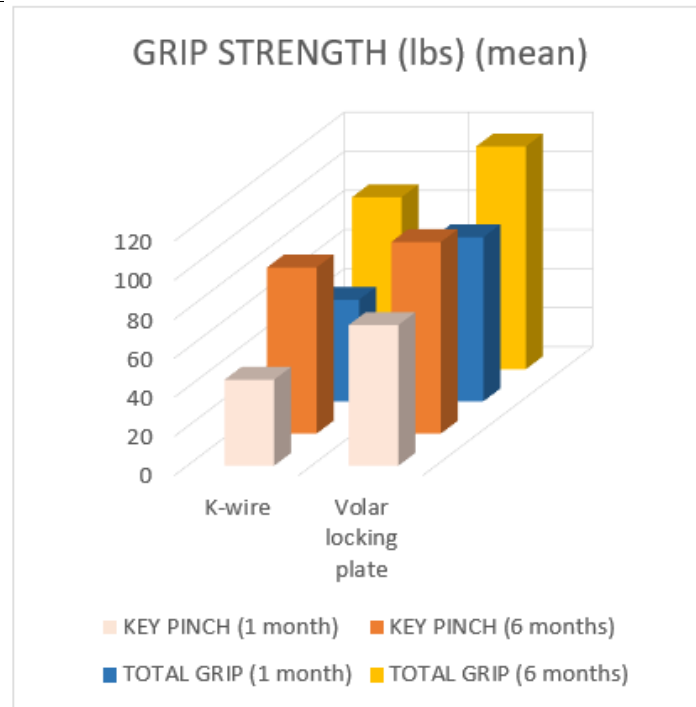
<b>FUNCTIONAL ASSESSMENT</b>			
<b>1 MONTH</b>			
	<b>RANGE OF MOTION (°) (WRIST) (MEAN)</b>		<b>p-VALUE (FROM MEAN)</b>
	<b>VOLAR LOCKING PLATE</b>	<b>PERCUTANEOUS K WIRE</b>	
DORSIFLEXION	25-75 (45)	18-62 (36)	>0.05
PALMARFLEXION	20-70 (35)	10-54 (28)	>0.05
ULNAR DEVIATION	5-36 (12)	4-15 (10)	>0.05
RADIAL DEVIATION	0-20 (15)	0-12 (10)	>0.05
SUPINATION	30-50 (34)	15-40 (22)	>0.05
PRONATION	20-60 (38)	15-45 (32)	> 0.05
	<b>GRIP STRENGTH (lbs) (MEAN)</b>		
KEY PINCH	20-104 (72)	12-96 (44)	0.03
TOTAL GRIP	28-130 (84)	16-106 (52)	0.04
	<b>MODIFIED MAYO WRIST SCORE (MEAN)</b>		
	45-85 (55)	25-75 (45)	>0.05
	<b>COMPLICATIONS</b>		
	SUPERFICIAL INFECTION (1 CASE)	SUPERFICIAL INFECTION (2 CASES) AND TENDON INJURY (WEAK EPL- 1 CASE)	
<b>6 MONTHS</b>			
	<b>RANGE OF MOTION (WRIST) (MEAN)</b>		<b>p-VALUE (FROM MEAN)</b>
	<b>VOLAR LOCKING PLATE</b>	<b>PERCUTANEOUS K WIRE</b>	
DORSIFLEXION	35-80 (65)	20-75 (45)	>0.05
PALMARFLEXION	30-75 (55)	15-65 (35)	>0.05
ULNAR DEVIATION	10-48 (32)	10-40 (28)	>0.05
RADIAL DEVIATION	6-25 (20)	0-22 (15)	>0.05
SUPINATION	40-80 (65)	25-75 (45)	>0.05

PRONATION	30-75 (60)	30-65 (40)	>0.05
	GRIP STRENGTH (lbs) (MEAN)		
KEY PINCH	28-128 (98)	14-116 (85)	>0.05
TOTAL GRIP	46-148 (114)	38-132 (88)	>0.05
	MODIFIED MAYO WRIST SCORE (MEAN)		
	55-100 (85)	35-85 (70)	0.03
	COMPLICATIONS		
	- CRPS (1 CASE) - TENDONITIS (1 CASE)	- CRPS (3 CASES) - DEFORMITY	

The radiological assessment showed restored parameters for both of the fixation modalities with volar locking plate sustaining the achieved parameters to 6-months assessment whereas there was a loss in radial height, ulnar variance and volar tilt in those operated with K-wire fixation. The 6-month assessment for difference in radial height and volar tilt of group A and group B was statistically significant ( $p < 0.05$ ), depicting better radiological results with volar locking plate over 6 months. The fracture union assessed using RUSS showed no significant difference between both groups over 1-month and 6-month assessment. Two cases (5%) of those operated with K-wiring had a residual articular step-off >2mm and one case of malunion which was managed by revision surgery with bone grafting and plating.

**Table 3**

<b>RADIOLOGICAL ASSESSMENT</b>			
<b>1 MONTH</b>			
<b>PARAMETERS ON PLAIN RADIOGRAPH (MEAN)</b>			<b>p-VALUE (FROM MEAN)</b>
	<b>VOLAR LOCKING PLATE</b>	<b>PERCUTANEOUS K WIRE</b>	
RADIAL HEIGHT (mm)	9-16 (13)	9-13 (12)	0.06
RADIAL INCLINATION (°)	19-26 (23)	18-24 (22)	0.07
ULNAR VARIANCE (mm)	-1 TO +3 (+1)	-2 TO +3 (+1)	0.07
VOLAR TILT (°)	9-14 (12)	7-12 (10)	0.06
ARTICULAR STEP OFF (>2mm)	-	2 CASES	
<b>RADIUS UNION SCORING SYSTEM (RUSS) (MEAN)</b>			
	3-5 (5)	2-5 (4)	0.07
<b>6 MONTHS</b>			
<b>PARAMETERS ON PLAIN RADIOGRAPH (MEAN)</b>			<b>p-VALUE (FROM MEAN)</b>
	<b>VOLAR LOCKING PLATE</b>	<b>PERCUTANEOUS K WIRE</b>	
RADIAL HEIGHT (mm)	9-15 (12)	8-12 (10)	0.04
RADIAL INCLINATION (°)	18-25 (22)	16-24 (19)	0.07
ULNAR VARIANCE (mm)	-2 TO +3 (+1)	-3 TO +3 (+1)	0.07
VOLAR TILT (°)	8-13 (11)	6-10 (8)	0.03
ARTICULAR STEP OFF (>2mm)	-	2 CASES	
GROSS DISPLACEMENT	-	MALUNION - 1 CASE	
<b>RADIUS UNION SCORING SYSTEM (RUSS) (MEAN)</b>			
	6-8 (8)	6-8 (7)	0.08



**Figure 1**

Hence, overall, statistically significant differences were found in grip strength at 1-month assessment, modified Mayo wrist score at 6-months assessment and radial height and volar tilt on radiological assessment; all in favor of volar locking plating.

## DISCUSSION

By end of the last century, use of locking angular stability plates applied through volar approach had been introduced and this laid the basis of a stronger construct, long term hold of the fragments, accurate joint line reconstruction and immediate range of motion without the risk of loss of reduction. However, the use of K-wires for percutaneous fixation of distal radius fractures had been gold standard before locking plates gained popularity; and K-wires still continue to be preferred for extra-articular fractures in young patients since they have merit of a closed percutaneous fixation. Yet, they come with de-merits including the need of immobilization, risk of loss of reduction and late onset of range of motion. Hence, need arises for a comparative analysis of functional and radiological outcomes following distal radius fracture fixation with either volar locking plate or percutaneous K-wiring.

The results of this study suggest that management of fractures of the distal radius, especially intra-articular type B and C, with VLP tend to have a better overall clinical and radiographic result compared to percutaneous wire fixation. Though pinning also provides satisfactory results, especially in less complex articular or extraarticular fractures of young patients, it delays return to activity. Hence, fixation modality must be chosen on the fracture pattern, patient characteristics and plan for post-operative rehabilitation.

The main advantages of internal fixation with plate and screws are represented by the anatomical reconstruction

of the fragments and articular surface, if the joint is involved. Moreover, it allows early mobilization of the wrist, hence reducing the time to restore range of motion and return to routine daily activity. The possibility of obtaining optimal restoration of the wrist anatomy, direct visualization of the fracture and maintenance of the achieved reduction, support to subchondral bone and articular fragments, applicability in the presence of metaphyseal comminution or osteoporosis and use of bone grafts with allowance of early mobility preventing muscle weakness and joint stiffness are all to the benefit of VLP.

On the other hand, percutaneous pin or Kirschner wire fixation holds advantage of being easier to perform, less invasive with a shorter surgical duration and cheaper<sup>3</sup>. Failure of K-wire fixation to maintain reduction in all patients, particularly in osteoporotic bone, has been previously reported. It is also evident that radial height, ulnar variance and volar tilt cannot be maintained with percutaneous pins and the loss of radiographic position correlates directly with suboptimal function.

On taking account of different studies, results comparing VLP and K-wiring follow-up, statistically significant differences were found in terms of flexion, extension and ulnar deviation in the study by Lee et al., in flexion, extension and supination by Marcheix et al. and in flexion by Dzaja et al. In the studies by Karantana et al. and Rozental et al., the VLP group showed better results in all ROM parameters at 6 weeks after surgery. However, no differences were detected at 12 months of

follow-up<sup>4</sup>. Five studies recorded no statistically significant difference between the two groups; conversely, other four studies found significant better outcomes in the patients undergoing plating. Biomechanical studies have demonstrated that volar locking plates are considerably more stable than percutaneous pins in unstable distal radius fractures. The locking screws create a rigid construct that allows the transfer of axial load across the fracture site and the implant supports the reduction until complete bone healing occurs<sup>5</sup>.

Drawbacks and shortcomings of K-wiring, as reported in the literature include a higher risk of secondary displacement, loss of radial height in osteoporotic bone, need for additional immobilization. Although it works well for young patients having good bone stock, especially with extra-articular fractures; but, a more stable fixation with VLP may be superior in terms of faster return to full professional and daily living activity in active and younger patients. Hence, of importance is to optimize the subjective patient outcome along with other perspectives of fixation<sup>6</sup>.

A meta-analysis found that volar locking plates show better DASH scores at 3- and 12-month follow-up compared with K-wires for displaced distal radius fractures in adults; however, these differences were small and unlikely to be clinically important<sup>7</sup>. Similarly in our study, although there is no statistically significant difference in the functional range of motion at both 1 and 6 months, cases with volar locking plate fared a higher mean range of motion, a statistically significant greater modified Mayo wrist score after 6-months owing to sustained corrected radiological parameters and early initiated range of motion, however with a risk of tendonitis<sup>8</sup>. Grip strength fared better for plating owing to early training and rehabilitation of muscles. Evidently, on account of higher rate of CRPS with K-wiring, early initiation of range of motion and prophylaxis is mandated and iatrogenic injury to tendons during insertion must be prevented. The radiological parameters were restored better and the sustenance of this correction was superior with volar locking plate owing to a lesser risk of rotational displacement and improved fracture site stability with a hold on the restored articular margin for intra-articular (AO/OTA type B and C) distal radius fractures with better but statistically insignificant radiological outcome based on the RUSS.

Limitation of study include a relatively short follow-up period, smaller cohort and no randomisation during selection of fixation modality. Further research is required to better delineate if there are specific radiographic, injury, or patient characteristics that may benefit from volar locking plates in the short term and whether there are any differences in long-term outcomes and complications in either plating or K-wiring.

## CONCLUSION

The overall results of this study do not demonstrate a clear superiority of either fixation method for the surgical management of distal radius fractures. Open reduction and internal fixation with a volar locking plate and closed reduction with percutaneous K-wire fixation provide comparable excellent clinical and radiographic results in patients with distal radial fractures. At 6 months from the procedure, clinical results seem to favour patients treated with plating, but there were no significant differences between the two types of treatment at long term follow-up.

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