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To compare the outcome of closed reduction external fixation versus open reduction internal fixation with volar locking plate in intra-articular distal radius fracture

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Abstract
Fractures of the distal end of radius are the most common fractures of the upper extremity and account for approximately 1/6th (17%) of all fractures seen and treated in emergency rooms, external fixation devices are an excellent means of overcoming the displacing forces of the forearm muscles (by ligamentotaxis), devices like volar locking plates allow improved fracture fixation. They have been shown to provide excellent stability for an unstable fracture.
The purpose of this study is to compare the two modalities for treatment of Intra-articular fracture of distal radius.
Methods: This prospective study will be conducted in participants admitted in Sri Siddhartha medical college hospital, Tumkur between September-2020 to September-2022 with intra-articular fracture of distal end of radius. Follow up at 6th week, 12th week and 16th week.
Results: In present study, the mean Quick DASH scores in external fixator group was 10.4±4.7 compaired to volar plating group 7.1±2.9 at the final (16 week) follow up. At final visit, VLP performed better in wrist palmar flexion (VLP: 65.7±5.3° vs EF: 72.7±5.4°, $p < 0.001$), dorsiflexion (VLP: 62.0±3.3º vs EF: 71.6±5.8º, $p < 0.001$), forearm pronation (VLP: 66.2±5.6° vs EF: 74.2±5.7°, $p < 0.001$), supination (VLP: 66.7±4.9° vs EF: 77.4±6.8°, $p < 0.001$), ulnar deviation (VLP: 19.6±1.8º vs EF: 21.1±1.6º, $p = 0.001$) and radial deviation (VLP: 17.6±1.8º vs EF: 18.9±1.6º, $p = 0.003$) than Ex fix group. Complication rate were higher in close reduction and external fixation group (30.3%) as compared to open reduction and volar plating group (21.2%).
Conclusion: Internal fixation with volar locking plate yield better functional outcome in unstable distal radius fracture in a short term follow up of 16 weeks, Range of movement was better in participants treated with volar locking plate.

Keywords: External fixator; volar locking plate; ligamentotaxis; AO classification

Introduction
Fractures of the distal end of radius are the most common fractures of the upper extremity, as these fractures accounts for approximately 1/6th (17%) of all fractures [1]. out of which 40 to 49% percentage are considered unstable and require surgical fixation [2].
Fall on outstretched hand with wrist in hyperextension is the usual mode of injury resulting in distal radius fracture [2].
No other fracture has greater potential to devastate the hand function as distal radius is most important for mechanical foundation of wrist [3].
There are very high chances of poor functional outcomes and early secondary arthritis of radio-carpal joint due to residual intra-articular incongruity in improperly reduced intra-articular distal radius fracture [4].
Closed reduction external fixation and open reduction internal fixation with volar locking plate are commonly used surgical procedures for the management of intra articular distal end radius fracture.
Closed reduction external fixation has various benefits like minimally invasive procedure, short learning curve, and ligamentotaxis providing improved reduction of fracture fragments leading to protection of fracture until it unites.

Although few demerits are also associated with procedure like collapse of intermediate compartment of the distal radius, pin loosening and pin tract infection, malunion and more loss of radiological parameters as compared to plating [2].
Many of studies showing that open reduction internal fixation with volar locking plate is having same functional outcome comparing with external fixation, even though in current practice most of the surgeons preferring plating as a treatment of choice.
Various studies have previously compared the merits and demerits of external fixation with internal fixation, but there is a lack of sufficient evidence about which technique has the best possible outcome.

Materials and Methods

This prospective study will be conducted 66 participants admitted in Sri Siddhartha medical college hospital Tumkur between September-2020 to September-2022 with intra articular fracture of distal end of radius, will be considered and selected for the study as per inclusion and exclusion criteria. Follow up at 6th week, 12th week and 16th week.
AO classification (Type B and Type C) of distal end of radius fractures will be used to find ideal participants for the surgery.
A detailed history taking, meticulous clinical examination, X-Ray, routine hematological investigation followed by written informed consent to be done.

Source of data

Participants attending outpatient department of orthopaedics and participants admitted in Sri Siddhartha medical college hospital, presenting with Intra articular distal end of radius fracture who are willing to undergo surgery, were enrolled for the study.

Inclusion criteria

1. Intra articular distal end of radius fracture. (AO-Type B and Type C)
2. Age between 18 to 70 years
3. Fresh fractures (< 3 Weeks old)
4. Closed fractures and Open fractures

Exclusion criteria

1. Associated head injury, spine injury, neurovascular injuries
2. Ipsilateral forearm fractures and associated pathologies
3. Any old fracture around wrist joint
4. Pathological fracture (Except osteoporotic bone fracture)

Methods of collection of data

The selected participants after taking consent are subjected to detailed history taking and clinical examination, after X-ray wrist AP and Lateral, AO type B and type C considered as ideal candidate.
Management includes open reduction internal fixation with volar locking plate or closed reduction external fixation and rehabilitation.
Follow up of participants with X-ray wrist AP and Lateral followed up at 6th week, 12th week and 16th week to determine the Progression of Union and functional outcome.

Results

In this study male (83.3%) population found to be more affected than female (16.7%) population (table 1).

Table 1: Sex distribution

Sex	Treatment		Total
	External Fixation	VLP	
Male	28 (84.8%)	27 (81.8%)	55 (83.3%)
Female	5 (15.2%)	6 (18.2%)	11 (16.7%)
Total	33 (100.0%)	33 (100.0%)	66 (100.0%)

Table 2: Age distribution

Treatment	N	Mean	Std. Deviation	Minimum	Maximum
External Fixation	33	45.3	15.2	18	70
VLP	33	45.7	15.2	18	70
Total	66	45.5	15.1	18	70

Table 2 shows participants included in study ranging from the age of 18 to70. Mean age in external fixator group found to be 45.5 years and in VLP group found to be 45.7 years.
Participants had more of right sided (ExFix:57.6% & VLP: 60.6%) predominance than the counterpart.

Table 3: Q Dash score

Parameters	Time	External Fixation	VLP	t-value	P-value
Quick dash	6th week	22.0±4.6	18.0±4.5	3.539	0.001
	12th week	14.2±5.1	11.9±3.5	2.107	0.039
	16th week	10.4±4.7	7.1±2.9	3.432	0.001

Table 3 shows comparison of Q-Dash score, found to be statistically significant on comparison between participants treated with Ex Fix and VLP. In either group QDASH system was seen to be in decreasing trend, whereas in VLP group there was much higher reduction seen by the end of 16th week follow-up (Ex Fix -10.4±4.7 & VLP - 7.1±2.9) which is statistically significant with P value 0.001.

Table 4: Radiological parameters

Parameters	Time	External Fixation	VLP	T-value	P-value
Volar tilt	6th week	10.8±4.2	11.3±3.5	-0.540	0.591
	12th week	11.2±4.2	12.0±3.2	-0.927	0.357
	16th week	11.5±4.1	12.2±3.2	-0.808	0.422
Radial inclination	6th week	21.9±3.0	21.7±4.5	0.259	0.797
	12th week	22.1±2.8	21.6±4.4	0.499	0.620
	16th week	22.2±2.8	21.5±4.4	0.764	0.447
Radial height	6th week	12.4±3.5	11.9±3.0	0.601	0.550
	12th week	12.3±3.5	11.8±3.0	0.606	0.547
	16th week	12.3±3.4	11.8±3.0	0.651	0.517

Table 4 shows comparison of radiological parameters, at the end of 16th week, volar tilt in participants treated with external fixation and VLP found to be 11.5±4.1 and 12.2±3.2 respectively with P value of 0.422, radial inclination found to be 22.2±2.8 and 21.5±4.4 respectively with P value of 0.447 and radial height found to be 12.3±3.4 and 11.8±3.0 respectively with P value of 0.517, all radiological parameters found to be statistically insignificant among comparison groups at all follow ups.

Table 5: Ulnar variance

Ulnar variance	6th week		12th week		16th week	
	External Fixation	VLP	External Fixation	VLP	External Fixation	VLP
Zero	8 (24.2)	7 (21.2)	9 (27.3)	7 (21.2)	9 (27.3)	7 (21.2)
Negative	24 (72.7)	25 (75.8)	23 (69.7)	25 (75.8)	23 (69.7)	25 (75.8)
Positive	1 (3.0)	1 (3.0)	1 (3.0)	1 (3.0)	1 (3.0)	1 (3.0)
Total	33 (100)	33 (100)	33 (100.0)	33 (100)	33 (100)	33 (100)

In current study 23 participants in ex fix group and 25 participants in VLP group achieved negative ulnar varience where as 1 participant in each group showed positive ulnar variance at 16th week follow up (Table 5).

Table 6: Range of motion (ROM)

Parameters	Time	External Fixation	VLP	t-value	P-value
Palmer flexion	6th week	59.2±6.1	68.5±5.7	-6.399	<0.001
	12th week	62.8±6.1	71.5±5.6	-6.043	<0.001
	16th week	65.7±5.3	72.7±5.4	-5.303	<0.001
Dorsiflexion	6th week	56.8±4.8	65.5±6.5	-6.126	<0.001
	12th week	60.5±3.8	70.2±6.6	-7.291	<0.001
	16th week	62.0±3.3	71.6±5.8	-8.325	<0.001
Supination	6th week	63.6±6.1	71.1±6.7	-4.764	<0.001
	12th week	65.2±5.7	73.5±7.3	-5.152	<0.001
	16th week	66.7±4.9	77.4±6.8	-7.318	<0.001
Pronation	6th week	63.7±6.9	68.9±6.0	-3.273	0.002
	12th week	65.1±6.1	72.7±5.8	-5.238	<0.001
	16th week	66.2±5.6	74.2±5.7	-5.710	<0.001
Radial deviation	6th week	14.5±2.3	17.1±1.9	-4.954	<0.001
	12th week	16.5±1.9	18.0±1.7	-3.141	0.003
	16th week	17.6±1.8	18.9±1.6	-3.140	0.003
Ulnar deviation	6th week	15.1±1.9	19.1±2.0	-8.396	<0.001
	12th week	17.6±1.9	20.1±1.6	-5.891	<0.001
	16th week	19.6±1.8	21.1±1.6	-3.543	0.001

Table 6 shows the comparison of range of motion (ROM) between the groups at 6th week. Palmar flexion found to be significantly higher (<0.001) in VLP group (68.5±5.7) than that in external fixator group (59.2±6.1), dorsiflexion also found to be significantly higher (<0.001) in VLP group (65.5±6.5) than that in external fixator group (56.8±4.8) at 6 weeks. Supination (VLP/EF: 71.1±6.7/63.6±6.1) and pronation (68.9±6.0/63.7±6.9) was significantly higher in VLP than that in EF. Radial deviation was significantly higher (<0.001) in VLP group (17.1±1.9) than that in external fixation group (14.5±2.3). Ulnar deviation was found to be significantly higher (<0.001) in VLP group (19.1±2.0) than that in external fixation group (15.1±1.9) at 6th week follow up.

Table 7: Complications

Complications	Treatment		Total	Chi-Square, P-value
	External Fixation	VLP		
Nil	23 (69.7%)	26 (78.8%)	49 (74.2%)	7.850, 0.346
Finger stiffness	0 (0.0%)	1 (3.0%)	1 (1.5%)	
Hand shoulder syndrome	1 (3.0%)	1 (3.0%)	2 (3.0%)	
Malunion	1 (3.0%)	1 (3.0%)	2 (3.0%)	
Pin loosening	1 (3.0%)	0 (0.0%)	1 (1.5%)	
Pin tract infection	3 (9.1%)	0 (0.0%)	3 (4.5%)	
Surgical site infection	0 (0.0%)	2 (6.1%)	2 (3.0%)	
Wrist stiffness	4 (12.1%)	2 (6.1%)	6 (9.1%)	
Total	33 (100.0%)	33 (100.0%)	66 (100.0%)	

Table 7 shows comparison of complication between groups, out of 66 participants, a total of 17 participants suffered from complications, in Ex fix group and VLP group, 30.3% and 21.2% respectively suffered from complications.

Discussion

The goal of surgery for unstable distal radius fracture is to obtain and maintain an acceptable reduction and to allow restoration of function. Achieving fracture stability is a prerequisite for attaining a satisfactory outcome for distal radius fractures.

Unstable fractures [5] are at increased risk for loss of reduction and subsequent malunion. Malunion can potentially lead to a poor functional outcome with residual pain, loss of motion, decreased endurance and grip strength, midcarpal instability and post-traumatic arthritis

The average age in our study is 45.5 years comparable to the studies of Abhishek Chattopadhyay *et al*. [6] who's study had an average age of 43.9 years, Raghu bagul *et al.* [7] who's study had an average age of 42 years and Raghu bagur venkatesh *et al*. [8] had 47.5 years

Our study showed male predominance in both groups with 84.8% and 72.7% male cases in Ex fix and VLP groups respectively, comparable to study conducted by Gill *et al* [9] showing 85.2% male cases in Ex fix group and 81.8% male cases in VLP group.

In our study Right side involvement seen in 19 (57.6%) participants in Ex fix group and 20 (60.6%) participants in VLP group.

Table 8: Comparison of Q-DASH score with other studies

Author	ExFix	VLP
Gill *et al*. [9]	9.71±2.18	6.79±0.93
Chakraborty *et al*. [10]	9.71±3.55	6.80±0.46
Present study	10.4±4.7	7.1±2.9

At 6 week follow up the mean Q-DASH scores were (Ex Fix - 22±4.6 vs VLP - 18±4.5, P-0.001) statistically significant. At 16th weeks the mean Q-DASH score reduced to (Ex fix – 10.4±4.7 vs VLP – 7.1±2.9, P - 0.001) being statistically significant.

The Q-DASH score decreased more in VLP group than the Ex fix group at 16th week follow up, showing better functional outcome in VLP group compared to Ex fix group.

Table 8 shows that the improvement in Q-DASH score in our study is comparable with the study done by Chakraborty *et al*.[10] which concluded mean Q-DASH to be 9.71±3.55 in Ex fix group and 6.80±0.46 in VLP group.

Table 9: Comparison of Volar tilt with other studies

Author	ExFix	VLP
Yu *et al*. [11]	4.9±5.3	5.5±6.1
Anant s *et al*. [12]	7.02±4.37	10.20±4.77
Gill *et al*. [9]	11.37±0.56	12.06±0.89
Present study	11.5±4.1	12.2±3.2

Table 10: Comparison of Radial inclination with other studies

Author	Exfix	Vlp
Yu *et al*. [11]	20.8±3.5	22.2±4.1
Anant s *et al*. [12]	23.6±3.56	23±4.19
Gill *et al*. [9]	22.26±1.45	23.36±1.63
Present study	22.2±2.8	21.5±4.4

Table 11: Comparison of radial height with other studies

Author	Exfix	Vlp
Yu *et al*. [11]	10.8±1.7	10.4±1.6
Anant s *et al*. [12]	10.93±3.26	11.07±2.31
Gill *et al*. [9]	12.20±0.46	12.49±0.32
Present study	12.30±3.4	11.8±3.0

In our study volar tilt, radial inclination, radial height found to be statistically insignificant among comparison groups with p value 0.422, 0.447, 0.512 respectively at 16 week follow up, which is comparable with study conducted by Yu *et al*.[11]

concluded P value equivalent to 0.317, 0.538, 0.693 respectively between comparison groups at final follow up.

Table 12: Comparison of Palmar flexion with other studies

Author	Exfix	Vlp
Sharma *et al.* [13]	63.13±2.72	75.53±6.09
Yu *et al.* [11]	62.3±7.7	69.7±9.6
Gill *et al.* [9]	70.07±4.64	78±2.01
Present study	65.7±5.3	72.7±5.4

Table 13: Comparison of dorsiflexion with other studies

Author	Exfix	Vlp
Sharma *et al.* [13]	60.27±1.98	67.93±3.69
Yu *et al.* [11]	60.2±11.8	61.1±10.1
Gill *et al.* [9]	64.89±4.86	67±1.85
Present study	62.0±3.3	70.2±6.6

Table 14: Comparison of supination with other studies

Author	Exfix	Vlp
Sharma *et al.* [13]	69.27±2.76	76.6±4.85
Yu *et al.* [11]	63.6±8.9	70.6±10.8
Gill *et al.* [9]	71.22±2.32	80.12±2.30
Present study	66.7±4.9	77.4±6.8

Table 15: Comparison of pronation with other studies

Author	Exfix	Vlp
Sharma *et al.* [13]	66.67±2.66	74.87±3.68
Yu *et al.* [11]	66.8±9.6	73.1±8.7
Gill *et al.* [9]	70.3±2.31	77.58±2.15
Present study	66.2±5.6	74.2±5.7

Table 16: Comparison of radial deviation with other studies

Author	Exfix	Vlp
Sharma *et al.* [13]	14.60±1.06	17.27±1.62
Yu *et al.* [11]	19.4±7.7	19.7±6.8
Gill *et al.* [9]	20.04±1.80	21.79±2.11
Present study	17.6±1.8	18.9±1.6

Table 17: Comparison of ulnar deviation with other studies

Author	Exfix	Vlp
Sharma *et al.* [13]	25.40±2.64	28.60±3.18
Yu *et al.* [11]	29.5±4.6	31±5.7
Gill *et al.* [9]	21.81±1.71	23.03±1.07
Present study	19.6±1.8	21.1±1.6

In our study all movements (dorsiflexion, palmar flexion, supination, pronation, radial deviation and ulnar deviation) showed improving trend in both comparison groups, there is statistically significant difference between both comparison groups at 16 week follow up showing better functional improvement in VLP group than Ex fix group.

In our study, although the external fixation group regain the movements after vigorous physiotherapy, the early recovery and movement in volar locked plating group gives better working capacity and yielded good functional outcome. Although two groups in our study have shown similar radiological outcome but the functional outcome which was evaluated by Q-DASH scoring system and range of movement is better in volar plated group participants than in external fixator group.

This evidence indicates that locked volar plates may be advantageous for a participant who desires an accelerated return of function.

Complications were at least and are comparable with standard studies (Table 7), 6 participants developed wrist stiffness and 1 participant developed finger stiffness and treated with physiotherapy including active and passive ROM exercise, wax bath, underwater exercise. 2 participants developed shoulder hand syndrome treated with physiotherapy, 2 participants developed malunion, 3 participants developed pin tract infection in Ex fix group and 2 participants developed superficial surgical site infection in VLP group managed with intravenous antibiotics as per culture and sensitivity reports.

Conclusion

Internal fixation with volar locking plate yield better functional outcome in unstable distal radius fracture in a short term follow up of 16 weeks, functional outcome as evaluated by QD score was better in VLP group.

Range of movement was better in participants treated with VLP as it allows earlier range of wrist motion which yields accelerated return of function. Complication was less in VLP group.

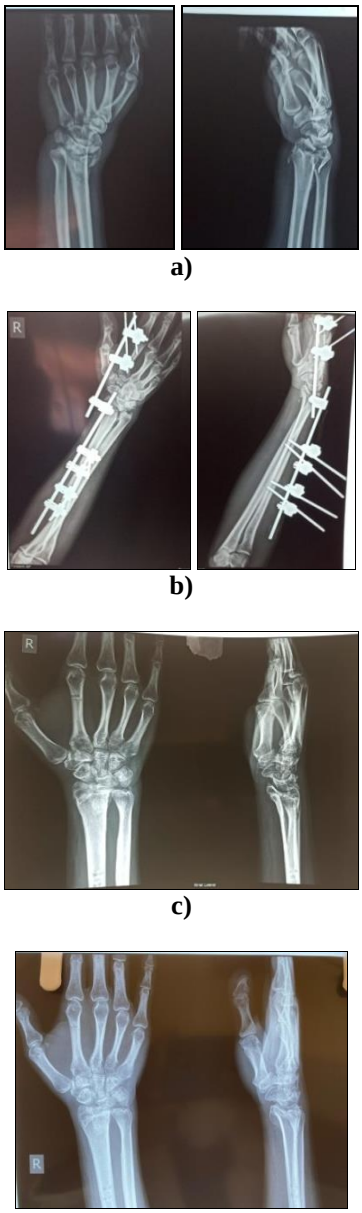

Fig 1: (a) Preoperative radiograph of DER fracture. (b) Follow-up radiograph at after external fixation. (c) Follow-up radiograph at 12 weeks. (d) Follow-up radiograph at 16 weeks

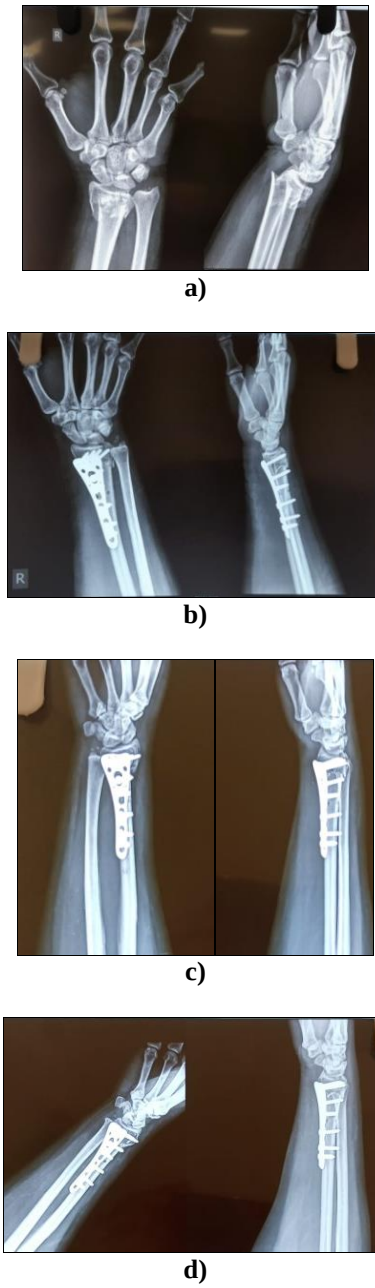

Fig 2: (a) Preoperative radiograph of DER fracture. (b) Follow-up radiograph at 6 weeks after volar plating. (c) Follow-up radiograph at 12 weeks. (d) Follow-up radiograph at 16 weeks

Fig 3: Clinical range of motion in external fixator case at 16th week follow-up

Fig 4: Clinical range of motion in volar locking plate case at 16th week follow-up

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