Original Paper

Functional Outcome of Intra-Articular Fracture of Distal End Radius Treated with External Fixator; A Prospective Study

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ABSTRACT: Fracture distal end radius is one of the most common fracture treated in orthopedic emergencies. Nearly 1/6th (16%) of all fractures in orthopedic emergencies involve the distal end of the Radius. This is a prospective-interventional study conducted in the department of Orthopedic Surgery, Sanjay Gandhi Memorial Hospital, Mangolpuri, New Delhi with a sample size of the study is thirty patients treated with an external fixator from January 2021 to June 2022. Out of 30 patients, the number of female patients was 16 (53.33%) and the number of male patients was 14 (46.67%). The mean age of the patient was 50.5 years. 27 (90%) out of 30 patients were right-handed people which was a common behavioral finding and thus we expect more right side distal radius fracture in our study. Functional outcome was evaluated with the Gartland & Werley scoring system. 14 patients (46.67%) showed excellent results, 11 patients (36.67%) showed good, 3 patients (10%) showed fair, whereas 2 (6.67%) patients showed poor results. Stiffness was the most common complication seen in 6 patients (20%). From this study, it is concluded that an external fixator is a simple, safe, and cost-effective method for the treatment of distal end radius fracture with a lesser duration of hospital stay. It reduces the fracture by means of ligamentotaxis and maintains the reduction as well as restores the radial length without interfering with the fracture healing process.

KEYWORDS: *Fracture distal end radius, distal end radius fracture, external fixator, ligamentotaxis, intraarticular fracture radius, fracture.*

Introduction

Fracture of distal end of radius was first identified by Sir Abraham Colle's in 1814 and defined as a displaced fracture of the lower end of radius within one and a half inches of the wrist joint [1].

Abraham colle's stated that "one consolation remains, that the limb at some remote period will again enjoy perfect freedom in all its motion, and be completely exempted from pain."

It is one of the most common fractures treated in orthopedic emergencies.

Nearly 1/6th (16%) of all fractures in orthopedic emergencies involve the distal end of the Radius [2,3].

It has a bimodal age distribution, with the young adult and elderly populations being the most affected.

High incidence in elderly people is usually associated with decreased bone mineral density (Osteopenia).

In young adults, these fractures are related to high-energy trauma like road traffic accidents or falls from height and usually have an intra-articular extension.

Elderly females are more prone to distal end radius fracture than males due to postmenopausal osteoporosis and result from low-velocity trauma.

Fall on an outstretched hand along with the wrist in dorsiflexion is the most common mechanism of injury for distal radius fracture [4].

About 50% of metaphyseal fractures of distal end Radius have involvement of the radio-carpal and/or distal radio-ulnar joint.

The management of distal end radius fracture not only requires anatomical union but also good functional outcomes as far as joint mobility is concerned.

Various treatment modalities are available for the treatment of distal end of radius fractures like close reduction and plaster cast immobilization, close reduction with percutaneous pinning, close reduction with external fixation with distractor with or without k-wire fixation, Joshi's external stabilization system application, open reduction internal fixation with volar or dorsal locking plate.

The choice of non-surgical or surgical treatment options highly depends on the patient's age, quality of bone, displacement, comminution, and demand for physical activity.

To treat the distal end radius fracture, first, we have to understand the normal anatomy of the wrist joint, various radiological parameters, type of displacement, degree of angulation, and degree of articular disruption [5,6].

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For un-displaced and extra-articular distal end radius fractures, a good functional outcome can be achieved by conservative management with plaster cast immobilization while unstable, intra-articular fractures of distal end radius need to be managed by one of the above surgical methods for better functional and radiological outcome because these fractures are easier to reduce but there remains the tendency for re-displacement within the plaster cast [7].

Having multi-planar adjustment of frame and application of the principle of ligamentotaxis, distraction with the help of an external fixator is one of the better techniques to achieve and maintain the reduction with restoring of the radial length leading to better functional outcome [8,9].

Ligamentotaxis is the molding of fracture fragments into alignment by traction forces applied through the surrounding soft tissue.

The traction and counter traction restore the length and guide the fracture fragment's alignment, which otherwise is very difficult to control.

Even in severe injuries, the soft tissues like ligaments, retinaculum, tendons, and periosteum, remain intact and are used for fracture fragment alignment by ligamentotaxis. The tension in the tissues is maintained by the distractor.

In view of the above-discussed aspects and patients' needs, we use that modality for the treatment of fracture distal end radius which is easily applicable, effective, least cumbersome, and functionally equivalent to complex treatment methods.

The use of an external fixator for displaced intra-articular distal end radius fracture requires fewer hospital stays with negligible surgical morbidity and gives good functional outcomes.

The aim of my study is to assess the functional outcome of fracture distal end of radius treated with an external fixator.

We will assess the effectiveness of external fixation along with possible complications in the treatment of distal radius fracture.

Materials and Methods

This is a prospective-interventional study conducted in the department of Orthopedic Surgery, Sanjay Gandhi memorial hospital, New Delhi with a sample size of the study is thirty patients treated with an external fixator from January 2021 to June 2022.

So the total duration of the study is 18 months.

We have taken approval from the Ethical Committee of Sanjay Gandhi Memorial Hospital for this study.

Inclusion Criteria

Patients who have sustained fractures of the distal end radius presented in the department of orthopedics, at Sanjay Gandhi memorial hospital were studied.

The inclusion criteria are 1) Age 20 years and above, 2) Closed fractures, 3) Comminuted and intra-articular fracture of distal end radius, and 4) Fractures less than 2 weeks old.

Patients who give written consent for the operative procedure, post-operative follow-up, and to be part of the study. Patients who were medically and anesthetically fit for surgery.

Exclusion Criteria

The exclusion criteria are 1) Patients with pathological/open fractures, 2) Fractures more than two weeks old, 3) Fractures with neurovascular complications, 4) Fractures associated with other bone fractures in the wrist, hand, or forearm, and 5) Patients medically unfit for surgery.

Methodology

All the patients who had fracture of distal end radius presented in the emergency or Orthopedic Out Patients Department (OPD) were subjected to detailed history including date of injury, mode of injury, massage history, any prior treatment received before reporting to the hospital, any other medical co-morbidity, or any drug allergy.

Complete systemic and local examination done to check for any associated systemic injury.

All routine pre-operative investigations were done.

Plain x-rays of the affected wrist joint and forearm in AP and lateral views were taken and the fracture was classified according to Frykman Classification for fracture distal end radius.

The affected limb was immobilized in an above elbow plaster cast for rest till the surgery and the patient was advised for active finger movement and limb elevation to prevent and decrease the swelling of the affected part.

Analgesics were given for pain relief.

After taking surgical fitness from the anesthetist, the patients were planned for surgery as early as possible within 2 weeks of the date of injury.

Consent was taken for surgery and for participation in the study pre-operatively.

Pre-operative preparation and anesthesia

The patient was kept on nil per oral before surgery as per direction by the anesthetist.

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A prophylactic dose of broad-spectrum intravenous antibiotic was given 30 min before surgery.

General anesthesia or supra-clavicular brachial plexus block was given as per the anesthetist's decision.

Implant used

Implants used for the application of fixators are 1) 2.5mm Schanz pins for 2nd metacarpal bone, 2) 3.5mm Schanz pins for radius, 3) Distractor / external fixator, 4) Mini clamps, and 5) Hand drill, drill bits, drill sleeve, T-handle, spanner, and Allen key.

Surgical Technique

Under the full effect of anesthesia and taking all aseptic precautions, painting, and draping was done with the patient in a supine position and limb placed on an arm board (Figure 1).

The reduction was done under C-arm guidance.

A stab incision was given on the lateral aspect of the radius, 8-10cm proximal to the tip of the radial styloid, and the periosteum was stripped.

The drill sleeve was fixed centrally and drilling was done with a 2.5mm drill bit. 3.5mm schanz pin inserted.

Care was taken not to injure the surrounding soft tissues like tendons, muscles, and nerves during drilling.

A stab incision was given at the lateral aspect of the diaphysis of the 2nd metacarpal avoiding injury to the neurovascular bundle.

A drill sleeve was placed and drilling was done with a 1.5mm drill bit. 2.5mm schanz pin inserted.

Distractor was applied to the Schanz pin with the help of clamps.

Similarly, one more 3.5mm Schanz pin was applied to radius, and one 2.5mm pin was applied to the 2nd metacarpal.

The reduction was achieved with distraction and manipulation under fluoroscopy guidance.

External fixation device tightened with Allen key.

Pin site dressing was done with a betadine-soaked gauge.

Post-operative distal neurovascular status was checked and the intravenous antibiotic cover was given for 48 hours (Figure 2).

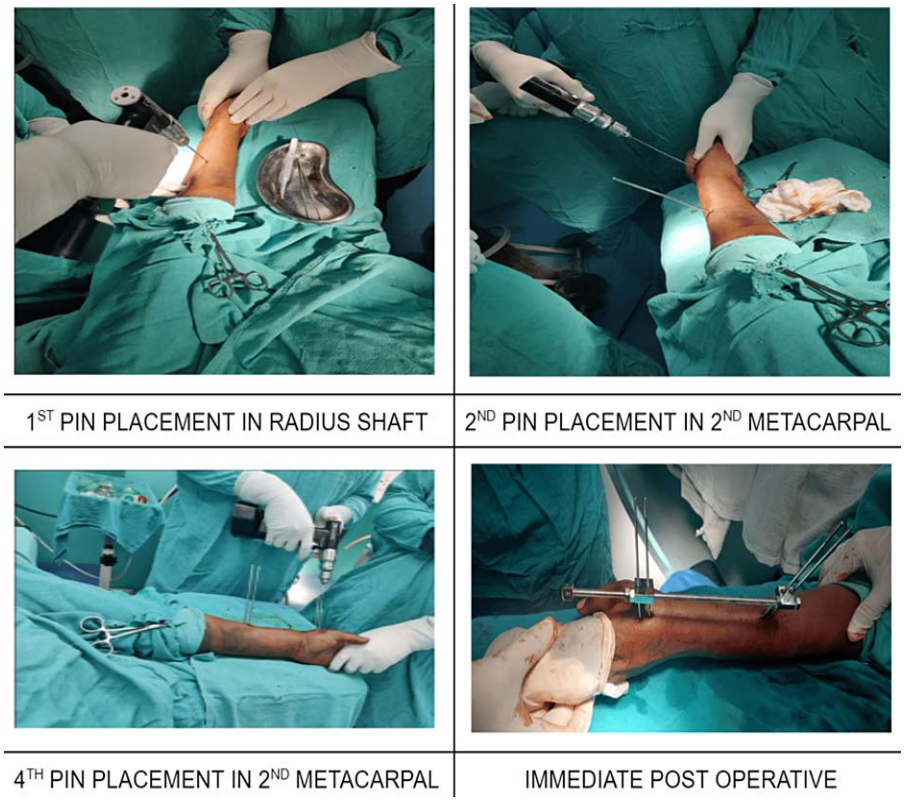

Figure 1. Intra-operative picture showing 1st pin was placed in shaft radius, 2nd pin was placed in 2nd metacarpal, 3rd and 4th pin were placed in radius and metacarpal after adjusting the fixator rod and clamp, and the last image shows immediately after reduction of the fracture.

Figure 2. X-ray radiographical picture of wrist AP and Lateral view showing fracture distal end radius, pre-operative (A), immediate post-operative with external fixator in-situ (B), x-rays just before removal of fixator (C), and x-ray after six months of follow-up showing the fracture is united (D).

Post-operative care and follow up

Active range of motion exercises of fingers, elbow, and shoulder joint was encouraged from the 1st post-operative day to achieve early rehabilitation and full/near full functional outcome.

The limb was kept in elevation with an arm pouch.

Pin site dressing was done on an alternate day till wound healing.

All the patients were followed-up at 2 weeks, 4 weeks, 6 weeks, 8 weeks and after that at monthly intervals till 6 months with the clinical and radiological examination.

The External fixator was removed at a 6-8-week follow-up after clinical and radiological healing of fractures.

All the patients were assessed with demerit point system or Gartland&Werley system for functional outcome (Figure 3).

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Figure 3. Clinical picture of wrist movement after 6 months of post-surgery showing the almost full range of motion.

Results

We conducted this study in the department of Orthopedics, Sanjay Gandhi Memorial Hospital over one and half a year to assess the functional outcome of intra-articular distal end radius fracture treated with an external fixator.

Out of 30 patients, the number of female patients was 16 (53.33%) and the number of male patients was 14 (46.67%).

We have seen in this study females are slightly more prone to distal end radius fracture compared to males.

The youngest person in this study was 28 years male & oldest one was 69 years old female.

The average age of the group was 50.5 years.

The study group had shown, that the number of patients with age 40 years or fewer is only 5 (16.67%) out of 30 while the rest of the 25 (83.33%) patients were above 40 years.

Out of 25 patients above 40 years, 9 (36%) were male while 16 (64%) were female.

All 5 (100%) patients less than or equal to 40 years are male.

We have seen in this study that two age groups commonly involved are young adult males and elderly females (Table 1).

Table 1. Demographic characteristics of the patients, classification, and functional outcomes.

Variables		Values (%)
Age group		Mean age 50.5 years
Sex (F:M)		8:7 (F>M)
Handedness		Right > Left (R:L=3:2)
Mode of injury	Fall	23 (76.67%)
	RTA	7 (23.33%)
Frykman classification	I	0 (0%)
	II	0 (0%)
	III	5 (16.67%)
	IV	6 (20. 00%)
	V	2 (6.67%)
	VI	6 (20. 00%)
	VII	6 (20. 00%)
	VIII	5 (16.67%)
Trauma surgery interval	<3 Days	3 (10%)
	3-7 Days	16 (53.33%)
	>7 Days	11 (36.67%)
Functional outcome (by GARTLAND & WERLEY SCORING SYSTEM)	Excellent	14 (46.67%)
	Good	11 (36.67%)
	Fair	3 (10%)
	Poor	2 (6.67%)

Note: RTA: Road Traffic Accident.

27 (90%) out of 30 patients were right-handed people which was a common behavioral finding and thus we expect more right-side distal radius fracture in our study.

In this study, 23 (76.67%) out of 30 patients suffered an injury due to self-fall, and the rest 7 patients had injuries due to road traffic accidents.

Fracture was classified on the basis of intra-articular involvement and the presence of an ulnar styloid fracture (FRYKMAN Classification).

Type I and II fracture patients were not included in the study. 5 (16.67%) were of type III (radio-carpal articular involvement), 6 (20%) were type IV (radio-carpal involvement with ulnar styloid fracture), 2 (6.67%) were type V(radio-ulnar involvement), 6 (20%) were type VI (radio-ulnar involvement with ulnar styloid fracture), 6 (20%) were type VII (radio-carpal and radio-ulnar involvement) and only 5 (16.67%) were type VIII (radio-ulnar and radio carpal involvement with ulnar styloid fracture). 3 (10%) patients were operated on within 72 hours, and 16 (53.33%) patients were operated on between 3 -7 days. 11 (36.67%) patients operated beyond 7 days due to delay in pre-anesthetic fitness or delayed presentation at the hospital. the average trauma surgery interval was 6.2 days.

The average time of external fixator removal in the study was 6.8 weeks. In 18 patients (60%), external fixator was removed in the 6th week.

In 10 patients (33.33%), Fixator was removed between 6-8 weeks. While in 2 (6.67%) patients, fixator was removed beyond 8 weeks.

Functional outcome was evaluated with GARTLAND & WERLEY SCORING SYSTEM. 14 patients (46.67%) showed excellent results, 11 patients (36.67%) showed good, 3 patients (10%) showed fair, whereas 2 (6.67%) patients showed poor results.

This evaluation was done at the final follow-up of the patients.

The following complication was noted during the follow-up.

Stiffness was the most common complication seen in 6 patients (20%). 2 patients (6.67%) had chronic pain, 1 patient (3.33%) had pin track infection, 1 patient (3.33%) had delayed union, whereas 1 patient (3.33%) had collapsed at the fracture site (Table 2).

Table 2. Complication of External fixator in Treatment of Fracture Distal end Radius.

Complications	Number of Patient (%)
Stiffness	6 (20%)
Chronic pain	2 (6.67%)
Pin tract infection	1 (3.33%)
Delayed union	1 (3.33%)
Collapse	1 (3.33%)

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The relationship between functional outcome and periods of fixation is shown below in (Table 3) which is statistically significant.

Excellent to good results were observed in 88.88% of patients when the period of fixation is 6 weeks while excellent to good results decreased to 0% beyond 8 weeks period of fixation.

Poor results were seen beyond 9 weeks in 100% of the patients. (Table 3 and Figure 4).

Table 3. The relationship between functional outcome and periods of fixation is shown.

PERIOD OF FIXATION (in weeks)		EXCELLENT	GOOD	FAIR	POOR	P VALUE
6	FREQUENCY	8	8	2	0	0.0001
	%	44.44%	44.44%	11.12%	0%	
7	FREQUENCY	1	1	1	0	
	%	33.33%	33.33%	33.33%	0%	
8	FREQUENCY	5	2	0	0	
	%	71.43%	28.57%	0%	0%	
9	FREQUENCY	0	0	0	2	
	%	0%	0%	0%	100%	

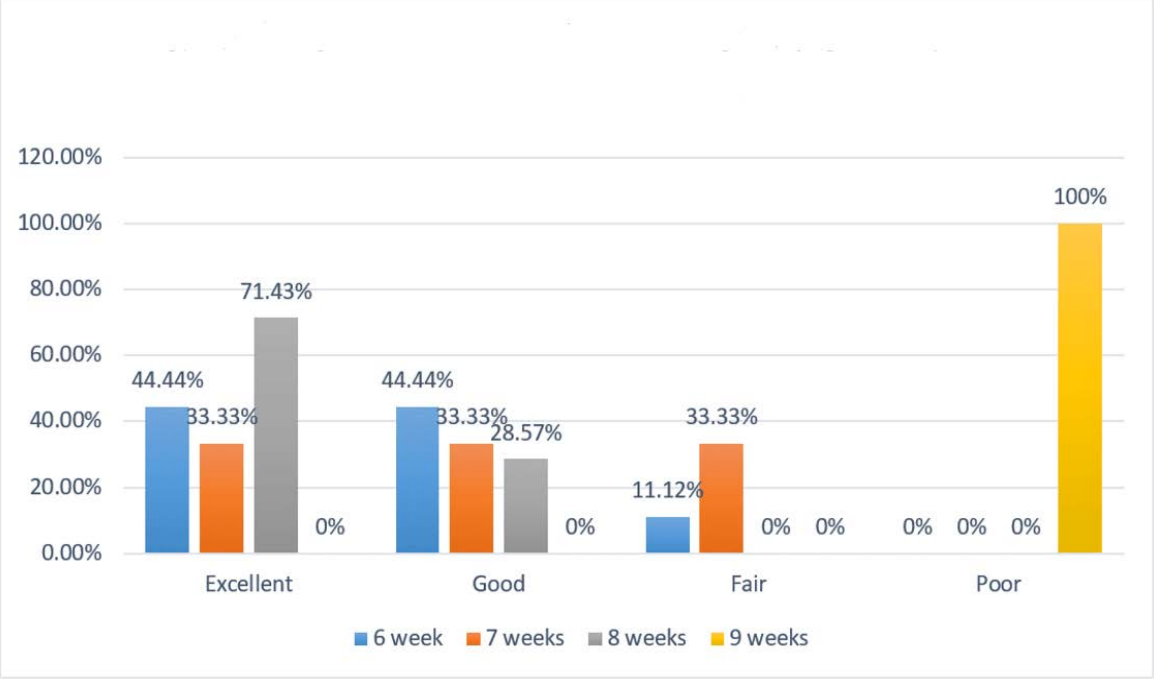

Figure 4. Graphical representation of the relationship between functional outcome and the periods of fixation of fracture distal end radius.

Discussion

Patients with distal end radius fractures make up most of the patients presenting in orthopedic emergencies and OPD.

Abraham Colle's was very much satisfied with the results of his treatment of distal radial fractures with close reduction and plaster cast immobilization in 1814, but further studies have drawn attention to the high prevalence of unsatisfactory results following conservative management.

Although anatomic reduction can be obtained by a close reduction in extra-articular fracture due to the tendency for re-displacement, the most appropriate method to maintain the reduction is still a considerable matter of debate [1].

De Palma in 1952 hypothesized that a residual dorsal tilt of more than 5 degrees in distal end of radius fracture leads to a poor result [10].

Gartland and Werley in their study found that close reduction with plaster cast immobilization of a distal radial fracture resulted in the loss of reduction in 60% and an unsatisfactory result

with respect to pain and loss of function in 2% of patients [11].

Cole and Obletz documented radial shortening of 3 mm or more in 22 out of 33 patients (i.e. 67%) and radial shortening of 6mm or more in 11 patients (i.e. 33%) after fixation with pins and plaster [12].

Short et al. found that loss of volar tilt after a distal radial fracture led to progressive load on the ulnocarpal and radio-scaphoid articulations, which caused pain and early degeneration of the joint.

Because of unsatisfied results with the available methods of treatment, Cooney et al., in 1979 critically reviewed external fixation to treat distal radial fractures and reported a good result for 51 (85%) of sixty patients, with decreased radial shortening and improved volar tilt [13].

Since then, external fixation has become a popular and reliable method to treat these frequently seen fractures.

A common algorithm for unstable distal radial fractures is external fixation, supplemental fixation with K-wires, and frequently the use of a bone graft or bone substitute.

The external fixator/distractor is a versatile tool for the management of intra-articular fractures of distal end radius.

The standard reduction technique is similar to the conservative method to treat fractures. Continued traction by external fixator results in controlled distraction of the distal radius and facilitates the manipulation.

This whole technique is simpler than the other techniques.

This procedure required a short duration of hospital stay.

External fixation is a reliable method to maintain reduction as well as restore the radial length. Ochen Y et al., 2020 in their study of 2254 patients found that 80.6% study population was female [14].

Vargaonkar G et al. (2014) in their study of 60 patients noted a 58% frequency of Distal Radius fractures in the female population [15].

In my study, 16 out of 30 patients (53.33%) were female and 14 patients (46.67%) were female.

Hence there is a slightly higher tendency for the fracture distal radius to occur in the female population.

Vargaonkar G et al., 2014 in their study of 60 patients noted a mean age of 46.45 years.

Dowdy PA et al. (1996) noted a mean age of 49 years in their study [16].

In my study, the age ranges from 28 to 69 years with a mean age of 50.5 years.

25 patients (83.33%) were of age more than 40 years while only 5 patients (16.67%) were of age less than or equal to 40.

Hence elderly population is at higher risk for distal radius fracture.

Dowdy PA et al., (1996) in his study noted that 58.8% (10 out of 17) patients have involvement of the dominant hand [16].

In my study, 27 out of 30 patients are right-handed people which are common behavioral finding while 18 (60%) out of 30 patients develop fractures in the dominant hand while the rest of the 12 (40%) patients develop fractures in the non-dominant hand.

Hence there is a higher tendency for distal end radius fracture to be occurring in the dominant hand.

Vargaonkar G et al., 2014 in their study of 60 patients noted that 58% of fractures were due to fall while the rest 42% was due to road traffic accidents.

Das AK et al., (2011) in their study found that 21 out of 32 (65.6%) develop fracture of Distal radius due to trivial falls [17].

In my study, 23 out of 30 patients (76.67%) suffered the injury due to self-fall means trivial fall is the most common mode of trauma in the elderly population.

The fracture was classified on the basis of FRYKMAN Classification.

Dienst M et al., 1997 in their study of 30 patients noted 3% type I, 7% type III, 7% type IV, 10% type V, 10% type VI, 33% type VII, and 30% type VIII fractures [18].

Only intra-articular fractures are included in my study.

5 patients (16.67%) were of type III (radiocarpal articular involvement), 6 patients (20%) were type IV(radio-carpal involvement with ulnar styloid fracture), 2 patients (6.67%) were type V(radio-ulnar involvement), 6 patients (20%)were type VI (radio-ulnar involvement with ulnar styloid fracture), 6 patient (20%) were type VII (radio-carpal and radio-ulnar involvement) and only 5 patients (16.67%)were type VIII (radio-ulnar and radio carpal involvement with ulnar styloid fracture).

Krukhaug Y et al., 2009 in their study of 71 patients documented mean trauma surgery intervals of 4 days [19].

As the time interval from trauma to surgery in the form of external fixation plays its own role in final outcome we have tried to operate as early as

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the patient represents and get the medical fitness from the anesthetics.

The mean trauma-to-surgery interval was 6.2 days. 3 patients (10%) were operated on within 72 hours, and 16 patients (53.33%) were operated on between 3-7 days.

11 patients (36.67%) operated beyond 7 days due to delay in pre-anesthetic fitness or delayed presentation at the hospital.

The average trauma surgery interval was 6.2 days.

Krukhaug Y et al., 2009 in their study document 43 days (6.14 weeks) average duration of external fixation.

Removal of the external fixator was done when a satisfactory union was seen on radiological examination.

In my study, the average duration of external fixation was 6.76 weeks.

In 18 patients (60%), the external fixator was removed in the 6th week. In 10 patients (33.33%), the fixator was removed between 6-8 weeks.

While in 2 patients (6.67%) fixator was removed beyond 8 weeks.

Capo JT et al., 2009 in their study of 24 cases found 87.5% excellent or good results [20].

Sanders RA et al., 1991 in their study of 35 patients documents 68% good to excellent results [21].

In my study, Patients were evaluated for functional outcomes with GARTLAND & WERLEY SCORING SYSTEM on final follow-up at 6 months 14 (46.67%) patients showed excellent results, 11 (36.67%) patients showed good, 3 (10%) patients showed fair, whereas 2 (6.66%) patients showed poor results.

The relationship between functional outcome with a period of fixation shows that poor results are associated with a longer duration of external fixation with (P value<0.05) which is statically significant.

The relationship between functional outcome with gender (P=0.069) and age (P>0.541) is statistically insignificant.

Yu X et al., 2019 in their study of 23 patients treated with an external fixator noted 9 complications that occurred in 8 patients (34.5%) with pin tract infection being the most common complication (13.0%), followed by complex regional pain syndrome (8.7%), fixation failure requiring (4.3%), a sensory branch of radial nerve injury (4.3%), reduce loss requiring re-adjustment (14.3%), and traumatic radio-carpal arthritis [22].

In my study, the incidence of complications was 36.67% with Stiffness of the wrist joint being the most common complication seen in 6 patients (20%). 2 patients (6.67%) had chronic pain, 1 patient (3.33%) had pin track infection, 1 patient (3.33%) had delayed union, whereas 1 patient (3.33%) had collapsed at the fracture site.

Our prospective study of the functional outcome of intra-articular distal radius fractures treated by an external fixator emphasizes that:

1) External fixation for distal radius fracture is a safe and reliable method of treatment in terms of fracture reduction and fixation with good functional outcomes and a very low complication rate, in comparison with other treatment methods for these fractures.

2) External fixator can be well tolerated for 6-8 weeks and can be left in place and as needed on basis of radiological evidence of healing.

3) External fixator is an adequate device to maintain the fracture reduction and radial length by virtue of sustained counter tractions by using the principle of ligamentotaxis.

4) Treatment with External fixation decrease the time of hospital stay and cost of treatment and leads to early rehabilitation.

5) Functional outcome of this study is comparable to the plating method and superior to the other treatment method like cast immobilization or per-cutaneous k-wire fixation.

6) External fixation is better than plating as no need for 2nd surgery for implant removal and is less invasive than plating.

There is the risk of fracture at the screw removal site after plate removal.

Conclusions

From this study, we conclude external fixator is a simple, safe, and cost-effective method for the treatment of distal end radius fracture with lesser duration of hospital stay.

It reduces the fracture by means of ligamentotaxis and maintains the reduction as well as restores the radial length without interfering with the fracture healing process.

Finger and elbow can be mobilized as early as possible on the same day of the operative procedure which helps in preventing the stiffness of the elbow and finger.

Though some patients develop stiffness at the wrist joint, which can be easily prevented by wrist mobilization immediately after the removal of the external fixator.

We can achieve Good to Excellent functional outcomes by external fixator in intra-articular fracture distal end radius.

Conflict of interests

None to declare.

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