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Functional Outcome of Distal end Radius Fracture Treated by Ligamentotaxis by External Fixator with or without K Wire Augmentation

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Abstract

Background: One of the most common injuries encountered in orthopedic practice are Distal Radius fractures. This comprises of 8%–15% of all fractures in adults[1]. The reason for comminuted DER fractures is high-energy trauma in young and low-energytrauma in elderly. They present as shear and impacted fractures involving the articular surface of the distal radius with displacement of the fragments[2-7]. External fixation for distal radius fracture relies on the principle of Ligamentotaxisin which, a distraction force applied to the carpus aligns the fragments by means of intact ligaments. The length and alignment of fracture fragment is guided by pull and counter pull which are otherwise difficult to control[8]. **Objective:** To study functional outcome of distal end radius fracture treated by ligamentotaxis with evaluation of functional results according to Disabilities of the Arm, Shoulder and Hand (DASH) score system. **Material and Methods**: We included 30 patients (Male 24 and Female 6) treated for distal end radius fracture during a period from 2015 to 2017. Patients were evaluated clinically by subjective assessment using DASH Scoring system. **Result:** After functional evaluation of patients according to the scheduled follow up with mean DASH Score of 76.08 at 1st month, 62.92 at 3rd month and 42.60 at 6th month, and was found to be Highly Significant ($p<0.001$) among all the compared groups. **Conclusion:** We concluded that external fixation and ligamentotaxis applied to complex distal radius fractures, when added with augmented K-wire fixation can provide direct augmentation of fracture stability and a good wrist function.

Keywords: Disabilities of the Arm, Shoulder and Hand (DASH) Score, Ligamentotaxis, Radius Fracture

1. Introduction

One of the most common injuries encountered in orthopedic practice are Distal Radius fractures. This comprises of 8–15% of all fractures in adults[1]. Many fractures of the distal aspect of the radius are relatively uncomplicated and are effectively treated by closed reduction and immobilization in cast. However unstable/ intra-articular fractures can jeopardize the integrity of the articular congruence and/or kinematics of these articulations[9]. The classic fracture described by Sir Abraham Colles in 1814 – low energy, extra articular, osteoporotic distal radius fracture – often does well with closed reduction and cast immobilization. High velocity injuries have resulted in severely comminuted and unstable fractures with intra articular components treatment has become increasingly difficult. Management of comminuted DER fractures continues to be a

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therapeutic problem and challenge for the orthopedic surgeon. Impacted intra-articular fractures have generated interest because of the articular congruity of <=2mm after fracture reduction which is required to avoid symptomatic post traumatic arthritis[10].

Many methods for treatment of distal end radius fractures differ greatly throughout the world but mainly include closed reduction and casting, pins and plaster, percutaneous pinning, external fixation with ligamentotaxis, internal fixation, combined internal and external fixation and arthroscopically assisted reduction[11]. Management of unstable intra articular fractures of distal radius with external fixation in along with percutaneous pinning has been found to be effective but has also been associated with many complications[12].

Bridging external fixation forms the heart of ligamentotaxis as it allows distraction at the radiocarpal joint[9].

External fixation for distal radius fracture relies on the principle of Ligamentotaxisin which, a distraction force applied to the carpus aligns the fragments by means of intact ligaments. The length and alignment of fracture fragment is guided by pull and counter pull which are otherwise difficult to control[8].

Distraction assisted reduction and maintenance of distal radius fracture is a widely used and reliable treatment method.

2. Material and Methods

This research is a prospective study design in a sample of 30 patients with distal end radius fracture undergoing ligamentotaxis by external fixator attending Department of Orthopedics Tertiary Health Care Centre. Most of the cases resulted from high velocity injuries and fall on outstretched hand. The cases presented with swelling, pain of the wrist and painful movements (Table 1).

Table 1. Mode of injury

RTA	18 (60%)
Fall on outstretched hand	12 (40%)

Twenty-four males and six females were included in the study (Table 2).

Table 2. Sex

Male	24 (80%)
Female	6 (20%)

All the patients were evaluated with X rays of the wrist postero – anterior view and lateral view. The patients for whom external fixation and ligamentotaxis was planned were temporarily given below elbow plaster splint to relieve pain and limb elevated for edema to subside.

2.1 Eligibility Criteria

2.1.1 Inclusion Criteria

- Fractures of distal end radius of either side or both with or without ulnar styloid fractures.
- Age between 20 – 70 years.
- Fractures up to 3 cm from distal articular surface of radius.
- Fractures with history of trauma < 2 weeks.
- Frykman's type III to VIII.

2.1.2 Exclusion Criteria

- Age group below 20 years and above 70 years.
- Fractures with history of trauma > 2 weeks.
- Frykman's type I and II.

In the prep operative period, splint age with POP slab and elevation was carried out which facilitated fracture reduction and precision of pins while applying external fixator[13]. Fracture was classified according to the Frykman classification.

Instability[14] was recognized based on the initial displacement as follows:

- >20 degree dorsal angulation.
- Marked dorsal metaphyseal comminution.
- Radial shortening >10mm.

2.2 Surgical Technique

Patient's pre-operative investigations were done, Supraclavicular block was given. Patients were lying in supine position and with the wrist to be operated rested on the Mayo's table. Prepared and draped under all aseptic precaution.

The fracture site was checked under C-ARM. Required manipulation was done and reduction was achieved which was confirmed under C-ARM. The metacarpal pins were applied first. 1cm incision made over metaphyseal flare of second metacarpal. The distal pin should be inserted

proximal to the transition of the metacarpal head into the shaft. The more proximal pin is inserted distal to transition of the shaft into the metacarpal base. The pins should obtain a good hold in both cortices (Figure 1).

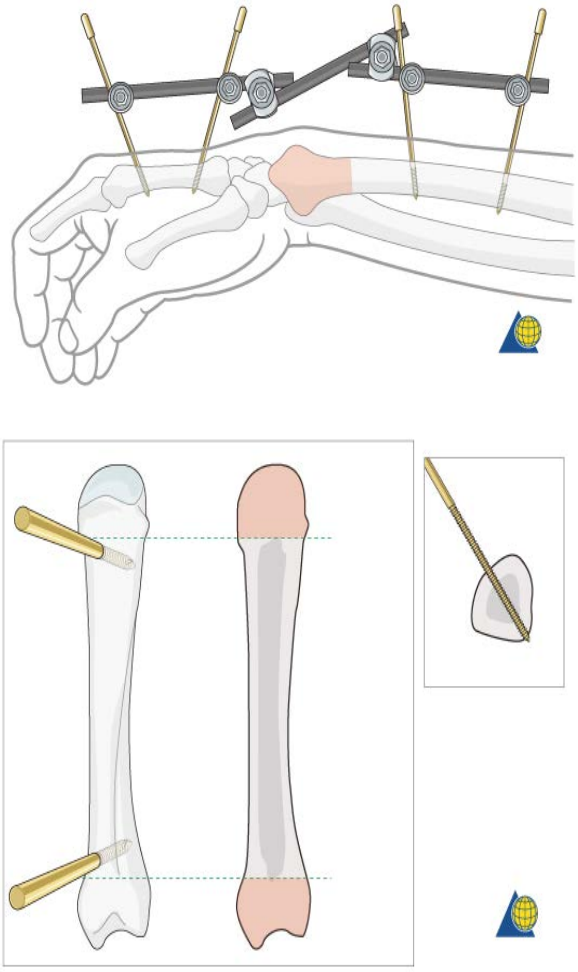

Figure 1. Pin insertion technique.

Blunt dissection was carried out avoiding injury of superficial radial nerve and first dorsal interosseous muscle.

Second metacarpal was drilled with 2.0mm drill bit while protecting soft tissues using drill guide. Then 2.5mm × 100mm schanz pin inserted. A second pin was applied distally by same method.

Radial pins were applied 10cm proximal to radial styloid. 1 cm incision was made along the line joining lateral condyle Humerus and Lister's tubercle of distal Radius, blunt dissection carried out to reach radial shaft avoiding injury to radial sensory nerve and extensor tendons.

Radial shaft was drilled with 2.5mm drill bit while protecting soft tissues with drill guide. Drilling was done in such a way that pins were placed on radial side and 30° dorsally. A 3.5mm × 100mm schanz pin inserted. Second radial pin was applied distal to first pin by same method.

The metacarpal pins were connected to Aesculap clamp and radial pins were connected to another Aesculap clamp. The clamps were connected to distraction rod. Check X rays taken and fine tuning of distraction done. No more than 2-3mm distraction was applied over radio carpal joint. In some cases the fracture was assessed after application of external fixator and augmented with the help of cross k-wires.

Postoperatively patients were encouraged to do active finger movements from day one. Six pack exercises were taught. Limb was kept elevated for 24 – 48 hours. Parental antibiotics were given for two days followed by oral antibiotics for one more week. Pin sites were regularly inspected, and Betadine dressings given.

Patients were discharged by fifth day and reviewed every month till six months. On every visit, extent of finger movements was noted. Pin site was examined for infection.

At six weeks after confirming union, external fixator was removed and sterile dressing and elastocrepe bandage applied. A radiograph was also taken.

Active wrist mobilization was started. Patients were reviewed on first, third and sixth month of treatment. Every time functional and radiological assessment were made and compared to the normal side. Disabilities of the Arm, Shoulder and Hand (DASH) scoring system was used to assess the functional outcome. DASH questionnaire is a 30-item questionnaire that looks at the ability of a patient to perform certain upper extremity activities[15,16]. This questionnaire is a self-report questionnaire that patients can rate difficulty and interference with daily life on a 5-point Likert scale.

In DASH a higher score indicates a greater level of disability and severity, whereas, lower score indicates a lower level of disability. The score on both test ranges from 0 (no disability) to 100 (most severe disability)[16]. The data was analysed using One Way Repeated measure ANOVA.

DASH Scoring Formula = ([(sum of *n* responses)/*n*] -1)·where *n* represents the number of completed items[15].

2.3 Results

After functional evaluation of patients according to the scheduled follow up with mean DASH Score of 26.23 at 1st month, 14.27 at 3rd month and 4.97 at 6th month, and

was found to be Highly Significant (p<0.001) among all the compared groups (Table 3 and Figure 2).

Table 3. DASH score

Follow up (in months)	DASH (Mean ± SD)
DASH 1 Month	76.08 ± 6.16
DASH 3Months	62.92 ± 4.50
DASH 6Months	42.60 ± 1.65

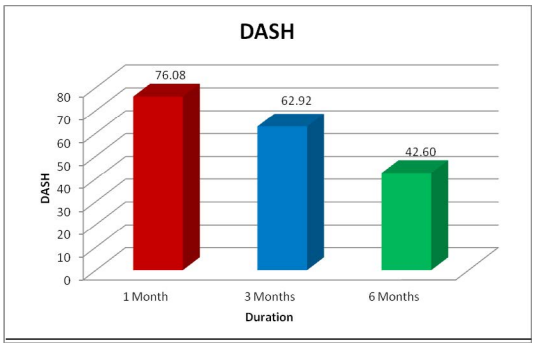

Figure 2. DASH score.

Table 4. One-way repeated measures ANOVA

	SS	df	MS	F Statistics
Columns	17069.507	2	8534.753	619.131
-Error	799.533	58	13.785	
-Subjects	968.217	29	33.387	
Total	18837.26	89		

F (2,58) = 619.131, F crit = 3.156, p-value = 7.44E-40 As F>Fcrit, (p<0.001), there is a HIGHLY SIGNIFICANT Difference in the outcome (Table 4).

By One-way Repeated Measures ANOVA (Table 5).

Table 5. Repeated measures ANOVA

F statistics	p-value	Significance
F (2,58) =619.131	7.44E-40	Highly Significant

There is highly significant difference between the compared groups (Table 6).

2.3.1 Post Hoc Test (Analysis between Individual Groups)

Table 6. Bonferroni corrected α value=0.017

Between Groups	p-value	Significance
DASH 1 & DASH 3	1.13E-15	Highly Significant
DASH 1 & DASH 6	5.49E-23	Highly Significant
DASH 3 & DASH 6	1.18E-20	Highly Significant

Complication: Pin tract infection in 4 patients (13.33%) and DRUJ Instability in 1 patient (3.33%) (Figure 3).

Figure 3. Case illustration.

3. Discussion

Preservation of radial length is the most important factor for preservation of function. Shortening of 2.5 mm and/or the residual dorsal tilt of distal radius transmits more axial load to ulnar shaft leading to ulnar impaction or dysfunction of Distal Radio Ulnar Joint, with limited range of motion in pronation and supination, depending on the volar or dorsal subluxation of the ulnar head within the sigmoid notch and degenerative arthritis leading to pain on ulnar side of the wrist[18,19].

The main shortcoming of the method is its inability to maintain volar tilt and in cases of over distraction it produced a dorsal tilt. Since the fracture occurs in cancellous region, the distraction causes a gap at the fracture which occurs due to fracture impaction.

So, in cases with metaphyseal comminution the fracture actually takes long time to consolidate. Therefore, in fractures with metaphyseal comminution, the external fixator has to be kept for a longer time or there should be addition of cancellous bone graft to avoid metaphyseal collapse. Residual dorsal angulation can precipitate ulnar impaction, midcarpal instability and altered stress concentration which may lead to early arthritis. Porter, in his study, felt that at least loss of 20 degrees of palmar tilt is required for loss of function.

In ligamentotaxis with external fixation, radial length, ulnar variance and radial angulation are restored to normal but correction of volar tilt though adequate, is not complete.

In the final functional assessment (Sarmiento) the results were[1] plaster 43% good and excellent, 50% fair and 7% poor[2] external fixator 80% good and excellent, 20% fair and poor results[3] open reduction and internal fixation 63% good and excellent, 26% fair, 11% poor. They recommend that displaced severely comminuted intra-articular fractures should be treated with an external fixator.

Margaliot and Hasse[20] conducted a meta-analysis of studies published between 1980 and 2004 on external and internal fixation of distal radial fractures. They concluded that there was not sufficient evidence to support the use of Open Reduction and Internal Fixation (ORIF) over external fixation.

Anvekar and Nimbargi documented that ligamentotaxis consistently had a positive outcome in the management of 40 intraarticular distal radius fractures treated by them with static external fixator. They achieved 70% good and excellent results using modified Gartland and Werley scoring system.[21]

Similarly, in another prospective study of unstable intra-articular fractures of the distal radius including 132 patients with an average age of 35 years, treated by external fixator. 83% of patients had good or[21,22] excellent results with a few complications.

This is attributed to the fact that volar ligaments being sturdier than dorsal ligamentson distraction become tense before the dorsal ligaments which are in a relative 'Z' orientation. So, on distraction, palmar cortex is brought out to length before dorsal cortex preventing full correction of dorsal tilt.

The external fixator was also unable to correct the depressed lunate fossa (as pointed out by Melone), which may need additional procedures like pinning and elevation of the depressed fragment.

The ulnar styloid fractures with displacements >3 mm indicates higher degrees of fracture displacements and injury to triangular fibrocartilage and it needs to be fixed.

Higher velocity injuries yield poor results. This reiterates the role of soft tissue and ligaments in fracture healing. So, the addition of palmar plaster splint (as advocated by Fernandez and Palmer) was effective in giving rest to soft tissues and also supportive in unstable fracture patterns.

If the principles of ligamentotaxis are applied rationally the factors that cause instability are identified clinically and managed surgically, a satisfactory outcome can be expected. In majority of cases prompt detection of articular fragments displacement, stability, and reducibility provides a rational basis of optimal management of these complex distal end radius fractures. Many fractures of the distal aspect of the radius are relatively uncomplicated and are effectively treated by closed reduction and immobilization in cast. However unstable/intra-articular fractures can jeopardize the integrity of the articular congruence and/or kinematics of these articulations. Treatment of fracture of distal end of radius is a challenge for orthopaedic surgeon starting from the reduction of fracture to maintenance of reduction till the fracture is united and mobility of the joint occurs after complete fracture union. Permanent disability can occur in case of treatment failure[23].

4. Conclusion

Thus the distal radius fracture is no longer a simple fracture to treat by cast alone and more aggressive treatment is needed to restore the articular congruity and functional outcome. We conclude that external fixation and ligamentotaxis applied to complex distal radius fractures, when added with augmented K-wire fixation can provide direct augmentation of fracture stability and a good wrist function.

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