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A prospective comparative study of functional outcome of unstable fracture of distal end of radius by volar plate fixation vs ligamentotaxis external fixation

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Abstract

Aims and Objectives: To assess the relative efficacy of external fixation versus plate fixation with regard to subjective, functional, and radiographic outcomes. To know the advantage, disadvantage and complication of the both surgical methods mentioned in the study.

Methodology: A prospective comparative study of 30 patients with an average follow up of 10 months postoperatively done between October 2020 to September 2021 of closed unstable distal radius fracture.

Results: Majority of the cases were type III frykman (n=8, 26%), intra-articular (n=19, 63.3%) fractures of distal end of non-dominant (n=16, 53%) radius seen in the males (n=23, 76%) of younger age group (average 41 yr) with road traffic accidents (n=20, 66%) being the most common. Complications were seen in 26.6% cases of external fixation & 20% cases of volar plating. External fixator group excellent to good result seen in 80% patients (n=12) and fair to poor in 20% patients. The volar plate group has an excellent result seen in 86.66% of patients (n=13) and fair to poor in 13.33% of patients.

Conclusion: Volar plating group has advantage of better anatomical reduction, better radiological parameters, early joint motion & disadvantage of more intraoperative time, extra hospital stay, more expenditure, surgical scar, re-surgery for implant removal with equal range of movements, complication rates and Gartland & werley score compare to external fixation.

Keywords: Distal radius fractures, external fixation, volar plate, Gartland, werley score

Introduction

Distal end radius fractures are the most common fractures of the upper extremity. In fact these injuries account for approximately one sixth of all fractures seen and treated [1]. Stable fractures can be treated non-operatively with closed reduction and cast immobilization with good outcomes [2]. There is evidence to suggest that anatomical articular reduction greatly reduce the incidence of post traumatic Osteoarthritis [3]. The amount of acceptable fracture displacement or angulation is not universally agreed, some previous studies have reported that imperfect reduction does not necessarily lead to osteoarthritis or worsening of patient satisfaction [4, 5]. In contrast, others stress the importance of restoring radial length, alignment [6, 7] and articular congruency [8, 9, 10]. Even when surgery is indicated, controversy surrounds the ideal method of fixation.

External Fixation used to be the first choice in operative treatment of almost any fracture of the distal radius. It is still the basic method in the armamentarium of several experienced surgeons who are out of their comfort zone treating fractures of distal radius. It is based on soft tissue support and ligamentotaxis due to distraction between the second metacarpal bone and the shaft of radius. EF acts by maintaining length while neutralising compressive, torsional and bending forces across the fracture site [11]. A longitudinal traction is transmitted mostly through volar radiocarpal ligaments correcting the radial height.

EF can be associated with a number of complications that include malreduction, wrist and finger stiffness, nerve injury and complex regional pain syndrome, pin loosening, pin tract infection, malunion [20, 21, 22]. The advantage of external Fixator is that it allows early mobilization of the joint, limited stay in hospital, low morbidity rate. Open reduction and internal fixation with dorsal or volar plates can yield successful results [12, 13]. Volar fixed angle fixation of distal radius fractures was introduced as a solution for the dorsal fracture.

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However plate fixation is associated with complications that include tenosynovitis, tendon rupture, complex regional pain syndrome, carpal tunnel syndrome and intra-articular penetration of screws [14, 15]. Tendon complications are higher with dorsal plating [13, 16]. Newer locking plates (LP) have higher resistance than the non-locking alternatives in biomechanical studies [17] and their use in clinical practice has been advocated [18, 19]. Advantage of plating is earlier bone healing in case of intraarticular fractures, stability of fixation is better, early return of function, improved final motion. Therefore the present study was conducted to compare between both the methods.

Materials and Methods

This is a prospective comparative hospital based prospective study being done at the Department of Orthopedics, Navodaya Medical College, Raichur starting from 1st October 2020 till 30th September 2021.

Methods of collection of data

- Data was collected from 30 patients aged 18 years and above both male and female diagnosed with distal radius fracture who have attended Orthopaedics opd and admitted in Orthopaedics wards of NMCHRC.
- Clinical study was through questionnaires and clinical examination.
- All patients has undergone preoperative and post-operative x-ray investigations, and if needed CT scan.
- Surgical management of the fracture.
- Post-operative observation of patients for any complications.
- Regular follow up and health education for the patients treated to study the functional outcome.

Inclusion criteria

1. Age group of 18-75 years of both sexes
2. Fractures of distal end radius of either side or both with or without ulnar styloid.
3. Patients who are medically fit and willing for surgery
4. Radiological findings confirming fracture of distal end radius

Exclusion criteria

1. Patients who are unfit for surgery due to associated medical problems.
2. Distal radius fracture associated with Neurovascular Deficit.
3. Distal radius fracture associated with Carpals injury
4. Old fracture more than 3 wks
5. Patients below 18 years
6. Open fractures
7. Pathological fracture
8. Patients with existing disorders having a relevant effect on the healing process, such as multiple sclerosis or paraplegia.

Preoperative assessment

Pre-operative evaluation, immediate management

Following admission, proper history regarding the mode of injury, severity of trauma was obtained. Their general condition, systemic diseases and associated injuries were noted. After stabilizing general condition of the patient all patients were carefully inspected for skin condition, swelling, tenderness, deformity, wound, bony irregularity and the relative position of radial and ulnar styloid process.

Movements of the wrist and forearm were checked. Distal vascularity was assessed by radial artery pulsation, capillary filling, pallor and paraesthesia. The involved forearm was immobilized in a below elbow POP slab and kept elevated.

Radiographic examination: Radiographs of injured wrist

1. Posteroanterior view
2. Lateral view

Fractures classified according to Frykman classification. Patients satisfying the inclusion criteria were selected.

Operative Procedure

Anaesthesia: Regional/ General Anaesthesia. Most of the patients were operated under the brachial block.

Position and tourniquet

Supine position with the forearm in supination Injured limb was exsanguinated, the mid-arm pneumatic tourniquet was applied and the limb was placed on a side arm board. Forearm and hand thoroughly scrubbed, painted with betadine and draped.

External fixation was considered if there was

- Significant volar or dorsal comminution.
- 2mm depression of articular fragment.
- 10 degree angulation of major fragments.

Involvement of radiocarpal and radioulnar joints with ulnar neck fractures.

- Failure to maintain reduction after an initial attempt at closed fractures.

If the length, rotation and angular alignment were obtained with the external fixator, then large radial styloid fragments were secured using 1.5mm/2mm. Kirschner wires.

Open Reduction was considered and resorted to in the following situation, if after an attempted closed reduction

- Joint incongruity is evident with an articular surface displacement of more than 2 mm.
- Dorsal tilt not reduced at least to neutral.
- Lack of volar cortical buttress.
- Comminution, which was > 50% of dorsovolar diameter.
- Type VIII Frykman is having a transverse split with a rotational displacement of a radiolunate fragment not amenable to longitudinal traction.
- Central depressed / impacted articular fragments.
- Subarticular void seen, which would favour displacement.

Operative technique

External fixation

- Reduce the fracture manually or with the aid of sterile finger traps or traction
- Make a stab incision over the dorsoradial aspect of the index metacarpal base and use blunt dissection with scissors to expose the metacarpal. Take care to preserve and reflect the branches of the dorsal radial sensory nerve.
- Place a soft-tissue protector on the metacarpal and insert 2.7-mm self-tapping schanz-pins at a 30- to 45-degree angle dorsal to the frontal plane of the hand and forearm. Confirm pin position and length with fluoroscopy.
- Make a stab skin incision 8 to 10 cm proximal to the

wrist joint and just dorsal to the midline.

- With blunt dissection, expose the superficial branches of the lateral antebrachial cutaneous nerve and the radial sensory nerve, the latter of which exits in the mid-forearm from the investing fascia between the brachioradialis and extensor carpi radialis longus.
- Insert two 3.5-mm schanz-pins, 1.5 cm apart, through a soft tissue protector between the radial wrist extensors at a 30-degree angle dorsal to the frontal plane of the forearm. The pins should just perforate the medial cortex of the radius. Confirm pin position and length with fluoroscopy.
- Gentle sustained longitudinal traction with manual molding of the fracture fragments back into a normal alignment was performed.
- Apply the selected external fixation frame according to the manufacturer's instructions. For relatively stable fractures and when using Kirschner wires for augmentation of the fixation, a simple single-bar frame usually is sufficient, more complex fixators allow independent palmar carpal translation to adjust the volar tilt.
- In the presence of articular depression, percutaneous Kirschner wire was used to maneuver the fragments and to secure the radial styloid fragment.
The fixation device was left in place for an average of 6 to 8 weeks until both clinical and radiological evidence of healing was seen.

Volar Plating

- **Approach:** Henry's volar approach
- **Skin incision:** Make an 8-cm incision over the forearm between the radial artery and the flexor carpi radialis. Extension of the incision distally at the wrist crease in a V-shape may provide wider fracture exposure and help prevent scar contracture. The distal incision does not need to cross into the palm.
- Carry the incision to the sheath of the flexor carpi radialis. Open the sheath and incise the forearm deep fascia to expose the flexor pollicis longus. Inter nervous plane between flexor carpi radialis (median nerve) and flexor pollicis longus (anterior interosseous nerve).
- Place an index finger into the wound and gently sweep the flexor pollicis longus ulnarly. Partially detach the flexor pollicis longus muscle belly from the radius to gain full exposure of the pronator quadratus.
- Make an L-shaped incision over the radial styloid along the radial border of the radius to expose the pronator quadratus and use a Freer elevator to elevate it from the radius. The entire fracture line across the distal radius is now fully exposed.
- Insert a Freer elevator or small osteotome into the fracture line to serve as a lever to reduce the fracture. Insert the elevator or osteotome across the fracture line all the way to the dorsal cortex to allow disimpaction and reduction of the distal fragment. Apply finger pressure to the dorsal cortex to reduce the dorsal fragments.
- With a displaced radial styloid fracture, the brachioradialis may prevent reduction by pulling on the radial styloid. To relieve the deforming force, the brachioradialis can be transacted or detached from the distal radius.
- If necessary, use a Kirschner wire to temporarily fix the distal fragment to the proximal fragment. This is usually unnecessary because distal traction should maintain

reduction while the volar plate is placed.

- Dis-impact and reduce the fracture through capsule oligamentotaxis achieved by an assistant for through finger traction. After successful fracture reduction, position the volar plate under fluoroscopic guidance and insert a screw into the oblong or gliding hole first to allow proximal-distal adjustment
- Use a 2.5-mm drill bit to drill into the center of the oblong hole and insert a self-tapping 3.5-mm screw.
- Confirm proper placement of the volar plate with C-arm fluoroscopy. If necessary, shift the plate proximally or distally to provide the best placement for the distal screws.
- Use a 2.0-mm drill bit to drill the distal holes. Measure the holes for screw length and insert smooth locking screws. Use a screw that is 2 mm shorter than the measured length to avoid having a prominent distal screw perforate the dorsal cortex; typically, 20- to 22-mm screws are optimal, except for screws directed into the radial styloid, which are significantly shorter. Threaded screws may gain better bone dorsally.
- Once the first screw is inserted, distal traction on the fingers can be released because the fracture usually is appropriately reduced and fixed.
- Because of the fixed-angle design, the screws may perforate into the radiocarpal joint if the plate is placed too far distally. Obtain fluoroscopic views tangential to the subchondral bone in both the coronal and sagittal planes to assess for intraarticular penetration. Adjust the plate or screws, or both as indicated.
- After placement of the distal screws, place the remaining proximal screws.
- Reattach the pronator quadratus with braided absorbable sutures. Note that the pronator will not be able to cover the entire plate; the distal portion should be covered when possible to reduce flexor tendon-plate contact. For better purchase, the pronator quadratus can be sutured to the edge of the brachioradialis.
- If the ulnar styloid is fractured and displaced, making the distal radioulnar joint unstable, fix the styloid with one or two percutaneous Kirschner wires. A volar approach may be helpful in obtaining ulnar styloid reduction.
- Close the wound in layers and apply a splint.
- In case of comminution, screws need not be inserted into the distal fragment.
- Corticocancellous bone graft may be packed, either through the fracture site or through a metaphyseal window to buttress the articular surface.

Post-operative care and rehabilitation

Patients were kept nil per oral for 4-6hours post-surgery. Intravenous fluids & analgesics were given as needed. Patients were encouraged limb elevation and active finger mobilization exercises in the immediate post-op period. Distal neuro vascularity was assessed regularly and intravenous antibiotics were given for 3 days and after that changed to oral antibiotics for 5 days. Suture removal was done for all the cases between 9 to 12 days post-operative. After suture removal, gentle active wrist mobilization exercises were started. Resisted exercises were started about 6 weeks after surgery. All the patients were then followed up at two weekly intervals for the first two months and then monthly for the next six months. The union was assessed by callus formation on both AP and

Lateral radiographs and clinically absence of tenderness at the fracture site.

After the union was achieved, each patient was subjected to a series of radiological and clinical examinations, which included both subjective and objective evaluations of the resultant.

The Augusto Sarmiento modification of the Gartland and Werley Demerit point system was used to evaluate each patient.

Results and analysis

Road Traffic accident is the most common mode of injury (n=20) in the present study. Fall on an outstretched hand is the second most common (n=7). High-velocity injury is the increasing cause of fracture distal end radius in the younger population.

Table 1: Age incidence

Age Groups	No. of Pts.	Percentage (%)
19-30	6	20%
31-45	14	47%
46-60	7	23%
61-75	3	10%

The youngest patient was 19 yrs old and the oldest patient was 73 yrs old. The mean age group was 41.37 yrs

Table 2: Sex incidence

	Frequency	Percentage
Male	23	76.6
Female	7	23.3
Total	30	100

Table 3: Distribution of Study Population according to treatment

Group	Treatment	No. Of patients	Percentage
Group I	External Fixator	15	50.00
Group II	ORIF with plate	15	50.00
Total		30	100.00

Table 7: Range of motion at last follow up

Treatment	Dorsiflexion	Palmarflxn	radial devia	ulanrdevia	Pronation	Supination	
Ex Fix	Mean	64.33	67.33	19.33	32.00	71.67	78.67
	Minimum	40	40	15	20	50	55
	Maximum	90	85	25	40	80	85
Volar	Mean	67.33	69.33	18.00	30.67	70.33	74.67
	Minimum	50	45	10	20	60	60
	Maximum	85	90	25	40	80	85
Total	Mean	65.83	68.33	18.67	31.33	71.00	76.67
	Minimum	40	40	10	20	50	55
	Maximum	90	90	25	40	80	85

Functional range of motion: Following ranges of motion as being the minimum for normal function: dorsiflexion, 45 degrees; palmar flexion, 30 degrees; radial deviation, 15

The number of patients in both the above groups was the same (n=15 each).

Table 4: Side of involvement

Side	No of Patients	Percentage
Dominant	14	46.6%
Non-dominant	16	53.3%

This shows that the non-dominant side was more involved (n=16) as compared to the dominant side(n=14) in our study. But the difference in the involvement of the side was not statistically significant.

Table 5: Mode of injury

Mode of injury	No of Patients	Percentage
RTA	20	66.6%
FOOSH	7	23.3%
Fall from Height	3	10%
Total	30	100

Road Traffic accident is the most common mode of injury (n=20) in the present study. Fall on an outstretched hand is the second most common (n=7). High-velocity injury is the increasing cause of fracture distal end radius in the younger population.

Table 6: Type of fracture according to frykman classification

Frykman type	No of Patients	Percentage
I	2	6.6
II	4	13.3
III	8	26.6
IV	5	16.6
V	1	3.3
VI	4	13.3
VII	4	13.3
VIII	1	3.3

The commonest type of injury was Frykman type III, which is intra articulate radio-carpal joint involvement.

Table 8: Radiological parameters

Treatment	Ulnar variance	Artic step off	Volar tilt	Radial inclination	
Ex Fix	Mean	1.07	.80	2.13	13.33
	Minimum	-2	0	-5	5
	Maximum	3	3	15	30
Volar	Mean	-.53	.33	8.00	19.67
	Minimum	-3	0	-5	10
	Maximum	2	2	15	30
Total	Mean	.27	.57	5.07	16.50
	Minimum	-3	0	-5	5
	Maximum	3	3	15	30

Table 9: Complications

Complication	Treatment			
	Ex Fix		Volar	
	N	%	N	%
No	11	73.3%	12	80.0%
Yes	4	26.7%	3	20.0%
Total	15	100.0%	15	100.0%

In the external fixator group, 2 patients had pin tract infection, which needed oral antibiotics and pin tract dressings. 2 patients had loosening of pins, one at 3 wks other at 4 wks. Out of which, one patient refused for further treatment and an external fixator was removed and a below elbow cast was applied.

In the volar plate group, 1 patient had Extensor pollicis longus tendon irritation because of the long volar to dorsal screw. 1 patient had stiffness of the wrist joint who had native treatment before surgery and did not have regular physiotherapy. 1 had a superficial infection which subsided with intravenous antibiotics.

Complications were seen in 26.6% of cases of external fixation and 20% of cases of volar plating.

Table 10: Gartland & Werley Score

Gartland & werley score	External fixator		Volar plate	
	Nu.	%	Nu.	%
Excellent 0-2	5	33.33	7	46.66
Good 3-8	7	46.66	6	40
Fair 9-20	2	13.33	2	13.33
Poor >20	1	6.66	0	0

External fixation group excellent to good results seen in 80%

Author	Dorisflexion	Palmar flexion	Radial Deviation	Ulnar deviation	Pronation	Supination
Melone 1986 ^[23]	39	42	26	21	70	71
Wright 2005 ^[24]	64	63	23	36	78	70
Ernst 2005 ^[25]	44	56	19	25	72	79
Present Study	67.33	69.33	18	30.66	70.33	74.66

Conclusion

This prospective comparative study of 30 cases of close unstable fractures of the distal radius with an average follow up of 10 months (6-16 months) was able to conclude that:

An increasing number of distal radius fractures are now found in the younger age group, as seen in our series majority of patients were in the age group of 31-45 years.

Male preponderance is due to their involvement in riding vehicles, heavy manual labour. Fractures occurring in the older individuals were due to trivial falls on outstretched hands causing extra articular fractures in the osteoporotic bone. Most of the fractures in the younger individuals are due to motor vehicle accidents or high energy trauma, which usually are intra-articular, displaced, and unstable.

In study the majority of the cases were type III frykman (n=8, 26%), intra-articular(n=19, 63.3%) fractures of distal end of non-dominant (n=16, 53%) radius seen in the males(n=23, 76%) of younger age group(average 41 yr) with road traffic accidents (n=20,66%) being the most common.

Average dorsiflexion & plantarflexion at last follow-up was more for the volar plating group. Radial deviation, ulnar deviation, pronation and supination were more at last follow up for the external fixator group. Ulnar variance, intraarticular step off, volar tilt and radial inclination were better maintained with the volar plating group. Volar plate provides the best articular anatomy and so least changes of

of patients (n=12) and fair to poor in 20% of patients.

Volar plate group excellent to good results seen in 86.66% of patients (n=13) and fair to poor in 13.33% of patients.

The average gartland & werley score for the external fixation group is 5.53 and for the volar plate group is 4.07

Discussion

The average range of motion obtained in patients treated by an external fixator in our study conforms with other series reviewed in the literature.

The average range of motion obtained in patients treated by ORIF with a plate in the present study is better than some series reviewed in the literature.

In my study, dorsiflexion in the External fixator group was 64.33° with only one pt having dorsiflexion below 45°, in the volar plating group average dorsiflexion was 67.33° with all patients more than 50°.

Palmar flexion for the external fixator group was 67.33°, in the volar plating group average palmar flexion was 69.33°. Both groups had one patient below 50° plantarflexion.

The radial deviation for the External fixator group was 19.33° with no patient having a radial deviation less than 15°. The volar plating group average radial deviation was 18° with 2 patients having a radial deviation less than 15°.

Ulnar deviation for the external fixator group was 32°, in the volar plating group, it was 30.66°. All the patients in both of the groups had more than 20° ulnar deviation.

Pronation for the external fixator group was 71.66°, in volar plating group it was 70.33°. All the patients in both of the groups had equal or more than 50° pronation.

Supination for the external fixator group was 78.66°, in the volar plating group, it was 74.66°. All the patients in both of the groups had equal or more than 50° supination.

degenerative arthritis. Complication rate were more with the external fixator group (26.6%) compared to volar plating group (20%). Gartland& werley score was excellent to good in 80% of cases of external fixator and 86.66% cases of volar plating with an average score of 5.53 and 4.06, respectively. Although volar plating gave the better radiological result, which is statistically significant but there is no statistical difference found in functional outcome, complication rate & Gartland & Werley score in patients treated with an external fixator as against volar plating at the end of 10 months of follow up.

Volar plating group has the advantage of better anatomical reduction, better radiological parameters, early joint motion & disadvantage of more intraoperative time, extra hospital stay, more expenditure, surgical scar, re-surgery for implant removal with equal range of movements, complication rates and Gartland & werley score compare to external fixation. External fixator has the advantage of less intraoperative time, short hospital stays, less expenditure, no pre-surgery required, and an excellent range of motion and can be used in open contaminated fractures.

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