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External fixator for intra-articular fractures of distal end of radius: A prospective study

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Abstract
Background: The primary goals of distal radius fracture fixation are to put the pieces back where they belong and, most importantly, to do so by a method that does not compromise hand function. Displaced comminuted intra-articular fractures of the distal radius are difficult to treat successfully by traditional non-operative methods. Thus, external fixation plays a very distinct role.
Methods: Twenty adult patients with closed comminuted intra-articular fractures of the distal radius were treated by closed reduction and immobilization with a external wrist fixator during a 2-year period [September 2003 to September 2005]. Six weeks later, the fixator was removed. The patients then were observed for an average of 8 months [6-10 months].
Results: An excellent outcome was seen in 2 patients (10%), a good outcome in 12 patients (60%), and a fair outcome in 5 patients (25%) and poor outcome in 1 patient (5%). Minor complication, pin tract infection was present in one (5%) patient but recovered completely after removal of the fixator.
Conclusions: External fixator is simple and inexpensive. Displaced severely comminuted intra-articular fractures should be treated with an external fixator. It effectively stabilises fractures y *et al* lowing for hand motion and prevents stiffness. The radial angle and volar tilt should be achieved for an optimal outcome, it is difficult to regain volar tilt by ligamentotaxis and maintain it by external fixators. Most complications are minor and easily treated and do not affect outcome. The ease of use of the implants and successful track record make it an extremely versatile tool for treating complex fractures of the distal radius.

Keywords: Distal radius, intra-articular fractures, external fixator, ligamentotaxis

Introduction
Fractures of distal end of radius refer to fractures beginning at the proximal end of pronator quadratus and ending at the radio-carpal articulation. Fractures of the distal radius are among the most common orthopedic injuries and account for approximately one-sixth of all fractures treated in emergency departments [1].
A number of studies over the past years have documented an upward trend, that is, overall increase in the prevalence of distal radius fractures. There is a 17% increase of distal radius fractures in United States and the rate has almost doubled in Sweden [2, 3]. The importance of knowing the information about incidence of different types of fractures is to determine the appropriate mode of treatment depending on articular involvement and degree of fracture displacement, which in turn has an impact on functional end result. The same factors also influence the cost and resource allocation for these injuries [4].
It is very important to consider fracture displacement and fracture severity characteristics because complications of fractures like malunion and neuropathies of median, radial and ulnar nerves are more frequent with increasing severity of the fractures [5]. "Fractures of the distal radius which are stable i.e., extra articular and not comminuted are different from fractures which are unstable i.e., intra articular and comminuted [6, 7]. Therefore, different treatment modalities are required for these types of fractures. The final aim in the management of restore normal function. The best method of obtaining and maintaining an accurate restoration of articular anatomy however remains a topic of considerable controversy.

External fixation in combination with percutaneous pinning has proved to be effective in the management of unstable intra articular fractures of distal radius, but has also linked with an unacceptably high rate of complications in some series [8]. The extra-articular distal radius fractures occur frequently in osteoporotic geriatric group, while the intra-articular type is more frequent in young adult patients with high-energy trauma [9]. Many fractures of the distal aspect of the radius are in fact relatively uncomplicated and are effectively treated with closed reduction and immobilization in a cast. However, fractures that are either unstable and/or involve the articular surfaces can jeopardize the integrity of the articular congruence and/or the kinematics of these articulations.
EF showed its distinctive advantages with non-demanding surgical procedures and unnecessity for hardware removal surgery for intra-articular distal radius fracture [10-12] External fixation for distal radius fracture is applied after ligamentotaxis achieved following fracture reduction [13].

External fixation
External fixation has shown to be effective in the surgical management of unstable intra-articular fractures of the distal radius, but has also been linked with an unacceptably high rate of complications in some series [14]. The successful use of external fixation necessitates careful assessment of the fracture fixation device and pins, judicious use of augmentation with internal fixation and bone grafting, aggressive early rehabilitation and careful post-operative monitoring. Hallmarks of unstable intra articular fracture of distal radius include significant volar or dorsal comminution, more than 2 mm spread and depression of articular fragments, more than 10° angulation of the major fragments, extension of fracture into radio-carpal and radio-ulnar joints and occasionally an ulnar neck fracture. Indications for external fixator application were Frykman's type III, IV, V, VII and VIII and decrease in radial height of greater than 3-4 mm.
The aim is to study the functional outcome of surgical management of comminuted intra articular fractures of distal end radius using external fixator.

Objectives
1. To assess the effectiveness of external fixator in intra-articular fracture distal end of radius.
2. To assess anatomical and functional outcome.

Material and Methods
It was a prospective study conducted among 20 patients with intra-articular distal radius fractures, in the Department Of Orthopedics, Sri Devaraj Urs Medical College, Tamaka, Kolar, during a period of 1 year (October 2018 to September 2019). All the patients with intra – articular fractures of distal end of radius, that is Frykmann's classification type III to type VIII attending the Orthopaedics Out – patient department during the study period, required surgical treatment and consented for the study were included in the study. Those patients with Exclusion criteria was patients presenting with pathological fractures, extra – articular fractures of the distal end of the radius, past or present history of any injuries or fractures of the ipsilateral upper limb (humerus head/neck), scapula fracture, presence of neurovascular injuries along with fractures or fractures with associated bone disorders, associated head injury,. A predesigned pretested questionnaire was used to collect data. The questionnaire had questions about the socio – demographic details, clinical and surgical details.

Statistical analysis: The data collected were entered in the Microsoft excel sheet and double checked for errors. Results of categorical variables are expressed in percentages and proportions.

Ethical clearance: Obtained from the institutional ethics committee. All the participants were explained about the purpose of the study in vernacular language in understandable manner. Confidentiality of the information was assured and the participants were free to withdraw anytime from the study if there was any breach in ethics during the course of the study.

Surgical Procedure
The static external fixator used in this series consisted of
1. 3.5mm schanz pins for the radius - 2 in number.
2. 2.5mm schanz pins for the second metacarpal – 2 in number.
3. Clamps.
4. 4mmconnecting.rod.

Under the effect of anesthesia, patient was placed supine on the operating table. After draping, the injured upper limb was placed on the side arm board. Longitudinal traction was given with manual moulding of the fracture fragments back into a more normal alignment (severe hyper-flexion or hyperextension is avoided). The wrist is maintained in mild flexion and ulnar deviation. Reduction was maintained with K-wires. A stab incision was made approximately 10 cm proximal to the radial styloid over the lateral aspect of the radius. Through the stab incision the periosteum was displaced and the drill sleeve was fixed centrally. Care was taken not to injure the tendons, muscles, nerves in the process of drilling. The radius was drilled with 2.5mm drill bit, and 3.5mm schanz pin was fixed. A stab incision was made over the lateral aspect of the base of the 2nd metacarpal. It was drilled with1.5mm drill bit, and then fixed with 2.5 mm schanz pin. Then the 4mm connecting rod was fixed to the schanz pins with the clamps. The other 2 schanz pins, one in the shaft of radius and the other in second metacarpal are fixed in similar fashion. Now the external fixation device is tightened and the reduction carefully assessed clinically (and when available under fluoroscopy. At the end of the surgical procedure sterile dressings were done to the pins. Fingers were checked for capillary refilling, the fingers were left free to go through a full range of motion. No cast or splint was given. Antibiotics were given along with analgesics for 5 days. The Average Duration from the date of Injury to Date of operation was 1-3days. Post – operatively, check X-rays were taken in both Antero-posterior and lateral views on post-operative day one. The reduction of the fracture was confirmed and any displacement of fracture was studied. Tension across the wrist generated by the external fixation device should provide enough ligementotaxis, so that on an Antero-posterior radiograph the radio-carpal articulation was seen to be 1 mm. wider than the mid-carpal joint. Active exercises of fingers and thumb were commenced from the day of operation. Third post-operative day the dressing were removed. The pins were cleaned with spirit on every alternate day for one week after; the patient was educated regarding pin-site care. The patient was thought the six-pack exercises (Palmer) for the hand. Pronation and supination of the forearm and active movement of the elbow and shoulder were advised throughout the period of the healing.
The patient was discharged after seventh post-operative day

and advised active exercise of the fingers and was reviewed weekly for 4 weeks. On 3rd week, k-wires used for augmentation were removed. The patient was assessed subjectively for pain at the fracture site; and clinically for tenderness and loosening of the pins.

On follow up at 6th week the fracture union was assessed clinically for absence of tenderness and radiologically for the bridging callus formation. Then external fixator was removed under anesthesia. The ranges of wrist movements were recorded and any deformity was assessed. The patient was advised not to lift heavy weight for 4 weeks. Physiotherapy of wrist was started at 6 weeks.

All cases were followed at an interval of 6 weeks, 3 months, 6 months. There was a superficial pin tract infection in one case and infection was controlled by oral antibiotics and proper pin tract care. There was no loss of fixation or breakage of pins; as long as they were followed up-till the external fixator was removed.

The criteria for results at 6 weeks includes Deformity; Subjective evaluation; Range of motion; complications according to modified Gartland and Werley scoring system [10].

Table 1: Shows Demerit score system modified after Gartland and Werley (1951)

Demerit score system modified after Gartland and Werley (1951).		
		Points
Deformity	Prominent ulnar styloid	1
	Radial deviation	1-2
	Dinner fork deformity	1-3
	Maximum	6
Subjective Evaluation	No pain, no limitation of motion	0
	Occasional pain, some limitation of motion, weakness pain, limitation of motion	4
	Activities restricted	6
	Maximum	6
Range of Motion	Limitation of motion<20%	0
	Limitation of motion <50%	2
	Limitation of motion> 5 0%	6
	Stiffness of wrist	6
	Maximum	6
Complications	None or minimal	0
	Slight crepitation	1-2
	Severe creptitation	3-4
	Median nerve compression	1-3
	Pulp-palm distance 1 cm	3
	Pulp-palm distance> 2 cm	5
	Pain in distal radioulnarjoint	1-3
	Maximum	15

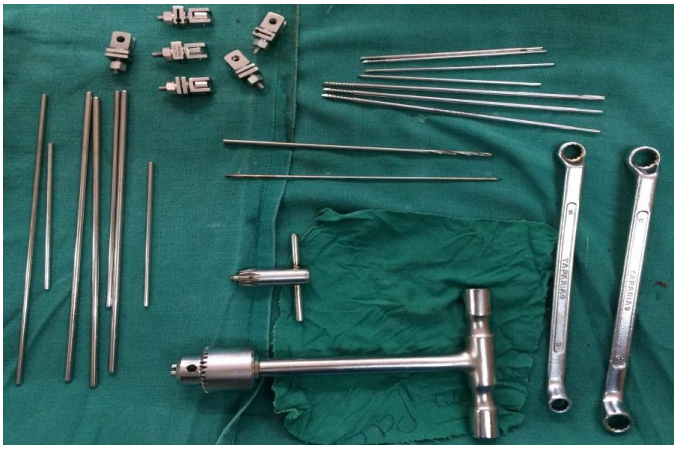

Fig 1: Types of Surgical tools

Results

The present study was conducted among 20 patients with distal radius fractures. Among the 20 patients,

General characteristics of patients

Table 2: General characteristics of patients (n = 20)

Characteristics	**Number (n = 20)**	**Percentage (%)**
Sex		
Males	17	85.0
Females	03	15.0
Age group		
11 – 20	02	10.0
21 – 30	11	55.0
31 – 40	03	15.0
41 – 50	03	15.0
51 – 60	01	05.0
Mechanism of injury		
Fall (Low impact)	13	65.0
RTA (High impact)	07	35.0
Side involved		
Dominant side	15	75.0
Non – dominant side	05	25.0
Frykmann classification		
III	03	15.0
IV	02	10.0
V	03	15.0
VI	03	15.0
VII	05	25.0
VIII	04	20.0
Additional fractures		
Fracture shaft of femur	02	10.0
Fracture of both bones of leg	01	05.0
Fracture of medial malleolus	01	05.0

The age of the patients ranged from 19 to 60 years. Distal radius fractures were common in 21 – 30 years age group, 11 (55%). Among the total of 20 patients, 17 were men and 3 were women. The mechanism of injury was a fall (low impact) in 13 (65%) patients and motor vehicle accident (high impact) in 7 (35%). The dominant side was injured in 15 cases (75%) and the non-dominant side in 5 cases (25%). All patients had unilateral closed fractures of the distal part of the radius. According to the Frykman classification, 3 fractures were Type III (15%), 2 were Type IV (10%), 3 were Type V (15%), 3 were Type VI (15%), 5 were Type VII (25%), and 4 were Type VIII (20%). Among all, 4 (20%) patients with high impact type injuries had additional fractures, 2 (10%) patients had fracture shaft of femur, 1 (5%) had fracture of both bones of leg, and 1 (5%) had fracture of the medial malleolus of the ankle.

Table 3: The overall results according to the rating system. Modified - based on Gartland & Werley 1951 demerit point rating was:

Excellent	**2**	**(10%)**
Good	12	(60%)
Fair	5	(25%)
Poor	1	(5%)

Discussion

Fractures of distal end of radius refer to fractures beginning at the proximal end of pronator Quadratus and ending at the radio-carpal articulation. Current and past clinical data point to a rise in the incidence of distal radius fractures in the

paediatric, adult and elderly populations in recent years. For the paediatric population, this increase can likely be attributed to a surge in sports related activities. The growth of the elderly population and a rise in the number of active elderly are directly responsible for the increase seen in this age group [2]. "Fractures of the distal radius which are stable i.e., extra articular and not comminuted are different from fractures which are unstable i.e., intra articular and comminuted [6, 7]. Therefore, different treatment modalities are required for these types of fractures. They are one of the commonest fractures encountered in orthopaedic practice. The final aim in the management is to restore normal function. The best method of obtaining and maintaining an accurate restoration of articular anatomy however remains a topic of considerable controversy. Although various methods of treatment are available, the best method still remains controversial.

It was found in the present study that the age of the patients ranged from 19 to 60 years. Distal radius fractures were common in 21 – 30 years age group, (55%). Among the total of 20 patients, 17 (85%) were men and 3 (15%) were women. The dominant side was injured in 15 cases (75%) and the non-dominant side in 5 cases (25%). In a similar study by Ivan Micic *et al*, [16] out of 20 patients treated with external fixator, 9 (45%) were males and 11 (55%) were females unlike the present study with majority (85%) being males. Dominant side was involved in majority (75%) in the present study similar to IvanMicic *et al*, [16] (75%). Similarly, Sridhar DK *et al*, [17] in their study found that there were 20 males (66.6%) and 10 females (33.3%). Similar to the present study, Channareddy H [18] found that 72.5% of the fractures were in men and the male to female ratio was 3:1.

The dominant side was injured in 15 cases (75%) and the non-dominant side in 5 cases (25%) in the present study, unlike a study by Channareddy H [18] in which both dominant and non-dominant sides were equally involved (50% each).

Yet another study by Sridhar DK *et al*, [17] consisted of 30 cases of comminuted intra-articular fractures of distal radius treated surgically by two surgical modalities, 15 cases by Ligementotaxis and 15 cases by percutaneous pinning. All cases were available for follow up. The average age in males were 41.35 years and female were 35 years. The fractures were common in the age group 41-50 years of age. The average age was 27.6 years in a study of 43 fractures in 40 patients conducted by Knirk *et al*, [19] while in a study conducted by Bradway *et al*. [20] between 1976 and 1986, the average age was 40 years. This is also similar in series reported by Foster and Kopta, Harish Kapoor with a mean age range of 36-40 years [21, 22] Others reported higher mean age of 47 years (Ruch DS), 55 years (Margaret W.M.), 56 years (Abe *et al*) and 64 years (Gradl G) [23-26] Horesh *et al*, [27] reported an average age of 48 years in their study of 40 patients. In a study by Channareddy H [18] these fractures were found more commonly in young adults (3rd and 4th decade). The mean age for males was found to be 37 years, lesser compared to females with mean age of 51 years.

In a study by Sridhar DK *et al*, [17] 22 cases (73.3%) were due to indirect trauma, caused by fall on outstretched hand and, direct trauma in the form of road traffic accidents was the mechanism of injury in 8 cases (26.7%) similar to the present study in which the mechanism of injury was a fall (low impact) in 65% patients and motor vehicle accident (high impact) in 35%. Ivan Micic *et al*, [16] also found that fall on an outstretched hand was the most common mechanism of injury (60%) and motor-vehicle accident was the mechanism of injury in 40% cases. Unlike the present study, Channareddy H [18] found that 72.5% fractures were caused by motor vehicle collision and 20% were due to fall and remaining 7.5% were due to other causes like work related accidents, sports injuries

In the present study, according to the Frykman classification, 15% fractures were Type III, 10% were Type IV, 15% were Type V, 15% were Type VI, 25% were Type VII and 20% were Type VIII. Similarly, Channareddy H [18] in his study found type VII fractures to be the most common (30%), followed by type IV (27.5%), type VIII (22.5%) and type V and type VI, 10% each.

It was found in the present study that, among all, 20% patients with high impact type injuries had additional fractures, 10% patients had fracture shaft of femur, 5% had fracture of both bones of leg, and 5% had fracture of the medial malleolus of the ankle. Similarly, in a study by Channareddy H, [18] associated injuries were present in 16 cases (40%). Ipsilateral concomitant upper limb injuries were present in 4 cases (10%) which included carpal bone fractures (Scaphoid fracture-1), fracture olecranon, elbow dislocation and open fracture shaft humerus each.

The present study reported excellent results in 10%, good results in 60%, fair results in 25% and poor results in 5% cases, unlike a study by Ghosh S *et al*. [28], which reported 66% excellent result and 33% good results in type II fractures treated by external fixation, while it was found that, out of eight type III fractures three (38%) had excellent result, four (50%) had good result and one (12%) had fair result. However, in a study by IvanMicic *et al*, [16] 50% had excellent, 45% good and 5% had fair results.

Conclusions and Recommendations

Successful management of complex distal radial fractures necessitates careful assessment of fracture pattern, appropriate patient selection, a careful and meticulous surgical approach, appropriate choice of fixation device and pins, judicious use of augmentation with internal

fixation, aggressive early rehabilitation and careful postoperative monitoring. The surgeon well oriented with the above principle will be in a position to optimize the outcome of the patients. External fixation technique was able to provide satisfactory result in treating intra – articular distal radius fractures.

External fixation of the distal radius has evolved from its early beginnings in pins and plaster fixation. The current designs of fixators are well established and can be used reliably to treat many fractures about the wrist. The rate of serious complications is low. With careful dissection and placement of the pins, injury to the superficial sensory branch of the radial nerve and extensor pollicis longus tendon can be avoided. Aggressive pin-tract care can prevent many superficial infections from occurring. Most complications are minor and easily treated and do not affect outcome.

The external fixator is simple and inexpensive. It effectively stabilizes fractures y *et al*. lowing for hand motion and prevents stiffness. When intra-articular fractures are treated by conventional methods, pain and restriction of joint motion are not uncommon. However, when treated by ligamentotaxis by external fixator, anatomical reduction is predictably achieved at fracture site. Though some cases have residual joint stiffness, pain and arthritis can be prevented.

Careful review of the recent literature reveals that external fixation appears to have benefits that outweigh associated complications and, as such, make it an attractive treatment option for fractures of the distal radius that require surgical treatment. Both its ease of use and successful track record

make it an extremely versatile tool for the treatment of these injuries. More multicentre studies in large samples with longer follow up may be conducted. Comparative studies with other modalities are recommended for further evidence.

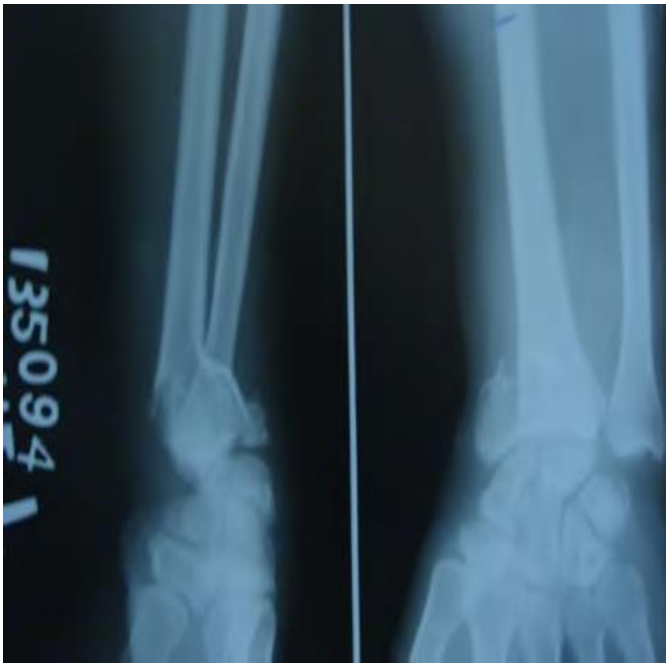

Fig 2: Pre - operative radiograph of the patient

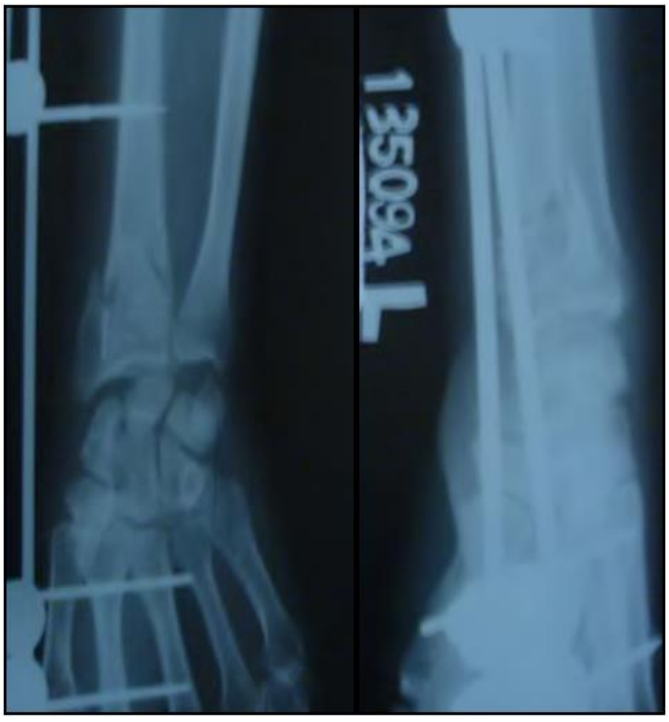

Fig 3: Post -operative radiograph of the same patient

Limitations

This is a study done with a small sample in a single setting. There were no controls in the study for accurate comparison. However, comparison has been made with results from previous studies.

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