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Treatment of Comminuted Distal Radius Fractures Using Spanning External Fixator

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ABSTRACT

Background: Distal radius fractures are common orthopedic injuries with a bimodal age distribution, affecting young patients following high-energy trauma and elderly patients with osteoporotic bone following low-energy falls.

Objectives: The aim of the study was to understand the advantages and disadvantages of spanning external fixation technique for treatment of comminuted distal radius fractures.

Patients and methods: This Prospective Cohort study was conducted in Orthopedic Surgery Department, Zagazig University Hospitals, Egypt on twenty-four patients with comminuted distal radius fractures treated by spanning External Fixator, during the period from January 2021 to December 2021**.**

Result: All patients achieved the full union; only 2 patients had delayed union beyond the 3 months. According to MMWS, 50% of patients had excellent outcome, 29.2% had good, while fair and poor outcome occurred in 12.5% & 8.3% respectively. Regarding the Complications, ten patients developed complications, most of them were minor complications, while 2 patients developed Delayed union and one patient had DRUJ instability.

Conclusion: It could be concluded that spanning external fixation is a good option for treatment of intra-articular DRF. The good outcomes achieved in this study suggest that use of the Spanning external fixators could be an alternative treatment method for intra articular distal radius fractures, as it is easier, need less operation time, decrease amount of blood loss and decrease risk of infection in comparison with spanning bridging plate or locked distal radius plates. All DRFs achieved good results; Functional outcomes were promising, including wide wrist ROM and no mal or non-union occurred.

Keywords: Distal Radius, Intra-articular, External fixator

INTRODUCTION

Distal radius fractures tend to occur in bimodal age distribution, in young age due to high-energy trauma, and low to moderate energy trauma in old age patients secondary to osteoporosis [(1)]**.**

There are many types of classification systems describing distal radius fracture (Fernandez, Frykman, Melon and AO classifications …etc.). The AO classification divides distal radius fractures into 3 broad groups that can divided into 27 distinct fracture patterns. Type A describes an extra-articular fracture, type B involves a partial disruption of the articular surface, and type C represents a complete disruption of the articular fragments from the shaft [(2)].

The surgical indications for distal radius fractures generally include displaced or unstable fracture patterns. Several fracture fixation constructs are available, with external fixation (Ex. Fix.) being a common and proven technique. The technique involves a closed reduction, or limited open reduction, with ligamentotaxis and application of an Ex. Fix. Frame to the radius proximally and the second metacarpal distally thereby spanning the fracture and wrist joint [(3)]**.**

The complications after distal radius fractures occur for many reasons and often vary depending on the method of treatment. The nerve injury is relatively common and the mostly median nerve injury, compartment syndrome, missed associated injury, loss of reduction, tendon rupture and infection [(4)].

The aim of the currents study was to understand the advantages and disadvantages of spanning external fixation technique for treatment of comminuted distal radius fractures.

PATIENTS AND METHODS

This prospective Cohort study included a total of on twenty-four patients with comminuted distal radius fractures treated by spanning External Fixator, attending at Orthopedic Surgery Department,, Zagazig University Hospitals, Egypt. This study was conducted between January 2021 to December 2021.

The mean age was 43.9±11.6 years, ranged from 27 to 69 years. Males were affected more than females. Most of patients injured due to RTA (41.7%)

***Ethical Consideration*:**

Written informed consent was obtained from all patients and the study was approved by the research ethical committee of Faculty of Medicine, Zagazig University (International review board: IRB#). The study was done according to The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

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Inclusion criteria:
All patients with comminuted distal radius fractures coming to the department of orthopedics at Zagazig university hospitals were included into the study respecting the following criteria:

1. Comminuted distal radius fractures with metaphyseal comminution.
2. Skeletally mature patients.
3. Without other significant comorbidity like pathological fractures other than osteoporosis.

Exclusion criteria:

1. Patients who were unfit for surgery.
2. Neglected cases.

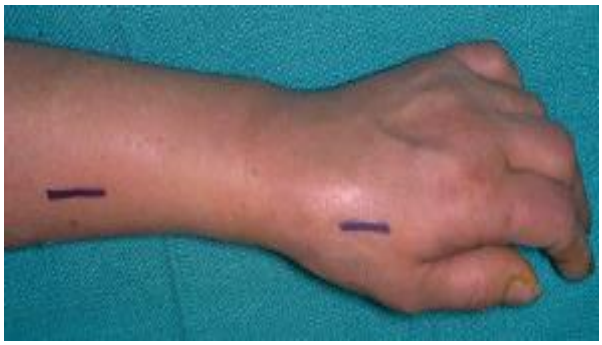
All patients were subjected to the following:
Personal data: Name, age, sex, address, occupation, dominant hand, and date of admission.
Complaints: (Pain, swelling of the wrist, limited range of movement of the wrist, paresthesia, affection of other regions).
History: (History of trauma, time of injury, side affected, mechanism of trauma, time before the start of definitive treatment, medical and surgical history, medications and allergies.

Laboratory evaluation: Complete blood picture (CBC), liver function tests (ALT, AST and albumin), serum creatinine, random plasma glucose (RPG), virology tests: HBV-Ag, HCV-Ab and HIV-Ab.

Radiological evaluation:
X-ray: postero anterior and Lateral views are taken to assess the following (Dorsal angulation, Radial shortening, Radial displacement, Dorsal displacement, Radial angle, Associated ulnar fractures
CT scan: Detect site and degree of articular comminution (scaphoid and lunate fossa). Evaluation the type of fracture according to classification.

Treatment:
Closed fractures: These fractures were temporarily reduced and put in a above elbow plaster cast till the time of operation, the limb was elevated, analgesics were prescribed, and the patients were kept under observation in the hospital till the time of surgery.
Open fractures: In the emergency room parenteral antibiotics were initiated and tetanus prophylaxis was given with careful assessment of the wound and putting saline soaked sterile dressings on it. Provisional fracture reduction and splint application should be done till the time of urgent operative fixation.

Interventions: Under general or regional anesthesia and supine position and application of pneumatic tourniquet. The locations of the external fixator pins marked over the index metacarpal and distal forearm before application.



(Figure 1): Pin sites are marked over the dorsoradial radius and the index metacarpal.

A three cm longitudinal skin incision was made along the midradial aspect of the radius, beginning about ten cm from the distal wrist crease. The subcutaneous tissues were dissected bluntly with protection of the sensory branch of the radial nerve.

(Figure 2): Radial pins are placed between the tendons of the extensor carpi radialis longus and brevis just proximal to the first compartment muscles.

Forearm pins placed just proximal to the first dorsal compartment muscles, along the dorso-radial forearm between the extensor carpi radialis longus and brevis tendons. A 2.7 mm drill was used to penetrate the radial cortex of the radius at the level of the insertion of the pronator teres. A4 mm threaded half-pin was drilled at the level of the insertion of the pronator teres while aiming at the ulnar shaft until it penetrates the ulnar cortex of the radius.

(Figure 3): Homan retractors and drill guides protect the soft tissues.

A second pins was inserted distal and parallel to the first with the aid of a guide or the proximal portion of the external fixation frame. Pins should be placed at radially plane in such a way that the device can be mounted so as not to obscure the antero-posterior and lateral X-ray views. The metacarpal pins placed approximately 45^{o} off the horizontal plane of the palm. A longitudinal skin incision was made over the proximal half of the second metacarpal bone along its radial aspect. The subcutaneous tissues were dissected bluntly and retracted to avoid injury of the small branches of the radial nerve. The portion of the first dorsal interosseous muscle over the metacarpal flare was elevated.

(Figure 4): The index metacarpal pins are placed through a small open incision.

A 2.7 mm drill was used to penetrate the proximal cortex of the second metacarpal bone at its metaphyseal flare. A three mm threaded half pin was inserted with a power driver into the second metacarpal at its metaphyseal flare to go into the base of the third metacarpal bone but not beyond this point. A second pin was Inserted parallel to the first in a similar fashion with the aid of a guide or the distal portion of the external fixation frame. The depth of penetration of the second pin should be no farther than the ulnar cortex of the second metacarpal. Skin incisions were closed loosely and sterile dressings were applied to the wounds.

(Figure 5): Pin sites are loosely closed while easily sutured without the frame.

The wrist external fixator, that has frame with a two sliding clamps linking by one bar, this was mounted on the predrilled pins leaving sufficient mobility in all planes for reduction by the unlocked joints and sliding bars providing an ideal device for three dimensional ligamentotaxis at the level of the fracture and the carpal rows. Fracture reduction itself was done by gentle manipulation, as in conservative treatment, through gentle longitudinal traction, palmar flexion, ulnar deviation, and pronation then the joint was locked to keep the wrist in that position of reduction.

(Figure 6): Gentle manipulation for fracture reduction.

The quality of the fracture reduction was determined using fluoroscopic control. The radial length was restored, any radial shift was corrected and dorsal angulation corrected to at least 0^{o}. Any articular step of more than 2 mm in active patients was not accepted.

Post-operative follow up:

Immediate post operatively, the patients were examined for neurovascular status. They were also instructed to do forearm and hand elevation, full range of fingers movement as well as the elbow and shoulder. They were also instructed how to do pin site care to avoid pin tract infection. Mild disinfectants and sterile saline were used for pin site care. Colored disinfectants were avoided, since the skin would be stained, and inflammation might be obscured. Check X-rays were obtained to assess the quality of reduction. Patients were kept in the hospital under observation for one to two days. Antiedematous medications as well as analgesics and antibiotics were prescribed to the patients.

Follow Up Examination:

Examination at two weeks:

Two weeks after the operation, the patients were followed up both clinically and radiologically.

Examination at six weeks:

The fixator was continued for six weeks then the frame was removed, and the fracture tested clinically and radiologically for union. Except two patient the frame was removed after eight weeks.

Final assessment:

At the end of follow up patients were examined clinically and radiologically. Deformity such as prominent ulnar styloid, dorsal tilt, and radial deviation of the wrist. Tenderness at the distal radio-ulnar joint (DRUJ). Neurological examination of the median, ulnar, and superficial radial nerves.

Statistical analysis:

SPSS version 20 was used for statistical analysis, a description was given of the demographic variables in the overall sample, with measures of central tendency (mean) and standard deviation for the quantitative variables, and percentages for the categorical variables.

A Student's t test was used for the quantitative variables, and a Chi-square test was used for the categorical variables. Level of significance was considered for $P < 0.05$ and high significance $P < 0.001$.

RESULTS

Table (1): Socio-demographic distribution among the studied group:

Variables			
Age (years) (Mean± SD) (Range)	43.9±11.6 Years (27-69)		
Variables	Groups	N	%
Age grouping	20-29 years	4	16.7%
	30-39 years	9	37.5%
	40-49 years	4	16.7%
	> 50 years	7	29.1%
Sex	Male	14	58.3
	Female	10	41.7
Side affected	Right	16	66.7
	Left	8	33.3
Smoking	Non-smoker	14	58.3
	Smoker	10	41.7
Co morbidity	No	16	66.7
	DM only	2	8.3
	HTN only	4	16.7
	Both DM & HTN	2	8.3

Table (1) shows that the mean age of the studied group was 43.9±11.6 years. Most of them were in their 3rd decade of life, followed by patients aged more than 50 years. Almost three quarters of patients aged below 40 years were males. While patients above age of 40 years more than half of them were females. Right side represents two thirds affected side. 41.7% of the studied group was smoker. And as comorbidities; most of patients had no co-morbidities, hypertension represent the most common co-morbidity, as it represents 16.7%.

Table (2): Injury characteristics among the studied group:

Variables		N	Percent
Mechanism of trauma	FFH	6	25
	FOOSH	8	33.3
	RTA	10	41.7
Type of fracture	Close	21	87.5
	Open	3	12.5
Associated injury	Absent	15	62.5
	Ulnar styloid	5	20.8
	DRUJ instability	3	12.5
	Neck of ulna	1	4.2
	Bennet fracture	1	4.2
Time before surgery	Less than 48h	18	75
	More than 48h	6	25

Table (2) shows the RTA was the leading cause of the fractures in this study, as it cause 10 fractures, 8 of them was below 40 years old. While FOOSH cause fractures in 8 patients 7 of them were aged more than 45 years. Most of patients had close fractures. And most of them had no associated injury, but the ulnar styloid fracture represent the most common associate fracture (20.8%) and is caused mostly by high energy trauma. Another 3 patients had DRUJ injury treated by K-wire fix the joint. Most of patients (75%) operated within the first two days. While the rest operated from the period of 3 to 7 days.

Table (3): Time of implant removal among the studied group:

Time of implant removal	NO(24)	%
3 to 4 weeks	11	45.8%
5 to 6 weeks	13	54.2%

Table (3) reveals that most of patients remove the external fixator in the 5th and 6th weeks, most of them aged more than 40 years. While the rest 45.8% remove the external fixator within the first 4 weeks.

Table (4): Time of union among the studied group:

Union Time	NO(24)	%
Up to 9 weeks	12	50%
10 to 12 weeks	10	41.7%
More than 12 weeks	2	8.3%

Table (4) shows that half of patients achieve union in the first 9 weeks, all of them were young adult. While 41.7% of patients achieve union in the period from 10 to 12 weeks and 2 patients aged above 50 years had delayed union.

Table (5): Complications distribution among the studied group:

Complications	NO(24)	%
No	14	58.3%
Pin Tract Infection	4	16.7%
Superficial Radial Nerve Injury	2	8.3%
Carpal Tunnel Syndrome	2	8.3%
Delayed Union	2	8.3%
Surgical Site Infection	1	4.2%
Distal Radio-Ulnar Joint Instability	1	4.2%

Table (5) reveals that most of our patient had no complications. Pin tract infection was the commonest complication as it occurred in 4 patients; all treated by serial debridement and oral antibiotics till the signs of infection was subsided, 2 of this patients developed delayed union. The SRNI occurred in 2 patients suffered from numbness and burning sensation over the dorsolateral aspect of the hand both treated by tri B and had spontaneously within 3 months. Another 2 patients had signs and symptoms of CTS both were females and both treated conservatively. Also one patient had DRUJ instability and another patient had SSI.

Table (6): Final outcome by Modified MAYO Wrist Score and the Quick DASH score among the studied group:

Final outcome	Variables	NO(18)	%
Modified MAYO Score	Excellent	12	50%
	Good	7	29.2%
	Fair	3	12.5%
	Poor	2	8.3%
the Quick DASH score	Excellent	12	50%
	Good	6	25%
	Fair	3	12.5%
	Poor	3	12.5%

Regarding the scoring system more than three quarters of patients had satisfactory outcome (50% had excellent & 29.2% had good outcome) according to MMWS. While the rest had unsatisfactory results (12.5% were fair & 8.3% were poor). The same was observed in Quick DASH score except the poor cases was 12.5, while the good outcome were 25%).

DISCUSSION

Comminuted Intra-articular distal radius fractures mostly hard to reduce and stabilize due to their multifragmentary and unstable characteristics. The aim of treatment is to achieve congruent articular surface and correct axial alignment while maintaining good reduction to preserve function. Inability to achieve congruent articular surface has been shown to cause posttraumatic arthritic changes in the wrist joint [(5)].

External fixation, with use of the principle of ligamentotaxis for reduction of the fragments has gained wide acceptance for the treatment of unstable fractures of the distal part of the radius [(6)].

This study was prospective study included 24 patients with intra-articular distal radius fractures, treated by spanning external fixation in the period from January 2021 to December 2021. The mean age was 43.9±11.6 years. Most of patients were on their 4th decade of life followed by patients aged more than 50 years. Males were affected more commonly than females. Most of patients injured due to RTA (41.7%) followed by FOOSH (33.3%).

All patients except 3 had closed fractures. Also, more than half of them had no associated injuries, while the ulnar styloid fracture represent the most common associated injury as 20.8% of patients had it as associated injury.

In this study the final outcome was done according to MMW score along with Quick DASH score, and it revealed that more than 79% of the patients had satisfactory functional outcome according to MMW score, as they were either excellent (50%) or good (29.2%). While only five patients (20.8%) had unsatisfactory outcomes, as 12.5% were fair and 8.3% were poor functional score according to Modified MAYO Wrist Score.

This was comparable with **Bentaher *et al.*** [7] who treated 12 patients had distal radius fractures treated by external fixator and found that the age was statistically significant as P value was 0.02, as the mean age of their satisfactory outcome was 39 year, in compare to 38 year in our study. While the mean age of unsatisfactory results was 56.41 year in compare to 58 year in this study.

Our results were better than those of **Marimuthu** [8] who documented that from 20 patients with distal radius fractures with age ranged from 20 to 65 years with mean age 44.9 year and had satisfactory functional outcome in 11 patients (55%) most of them were good (40%), while only 15% of them were excellent. While 9 patients (45%) of them were unsatisfactory most of them were fair (35%) and 10% were poor. this could be because of older mean age patients in his study, and majority of them (70%) aged more than 40 years old.

Micic *et al.* [5] stated that the mean age was 41 years, and the final outcome was 95% of patients were satisfactory, only one patient had fair outcome. This difference between the results of their study and the current study could be due to different scoring systems used in these studies, as we use MMWS while Micic *et al*. used New York Orthopedic Hospital wrist scoring scale.

Regarding the associated injuries; this study showed that 14 out of 15 patients had isolated distal radial fracture with satisfactory outcome. Only one patient with isolated DRF had poor outcome. While 9 patients in this study had associated injuries, 5 had satisfactory outcome. While 4 of them had unsatisfactory MMWS two had DRUJ instability, one with ulnar styloid fracture and the other had fracture neck of ulna.

This was comparable with **Marimuthu** [8] who observed two patients among his study group had associated injuries both of them had distal ulnar fracture and both of them had unsatisfactory functional outcome.

Regarding the correlation between time of implant removal and functional outcome; our results showed no patient remove external fixator frame from 3 to 4 weeks had unsatisfactory results. While 5 out of 13 patients with frame removed in the period from 5 to 6 weeks had unsatisfactory MMWS. All patients need cast immobilization after frame removal till the full union achieved radiologically and clinically.

This was agreed with **Beeres *et al.*** [9] who reported that the external fixator frame continued for 4 to 6 weeks, and their results was comparable with our results as the satisfactory outcome was in 45% of patients had good results. 45% fair and 10% had poor outcome.

Also **Bentaher *et al.*** [7] who had 83.3% of their patients had satisfactory results, and all of their patients remove the frame in the 6th weeks except 2 patients continued to have the frame to eight weeks.

Our results showed that the mean union time was 9.4 weeks ranged from 6 to 15 weeks. Half of DRF fractures were united in the period from 6 to 9 weeks and all of them were young adult patients. Ten patients had fracture healed from 10 to 12 weeks. This result was comparable with **Margaliot *et al.*** [10] who treated 70 patients with articular fractures of the distal radius by closed reduction and external fixation, and documented that the mean union time was 5.8 weeks ranged from 4 to 10 weeks, the mean age of this patients was 58.9 years.

Also **Bentaher *et al.*** [7] documented that most of DRFs united by 6 weeks, only 3 patients need 8 weeks to achieve full union. This results was superior to our results mostly due to small sample size of their study as the included patients were half of patients included in this study.

On the other hand **Beeres *et al.*** [9] documented that the mean union time was 8 weeks, most of them (75%) had fracture united in the first two months, while the rest need longer period with no case of delayed or non union. This results was better than our results due to compination in their study between external fixator and locked T-Plate internal fixation for comminuted distal radial fractures.

In this study, the complications were occurred in ten patients, most of them had minor complications as PTI, SRNI, CTS and SSI. Only three patients had major complications (12.5%) two of them had delayed union and one patient had DRUJ instability need fixation by K-wire passed through the DRUJ.

This was comparable with **Abdel-Ghany *et al.*** [11] who ststed that five patients (20.8%) of the external fixation group had complications, two cases had slight deformity, two cases had dorsal angulations of 1 - 10˚, and one case had shortening of 5 mm. Also, **Sharma *et al.*** [12] found that 13.33% of the external fixator group had stiffness as the most common complication, followed by PTI in 3.33%.

Bentaher *et al.* [7] observed that PTI was the most common complication as it represented 25% of the total patients. While the rest of complications as Sudeck's atrophy, superficial radial nerve affection, DRUJ instability occurred in 8.33% of the DRF.

CONCLUSION

It could be concluded that spanning external spanning external fixation is a good option for treatment of intra-articular DRF. The good outcomes achieved in

this study suggest that use of the Spanning external fixators could be an alternative treatment method for intra articular distal radius fractures, as it is easier, need less operation time, decrease amount of blood loss and decrease risk of infection in comparison with spanning bridging plate or locked distal radius plates. All DRFs achieved good results; Functional outcomes were promising, including wide wrist ROM and no mal or non-union occurred.

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REFERENCES

1. **Brogan D, Richard M, Ruch D *et al.* (2010):** Management of severely comminuted distal radius fractures. J Hand Surg Am., 40(9): 1905–14.
2. **Kural C, Sungur I, Kaya I *et al.* (2010):** Evaluation of the reliability of classification systems used for distal radius fractures. Orthopedics, 33(11): 1–5.
3. **Leixnering M, Rosenauer R, Pezzei C *et al.* (2020):** Indications, surgical approach, reduction, and stabilization techniques of distal radius fractures. Arch Orthop Trauma Surg., 140(5): 611–21.
4. **Mathews A, Chung K (2015):** Management of complications of distal radius fractures. Hand Clin., 31(2): 205–15.
5. **Micic I, Kholinne E, Sun Y *et al.* (2019):** The role of additional k-wires on AO type C distal radius fracture treatment with external fixator in young population. Advances in Orthopedics, 6: 1-6.
6. **Alam W, Shah F, Qureshi K *et al.* (2014):** Intra-Articular Fractures Of Distal Radius. Prof Med J., 21(04): 649–53.
7. **Bentaher M, Salama A, Eladawy A *et al.* (2020)** Results of Ligamentotaxis Technique in Treatment of Intra-articular Distal Radius Fracture. Zagazig Univ Med J., 20: 1-4.
8. **Marimuthu S (2010):** Role of ligamentotaxis in Unstable Distal Radius Fractures. Kilpauk Medical College, Chennai., 2010. http://repository-tnmgrmu.ac.in/id/eprint/2980
9. **Beeres F, Liechti R, Link B *et al.* (2021):** Role of a spanning plate as an internal fixator in complex distal radius fractures. Operative Orthopädie und Traumatologie, 33(1): 77-88.
10. **Margaliot Z, Haase S, Kotsis S *et al.* (2005):** A meta-analysis of outcomes of external fixation versus plate osteosynthesis for unstable distal radius fractures. J Hand Surg Am., 30(6): 1185-87.
11. **Abdel-Ghany M, Tohamy T, Shaaban W *et al.* (2017):** Ligamentotaxis versus Open Reduction and Internal Fixation for Distal Radius Intra-Articular Fractures. Open J Orthop., 07(01): 21–31.
12. **Sharma A, Pathak S, Sandhu H *et al.* (2020):** Prospective Randomized Study Comparing the External Fixator and Volar Locking Plate in Intraarticular Distal Radius Fractures: Which Is Better? Cureus, 12(2): 6849.