

Management of Intra-Articular Distal Radius Fractures by Open Reduction Internal Fixation and Plate Osteosynthesis Vs Ligamentotaxis : A Comparative Study

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Abstract: AIM: To analyze and compare the functional and radiological outcome of different methods of surgical management of intra-articular distal radius fractures in 50 patients treated by either open reduction, internal fixation and plate osteosynthesis using distal radius volar locking plate or by closed reduction and ligamentotaxis using external fixator with the addition of k wires.

MATERIALS AND METHODS: This prospective interventional study was conducted among 50 patients with distal radius intra-articular fracture, treated by either open reduction internal fixation and plate osteosynthesis using distal radius volar locking plate or by closed reduction and ligamentotaxis using external fixator with the addition of k wires if needed in our institute between July 2020 and November 2022 over a period of 2 years and 5 months.

RESULTS: In our study, there were 43 male and 7 female patients, most of whom were in the age group 30-50 years (48%). The mode of injury in most cases was RTA (Road traffic accident). Out of 50 patients, 25 were treated by Open reduction, internal fixation with Volar locking compression plate and 24 were treated by Closed reduction and external fixation augmented by K wire fixation (Ligamentotaxis). There was also found to be no significant difference in the radiological outcome in both groups of patients, i.e Radial length ($p=0.253$), Palmar tilt ($p=0.08$), Radial inclination ($p=0.075$) and articular step-off ($p=0.207$). In terms of functional outcome of both procedures, only significant difference was found to in palmar flexion of the wrist joint ($p=0.003$) with better range of palmar flexion seen in the Open reduction and internal fixation with volar locking compression plate group. There was no significant difference seen in dorsiflexion, ulnar and radial deviation, supination and pronation between both surgical techniques. We had a few complications such as malunion, pin loosening and wrist stiffness in our study, majority of which was seen in the Ligamentotaxis group, but it had no statistical significance. A mean DASH score of 11.788 was seen in the VLCP group and 15.192 was seen in the Ligamentotaxis group, the difference was not statistically significant.

Keywords: We conclude that both Open reduction internal fixation with volar locked plating and Closed reduction with external fixation (Ligamentotaxis) may be performed with effective functional and radiologic outcome in patients with intra-articular fractures of the distal radius, however long term follow-up is required.N

INTRODUCTION

Fractures of the distal radius are among the most common fractures in adults.^[1] They may occur after a low energy trauma such as fall on outstretched hand in the elderly, or following high velocity trauma due to road traffic accidents or sports injuries in younger people. As such, the fractures of distal radius follow a bimodal distribution with regards to age.

Most intra-articular fractures are unstable and require surgical management to restore anatomical alignment of the bone and subsequent optimal functional ability.^[2-4] Also, surgical fixation allows an earlier return to function as compared to plaster cast immobilization.

Both open reduction with internal fixation and indirect (closed) reduction and ligamentotaxis are generally accepted methods of surgical treatment at present depending on the individual fracture characteristics and yield comparable outcomes yet the superiority of one over the other is to be proven.^[5,6]

Indications for surgical treatment should be based on radiographic findings after initial reduction, expected functional needs, associated medical comorbidities and the presence of other injuries. Certain studies have shown internal fixation following open reduction to be more effective, a few have shown external fixation to be better, when most others have reported equivocal results.^[4, 7-10]

The primary technique of treating distal radius fractures in the past has been closed reduction and cast immobilization but complications are seen frequently, namely malunion of the fracture and subluxation /dislocation of distal radioulnar joint, leading to poor functional, radiographic and cosmetic results.^[11]

The residual deformity that occurs in the malunited wrist adversely affected the function of the wrist and hand by diminishing the function of the extrinsic muscles of the forearm compartments producing movement across the wrist due to variance of position.^[12]

Also, posttraumatic arthritic changes of the radiocarpal and distal radioulnar joint due to malreduction cause pain, limitation movement of the wrist and forearm, and a reduction in grip strength.^[13, 14]

Open reduction and internal fixation has come to be a means of achieving anatomical reduction and its maintenance. Any metaphyseal defect may also be grafted at the time of open reduction, although it is not generally indicated in fresh fractures in patients with good bone quality.^[15]

Ligamentotaxis by closed reduction and fixation using bridging external fixators is another efficient technique of restoring anatomy, especially in the case of severely comminuted fractures with loss of radial height. The traction force applied through surrounding soft tissues (ligamentotaxis) is effective in maintaining the reduction following fixation, as first demonstrated by Anderson and O Neil and supported by multiple other studies that have followed.^[16, 17, 18]

The purpose of this study is to bring out the differences, if any, between either technique and to conclude the better technique to provide the best possible outcome in terms of function to the patient.

MATERIALS AND METHODS

Study area: Saveetha Medical College and Hospital

Study design: Prospective interventional study

Study period: July 2020 and November 2022

Study population: Patients with a clinical and radiological diagnosis of intra-articular distal radius fracture (AO Types B and C)

Sample size: 50

Sampling technique: Non random sampling- Convenience sampling

Inclusion criteria:

- Patients who are in the age group of 18-80 years of age, who were functionally active prior to injury
- Patients of either sex
- Patients with intra-articular distal radius fractures
- Patients consenting for a surgical intervention
- Patients who agree to follow up for a minimum of 6 months

Exclusion criteria:

- Patients with compound fractures
- Patients with distal radius fracture not extending into the articular surface
- Patients with pre-existing wrist joint stiffness/pain
- Patients who underwent native treatment prior to presentation
- Patients not consenting for a surgical intervention
- Patients who do not agree for a follow up
- Skeletally immature individuals

Outcome measures:

Clinical review: 2 weeks, 6 weeks, 3 months, 6 months

Radiological followup: 6 weeks, 3 months, 6 months

Fracture union will be determined radiologically

Functional scoring system: DASH score- The Disabilities of the Arm, Shoulder and Hand Score

Post-op protocol:

The operated limb was elevated in a saline stand.

A broad spectrum antibiotic was given intravenously post surgery (Single dose)

POD-0 Active finger mobilization was initiated

POD-1 Active wrist range of motion exercises was initiated in patients who underwent ORIF with volar locking plate fixation and Active finger mobilization was continued in patients who underwent closed reduction and ligamentotaxis. Both groups of patients were also started on forearm, elbow and shoulder mobilization exercises.

Regular dressing was done on POD- 2, 5, 8, followed by suture removal on POD-10 and daily pintrack dressing was done for patients with external fixator

At 6 weeks, external fixator and k wires were removed and Active wrist range of motion exercises were started for patients who underwent ligamentotaxis

Statistical Analysis:

Analysis of statistical was done using SPSS version 19.0. Chi square tests were done to compare data like type of fracture, age groups, complications ad DASH score.

P value less than or equal to 0.005 was considered significant.

OBSERVATIONS AND RESULTS

Table 1 Age in years

Age in years	No. of Cases	Percentage
Less than 30 years	17	34%
30-50 years	24	48%
Greater than 50 years	9	18%
Total	50	100%

The majority of patients were between 30-50 years (48%). 34% of patients were Less than 30 years and 18% of patients were Greater than 50 years of age.

Age in years

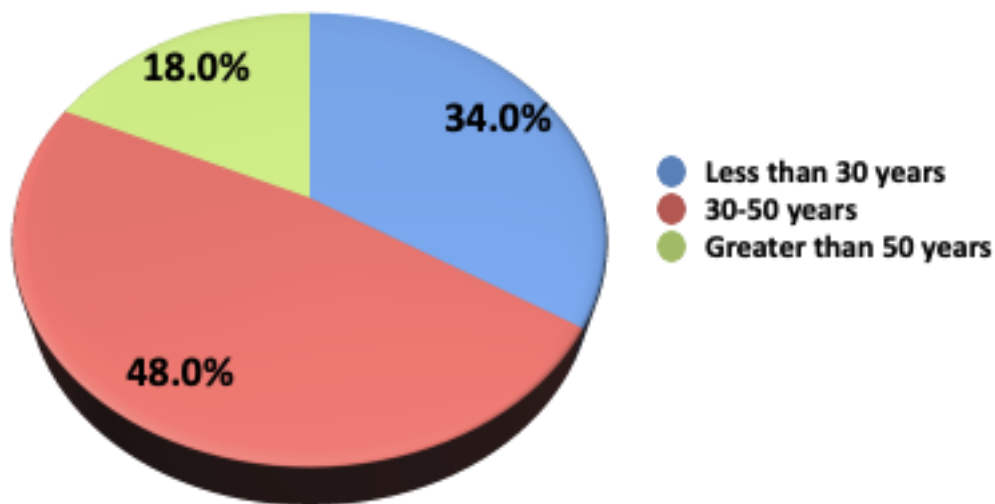


Table 3 Sex of the patients

Sex	No. of Cases	Percentage
Male	43	86%
Female	7	14%
Total	50	100%

The maximum numbers of patients were Male (86%). 14% of patients were Female.

Table 4 Mode of Injury

Mode of Injury	No. of Cases	Percentage
Fall From Height	4	8%
Fall on Outstretched Hand	7	14%
Road Traffic Accident	39	78%
Total	50	100%

Out of 50 patients majority of them had injury from Road Traffic Accident (78%). 14% of patients had injury from Fall on Outstretched Hand and 8% of patients had injury from Fall From Height.

Table 5 A.O.Type

A.O.Type	No. of Cases	Percentage
2R3B2	16	32%
2R3B3	15	30%
2R3C1	4	8%
2R3C2	10	20%
2R3C3	5	10%
Total	50	100%

In our study, most of the patients were in A.O. type of 2R3B2 (32%). 30% of patients were in A.O. type of 2R3B3 and 20% of patients were in A.O. type of 2R3C2. Similarly 10% of patients were in A.O. type of 2R3C3 and 8% of patients were in A.O. type of 2R3C1.

A.O.Type

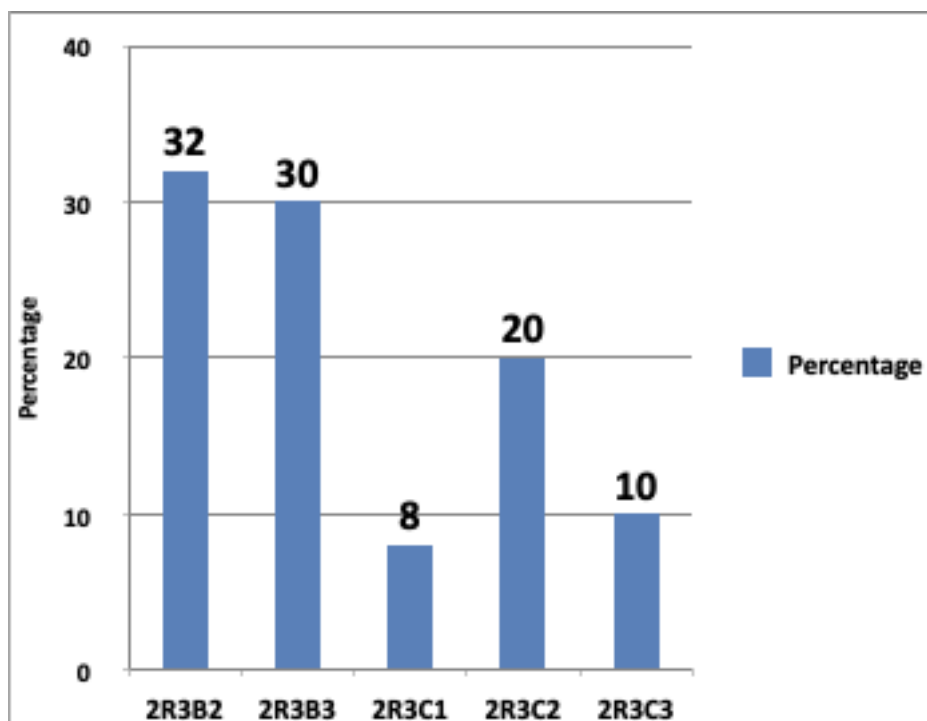


Table 6 Side of Injury

Side of Injury	No. of Cases	Percentage
Left Side	25	50%
Right Side	25	50%
Total	50	100%

The result shows that half of the patients had injury on Left Side (50%). 50% of patients had injury on Right Side.

Table 7 Associated Injuries

Associated Injuries	No. of Cases	Percentage
Head Injury	3	6%
Left humerus shaft fracture	1	2%
Left proximal humerus fracture	1	2%
Left shaft of femur fracture	1	2%
No Associated Injuries	44	88%
Total	50	100%

The majority of patients had No Associated Injuries (88%). 6% of patients had Head Injury and 2% of patients had Left humerus shaft fracture. Similarly 2% of patients had Left proximal humerus fracture and 2% of patients had Left shaft of femur fracture.

Table 8 Procedure undergone

Procedure	No. of Cases	Percentage
VLCP	25	50%
Exfix and K Wire	25	50%
Total	50	100%

Half of the patients were treated with VLCP procedure (50%). 50% of patients were treated with Exfix and K Wire procedure.

Table 9 Relation between Age in years and Procedure

Procedure	N	Mean	SD	t Value	P Value
VLCP	25	34.760	12.146	-1.637	0.108
Exfix and K Wire	25	41.160	15.321		

The independent 't' test results shows that there is no significant difference in mean of Age in years with respect to the Procedure (t value=-1.637, P=0.108).

Table 10 Correlation between Age in years and Procedure

			Procedure		Total
			VLCP	Exfix and K Wire	
Age in years	Less than 30 years	Count	9	8	17
		% within Procedure	36.0 %	32.0%	34.0%
	30-50 years	Count	14	10	24
		% within Procedure	56.0 %	40.0%	48.0%
	Greater than 50 years	Count	2	7	9
		% within Procedure	8.0%	28.0%	18.0%
Total	Count	25	25	50	
	% within Procedure	100.0 %	100.0%	100.0%	

Chi-Square Value = 3.503 P value = 0.173 Not Significant

The chi-square test shows that there is no significant difference between the groups with respect to Age in years ($p=0.173$).

Table 11 Correlation between Mode of Injury and Procedure

			Procedure		Total
			VLCP	Exfix and K Wire	
Mode of Injury	Fall From Height	Count	2	2	4
		% within Procedure	8.0%	8.0%	8.0%
	Fall on Outstretched Hand	Count	3	4	7
		% within Procedure	12.0%	16.0%	14.0%
	Road Traffic Accident	Count	20	19	39
		% within Procedure	80.0%	76.0%	78.0%
Total	Count	25	25	50	
	% within Procedure	100.0%	100.0%	100.0%	

Chi-Square Value = 0.168 P value = 0.919 Not Significant

The chi-square test shows that there is no significant difference between the groups with respect to Mode of Injury ($p=0.919$).

Table 12 Correlation between A.O.Type and Procedure

			Procedure		Total
			VLCP	Exfix and K Wire	
A.O.Type	2R3B2	Count	7	9	16
		% within Procedure	28.0%	36.0%	32.0%
	2R3B3	Count	10	5	15
		% within Procedure	40.0%	20.0%	30.0%
	2R3C1	Count	3	1	4
		% within Procedure	12.0%	4.0%	8.0%
	2R3C2	Count	2	8	10
		% within Procedure	8.0%	32.0%	20.0%
	2R3C3	Count	3	2	5
		% within Procedure	12.0%	8.0%	10.0%
	Total	Count	25	25	50
		% within Procedure	100.0%	100.0%	100.0%

Chi-Square Value = 6.717 P value = 0.152 Not Significant

The chi-square test shows that there is no significant difference between the groups with respect to A.O.Type ($p=0.1$).

Table 13 Relation between Days to Surgery and Procedure

Procedure	N	Mean	SD	t Value	P Value
VLCP	25	1.560	0.961	-1.274	0.209
Exfix and K Wire	25	1.960	1.241		

The independent 't' test results shows that there is no significant difference in mean of Days to Surgery with respect to the Procedure (t value=-1.274, P=0.209).

Relation between Days to Surgery and Procedure

Table 14 Mean comparison of Radiological Findings between VLCP group and External fixation with additional K Wire

Radiological Findings	VLCP (Mean±SD)	Exfix and K Wire (Mean±SD)	t Value	P Value
Radial Length (mm)	10.208±0.833	9.92±0.909	1.156	0.253
Palmar Tilt (degrees)	8.54.304	5.96±5.534	1.788	0.08
Radial Inclination (degrees)	20.25±2.967	18.76±2.758	1.822	0.075
Articular Stepoff (mm)	0.958±0.624	1.16±0.473	-1.279	0.207

The independent t test result shows that there is no significant difference in Radiological findings between the groups.

Table 15 Relation between Palmar Flexion and Procedure

Procedure	N	Mean	SD	t Value	P Value
VLCP	24	70.417	4.872	3.116	0.003*
Exfix and K Wire	25	65.400	6.278		

*-Significant

The independent 't' test results shows that **there is a significant difference in mean of Palmar Flexion with respect to the Procedure (t value=3.116, P=0.003*)**.

Table 16 Relation between Dorsiflexion and Procedure

Procedure	N	Mean	SD	t Value	P Value
VLCP	24	66.458	4.032	0.933	0.356
Exfix and K Wire	25	65.200	5.299		

The independent 't' test results shows that there is no significant difference in mean of Dorsiflexion with respect to the Procedure (t value=0.933, P=0.356).

Table 17 Relation between Supination, Pronation and Procedure

	Procedure	N	Mean	SD	t Value	P Value
Supination	VLCP	24	68.542	3.753	1.892	0.065
	Exfix and K Wire	25	65.800	6.069		
Pronation	VLCP	24	67.292	5.103	-0.291	0.772
	Exfix and K Wire	25	67.800	6.934		

The independent 't' test results shows that there is no significant difference in mean of Supination with respect to the Procedure (t value=1.892, P=0.065) and also there is no significant difference in mean of Pronation with respect to the Procedure (t value=-0.291, P=0.772).

Table 18 Relation between Radial Deviation, Ulnar Deviation and Procedure

	Procedure	N	Mean	SD	t Value	P Value
Radial Deviation	VLCP	24	14.792	1.793	0.864	0.392
	Exfix and K Wire	25	14.320	2.015		
Ulnar Deviation	VLCP	24	22.292	3.895	0.745	0.46
	Exfix and K Wire	25	21.400	4.454		

The independent 't' test results shows that there is no significant difference in mean of Radial Deviation with respect to the Procedure (t value=0.864, P=0.392) and also there is no significant difference in mean of Ulnar Deviation with respect to the Procedure (t value=0.745, P=0.46).

Table 19 Mean comparison of Functional outcome between VLCP group and External fixation with additional K Wire

Functional outcome	VLCP group (Mean±SD)	Exfix and K Wire (Mean±SD)	t Value	P Value
Palmar Flexion	70.417±4.872	65.4±6.278	3.116	0.003*
Dorsiflexion	66.458±4.032	65.2±5.299	0.933	0.356
Supination	68.542±3.753	65.8±6.069	1.892	0.065
Pronation	67.292±5.103	67.8±6.934	-0.291	0.772
Radial Deviation	14.792±1.793	14.32±2.015	0.864	0.392
Ulnar Deviation	22.292±3.895	21.4±4.453	0.745	0.46

*-Significant

The independent t test result shows that **there is a significant difference in Palmar Flexion value between the groups (p=0.003) with better palmar flexion in VLCP fixation group. Rest of the functional outcome parameters didn't have any significant difference between the groups.**

Table 20 Correlation between Complications and Procedure

			Procedure		Total
			VLCP	Exfix and K Wire	
Complications	Malunion	Count	0	2	2
		% within Procedure	0.0%	8.0%	4.0%
	Pin Loosening	Count	0	2	2
		% within Procedure	0.0%	8.0%	4.0%
	Stiffness	Count	3	4	7
		% within Procedure	12.0%	16.0%	14.0%
	No Complications	Count	22	17	39
		% within Procedure	88.0%	68.0%	78.0%
Total	Count	25	25	50	
	% within Procedure	100.0%	100.0%	100.0%	

Chi-Square Value = 4.784 P value = 0.188 Not Significant

The chi-square test shows that there is no significant difference between the groups with respect to Complications (p=0.188).

Table 21 Relation between DASH Score and Procedure

Procedure	N	Mean	SD	t Value	P Value
VLCP	24	11.788	5.171	-1.846	0.071
Exfix and K Wire	25	15.192	7.480		

The independent ‘t’ test results shows that there is no significant difference in mean of DASH Score with respect to the Procedure (t value=-1.846, P=0.071).

In our study, there were 43 male and 7 female patients, most of whom were in the age group 30-50 years (48%). The mode of injury in most cases was RTA (Road traffic accident), followed by fall on outstretched hand and fall from height.

Most of our patients had no associated injuries (88%), except a few of whom 3 patients had head injury, 1 patient each had a left humerus shaft fracture, a left proximal humerus fracture and a left shaft of femur fracture.

Out of 50 patients, 25 were treated by Open reduction, internal fixation with Volar locking compression plate and 24 were treated by Closed reduction and external fixation augmented by K wire fixation (Ligamentotaxis).

There was no significant difference in the AO types of the fractures distributed across both groups of fixation techniques.

There was also found to be no significant difference in the radiological outcome in both groups of patients, i.e Radial length (p=0.253), Palmar tilt (p=0.08), Radial inclination (p=0.075) and articular step-off (p=0.207).

In terms of functional outcome of both procedures, only significant difference was found to in palmar flexion of the wrist joint (**p=0.003**) with better range of palmar flexion seen in the Open reduction and internal fixation with volar locking compression plate group.

There was no significant difference seen in dorsiflexion, ulnar and radial deviation, supination and pronation between both surgical techniques.

We had a few complications such as malunion, pin loosening and wrist stiffness in our study, majority of which was seen in the Ligamentotaxis group, but it had no statistical significance.

A mean DASH score of 11.788 was seen in the VLCP group and 15.192 was seen in the Ligamentotaxis group, the difference was not statistically significant.

DISCUSSION

Distal radius fractures are among the commonest injuries encountered by an Orthopedic surgeon, with more and more being seen in younger individuals following high energy trauma.

With increasing evidence of the need for anatomical reduction and surgical fixation for return to optimal function, there also arises a question on the surgical technique to be employed.^[19]

Intra-articular fractures in particular, especially ones that are comminuted require open or closed reduction to restore anatomy and surgical fixation to maintain congruity of the joint surface.

In our study, we compared two different surgical techniques that have both been successfully employed in the past to treat intra-articular fractures of the distal radius, namely Open reduction and internal fixation with volar locking compression plate and Closed reduction with external fixation, augmented with K wire fixation, following the principle of ligamentotaxis.

There have been numerous studies conducted with varying results while comparing the aforementioned techniques.

In our study of 50 patients, there were 43 male and 7 female patients, most of whom were in the age group 30-50 years (48%), followed by 34% patients who were less than 30 years of age and 18% over 50 years, median age being 35.5 years (ranging from 17-77 years). Earlier, distal radius fractures were seen more commonly in the older age group, following a fall on outstretched hand. Also females were more commonly affected, especially post menopausal women who are osteoporotic causing poor bone quality and increased susceptibility to fractures. In our study however we had a male preponderance with most of them being under 50 years of age. This is possibly due to the increasing use of vehicles and subsequent road traffic accidents which was the mode of injury seen in majority of our patients. Other patients had fractures due to fall on outstretched hand (14%) and fall from height (8%). This was similar to the study by Abdel Ghany M et al. In their study, 86.4% patients had intra-articular distal radius fractures following motor vehicle accidents.^[20] A few of our patients had associated injuries such as head injury, fractures of the shaft of humerus, the shaft of femur and proximal humerus.

According to A.O. classification, the highest number of patients were found to have fracture type B2 (32%), followed by B3 (30%) and C2 (20%) types with 10% patients having type C3 and 8% having type C1. There was no significant difference found in the distribution of fracture types among the two groups treated by either Open reduction and internal fixation with volar locking compression plate or Closed reduction with external fixation, augmented with K wire fixation. Pradhan U et al had four patients (13.33%) had 23.B2 type of fracture, 10 patients (33.33%) had 23.B3 type of fracture, 5 patients (16.66%) had 23.C2 type of fracture and 11 patients (36.66%) had 23.C3 type of fracture, which is similar to our study. Abdel Ghany M et al. had patients with only type C2 and C3 fractures.

Radiographic evaluation showed a mean Radial length attained to be 10.20 in volar locking compression plate group and 9.92 in Ligamentotaxis group, mean Palmar tilt attained to be 8.50 in volar locking compression plate group and 5.96 in Ligamentotaxis group, mean Radial inclination restored to be 20.25 in volar locking compression plate group and 18.76 in Ligamentotaxis group and the mean articular stepoff was seen to be 0.958 in volar locking

compression plate group and 1.16 in Ligamentotaxis group. Though the parameters appear to be better in the VLCP group, there was no statistical significance in the radiographic parameters between both the groups.

Functional assessment of post-operative range of motion of the wrist showed mean palmar flexion of 70.417 in the VLCP group and 65.400 in the Ligamentotaxis group, which was found to be statistically significant with a p value of 0.003. The mean dorsiflexion was found to be 66.45 in the VLCP group and 65.20 in the Ligamentotaxis group. The mean supination and pronation were found to be 68.54 and 67.29 in the VLCP group respectively and 65.80 and 67.80 in the Ligamentotaxis group. The mean radial and ulnar deviation were found to be 14.79 and 22.29 in the VLCP group respectively and 14.32 and 21.40 in the Ligamentotaxis group.

There was no significant difference in the functional outcomes of both groups of patients except the degree of palmarflexion during post-surgical follow-up which was found to be better in patients who had undergone Open reduction and internal fixation with volar locking compression plate.

A variety of studies showed Volar locked compression plating to have better outcomes than External fixation Gill SP et al^[21] in their comparative study on 60 patients found that volar locking plate fixation gave better functional outcome with lesser complications than external fixation. Rizzo M et al^[22] had similar results with functional outcome and certain radiographic parameters following plating being superior in their 55 patients with a two year follow-up, as did Musa R et al.^[23]

There have also been multiple studies similar to our own showing no difference in outcomes between both procedures.

Abdel Ghany M et al in their 46 patients found no significant difference in the functional outcome with either procedure, i.e. locked volar plating and external fixation, similar to our study.^[20]

Wilcke MK et al^[24] found that while there was better function reported in the group with locked volar plating in the earlier months of follow-up as compared to the group of patients who had undergone external fixation, there was no significant difference found at the end of 1 year, as did Pradhan U et al, at the end of 6 months, even though the plating group showed significantly better functional outcome at the end of 3 months.^[25]

Both sets of patients had similar functional outcome.

We had a few complications such as malunion (8%), pin loosening (8%) and wrist stiffness (16%) in our study, majority of which was seen in the Ligamentotaxis group, a few patients experienced wrist stiffness following locked volar plating (12%) as well but it had no statistical significance, We did not notice any complications requiring additional procedures in any patients in our study, belonging to either groups, similar to the study by Abdel Ghany M et al.^[20] We also did not have any cases of infection, non union, implant prominence or neuropraxia in our study.

In summary, though there were more complications seen in the external fixator group than the volar locking compression plate group, none were serious requiring further intervention. Volar locking compression plating allowed earlier return to function, the functional outcome was similar between both groups (except the range of palmar flexion) and also, there was no significant difference in the radiological outcomes between both groups. Both of the procedures were found to be equally effective in the treatment of intra-articular fractures of the distal radius.

CONCLUSION

Based on the results we obtained in our study, we conclude that both Open reduction internal fixation with volar locked plating and Closed reduction with external fixation (Ligamentotaxis) may be performed with effective functional and radiologic outcome in patients with intra-articular fractures of the distal radius, however long term follow-up is required to assess the continuity of the result obtained.

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ILLUSTRATIONS

CASE 1



Pre op



1 month



3 months



6 months

Functional outcome:

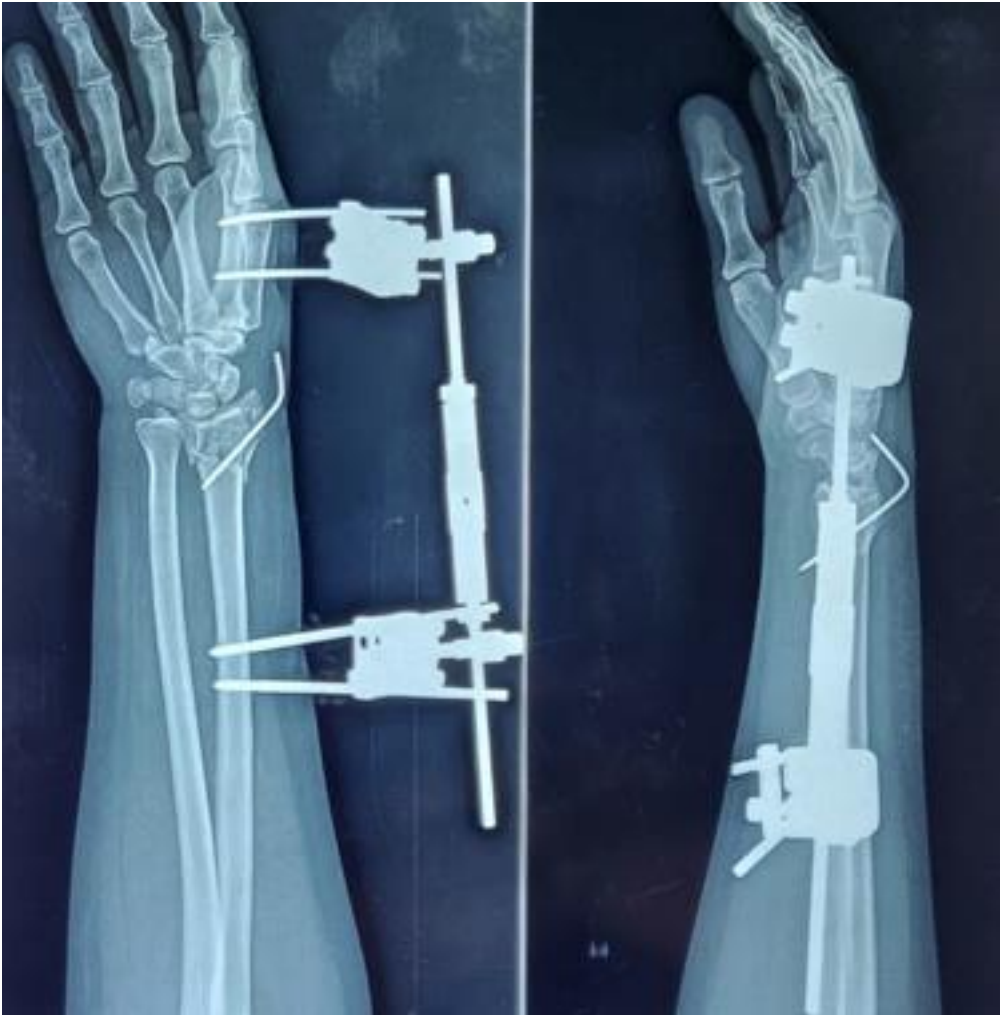




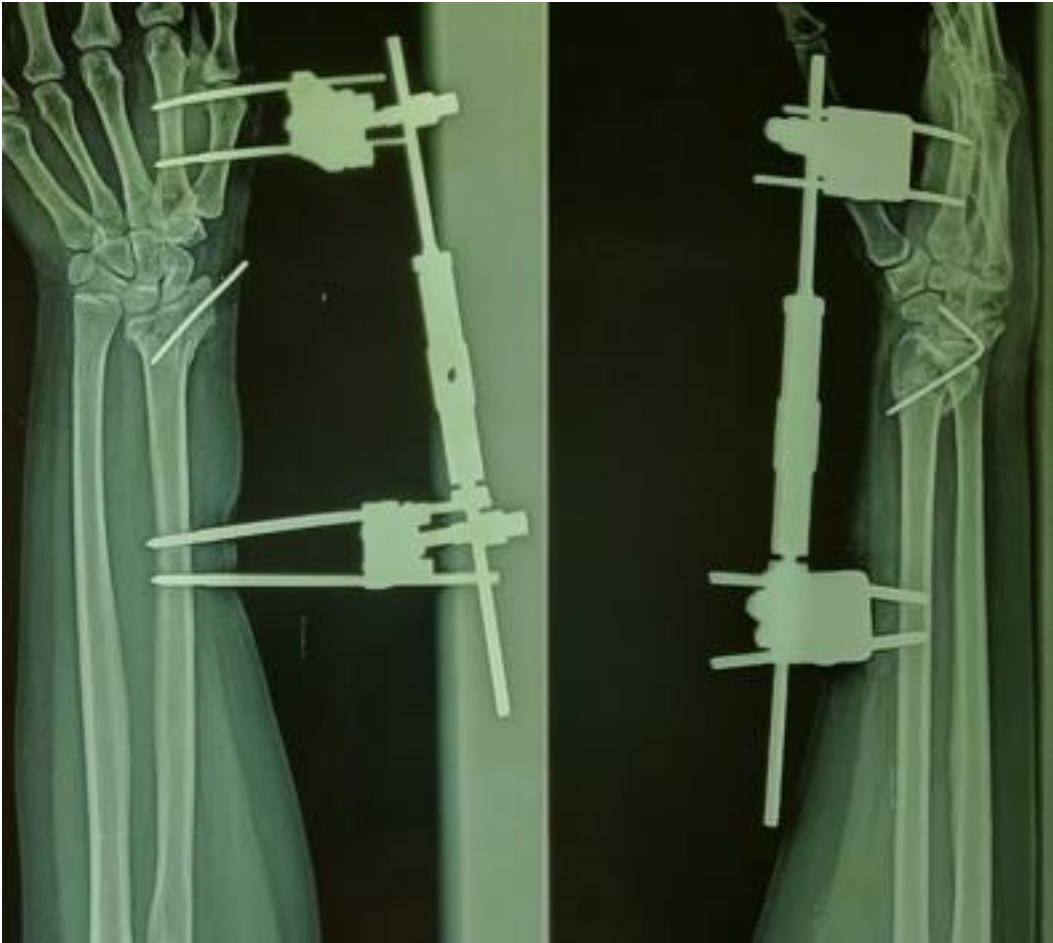
CASE 2



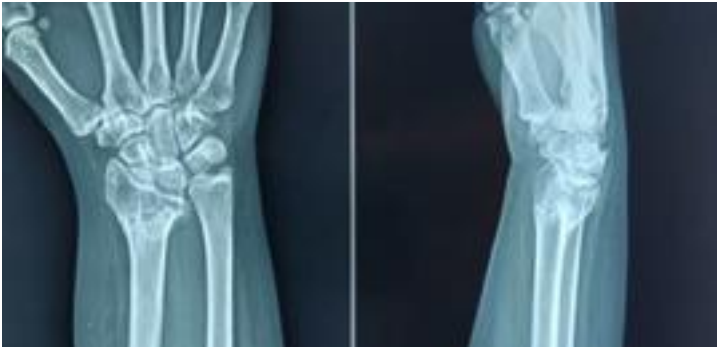
Pre op



Immediate post op



1 month



3 months



6 months

Functional outcome:







DOI: <https://doi.org/10.15379/ijmst.v10i4.2362>

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