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The Results of Fragment-Specific Fixation for Treatment of Intra-Articular Distal Radius Fractures

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ABSTRACT
Background: Distal radius and ulna fractures are the most common fracture in adults representing 44% of all fractures. Fragment-specific fixation can be a useful tool in treating distal radius fractures.
Objective: The aim of the present study was to evaluate the results of treating intra-articular distal radius fractures with fragment-specific fixation to provide good functional outcome.
Patients and methods: This prospective study included 36 patients with distal radial fractures. They were admitted and operated in the Casualty Unit of the Orthopedic Department, Zagazig University Hospitals. The average time of follow up period of the cases was 9 months. **Results:** Age was distributed as 39.5 ± 9.17 years, male were 61.1% and dominant right were in 88.9%. Mayo score distribution at different time among studied group was significant increase from 6 weeks to 3 months and to 6 months. There was significant increase in range of motion distribution from 6 weeks & 3 months to 6 months. There was significant increase in grip strength distribution from 6 weeks & 3 months to 6 months. Overall complicated cases were 6 cases. Complicated cases were significantly associated with longer union time and significant delayed return to work. **Conclusion:** Fragment-specific fixation is a valuable technique for intra articular distal radius fractures in well planned and selected patients. As it achieves a high rate of union and good functional outcome on follow up and it allows excellent grip strength and range of motion of wrist joint.
Keywords: Distal radius fractures, AO classification, Fragment-specific fixation.

INTRODUCTION

One-sixth of all fractures seen and treated in Emergency Departments are distal radial fractures. This injury is most likely to occur in children and the elderly [(1)]. A simple fall in the elderly with weak bones can result in a distal radius fracture, as can high-energy trauma in young individuals. The AO categorization system is one of the classification systems used for prognostic management and prediction. All fractures should be treated with the objective of restoring wrist function and minimising discomfort as much as possible [(2)]. There are various alternatives for fixing comminuted distal radial fractures to achieve this aim as quickly as feasible, including K-wire pinning, volar fixed angle locking plate, enhanced external fixators, and fragment-specific fixations. Each approach has benefits and drawbacks, but there is no consensus on which is the best [(3)]. The fragment-specific approach uses metal pins and plates that are shaped to exactly fit the normal contour of the distal radius [(4)]. The fragment-specific implants, despite their small size, are engineered to endure the stresses of instant wrist motion and are meant to be employed as part of a post-surgery early wrist mobility program [(5)].

This study aims to assess the clinical, radiological and functional outcome of treating intra-articular distal radius fracture with fragment-specific fixation, and whether it is a safe, sufficient and beneficial method of fixation for this particular type of fractures.

PATIENTS AND METHODS

This prospective study was conducted during the period from 2018 to 2021. Thirty-six patients with distal radial fractures were admitted and operated in the Casualty Unit of the Orthopedic Department, Zagazig University Hospitals. According to the AO classification of distal radius fractures, 18 patients had type B fractures, 14 patients had C1 fractures, and 4 patients had type C2. The follow up period of the cases ranged from 6 to 12 months with average of 9 months.

Inclusion criteria: Patients with less than 1 month old injury fractures, Age ≥ 18 and ≤ 60 years old. Type B, C1, C2 fractures according to AO classification.
Exclusion criteria: Patients with pathological fractures due to tumors or secondaries. Age > 60 and <18 years old, neurovascular injury and type A fractures according to AO classification.

Pre-operative evaluation:

1- **History:** Careful history taking were done for all patients with special care was given to the mode of trauma, time of trauma, hand dominance, occupation, any previous surgery especially involving the wrist and history of chronic medical illness.
2- **Clinical examination:** Careful examination was done to detect any associated injuries, abrasions and deformity of the affected wrist. Assessment of peripheral arterial pulsation at the affected extremity. Detection of any possible insult to radial arteries. Whenever the patient's condition permitted, a complete neurological examination was performed to assess any median nerve injury with special attention to the axillary nerve. In our study the motor testing was usually not possible at this stage because of pain.
3- **Radiological evaluation:** Each patient underwent wrist trauma series, which included antero-posterior (AP), and lateral radiographs. Computed tomography (CT) was indicated.

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4- Laboratory Investigations:

All patients had the preoperative routine lab investigations including complete blood count, random blood glucose level, bleeding profile and liver and kidney function tests.

Patient Counseling: Details of operative procedure and informed consent process were done. Patient counseling was essential in order to decrease patient anxiety and to achieve the maximum cooperation of the patient

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Ethical Consideration:

The study was approved by the Local Ethical Committee of Zagazig University. Written consent was obtained from every patient prior to the procedures. This study has been carried out in accordance with the code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Operative management:

Anesthesia: All patients in the study were managed using general anesthesia and 1 patient managed under regional supraclavicular anesthesia**.** Prophylactic broad-spectrum antibiotic was taken before induction of anesthesia by about half hour.

Surgical preparations:

The laboratory investigations revealed that all the patients are fit for general anaesthesia. The patient was placed on the operating table in supine position, the affected limb was elevated for a while and then the hand cuff was placed over the arm and pressure was elevated to 250 mm Hg. The affected limb was placed over a side table exposing the volar, dorsal or radial surface according to planned approach.

Surgical technique:

A radial incision of 8 cm was done directly on the flexor carpi radialis tendon. The incision was made through the sheath of the flexor carpi radialis tendon. The flexor carpi radialis tendon sheath was opened, and the forearm fascia on the radial border was incised. After the retractors were placed, the connection of the flexor pollicis longus to the radius was incised and partially separated to allow a complete view of the pronator quadratus. To prevent complete elevation of the pronator quadratus from the radius, an L-shaped incision was made over its radial border [(6)].

Through a volar incision, the extended flexor carpi radialis (FCR) method was established to handle complicated dorsal fractures. To reach the dorsal side of the fracture, the radial septum was released and the proximal radius was pronated out of the way. Debridement of the fracture hematoma or callus was possible with this procedure, resulting in a decrease of complicated articular injuries [(7)]. Variable types of plates were used in this operation according to the type and extent of the fracture.

Postoperative management protocol: Postoperative care and rehabilitation program were done.

Follow up: The duration of follow up was 6 -12 months postoperatively with average 9 months. X-ray was done immediately post-operatively then at 2, 4, 6 and 8 weeks. Patients were assessed using Mayo wrist score at end of follow up period.

Clinical evaluation: Every patient was evaluated at the end of the follow up period according to the Mayo wrist score, which is a 100-point score system. This scoring system consists of four variables that are used to assess the function of the wrist.

Statistical analysis

Data were analyzed using Microsoft Excel software. Data were then imported into Statistical Package for the Social Sciences (SPSS version 22.0) software for analysis. Data were tested for normal distribution using Shapiro Walk test. Qualitative data were represented as frequencies and relative percentages. Chi square test (χ^2) was used to calculate difference between two or more groups of qualitative variables. Quantitative data were expressed as mean ± SD. Independent samples t-test was used to compare between two independent groups of normally distributed variables (parametric data). ANOVA or Kruskal Wallis was used for differences between multiple quantitative independents. P value ≤ 0.05 was considered significant.

RESULTS

The present study showed that age was distributed as 39.5 ± 9.17 with minimum 23 and maximum 56 years, males were 61.1% and females were 38.9%, dominant right were in 88.9% and left were in 11.1%. 77.8% had no Co-morbidity, 16.7% had DM, 5.6% had HTN and 38.9% were smoker (Table 1).

Table (1): Demographic data distribution among studied group (N=36)

		Age	
Mean ± SD		39.5 ± 9.17	
Median (Range)		39.0 (23-56)	
		N	**%**
Sex	**Male**	22	61.1
	Female	14	38.9
Dominant	**Left**	4	11.1
	Right	32	88.9
Co morbidity	**No**	28	77.8
	DM	6	16.7
	HTN	2	5.6
Smoking	**No**	22	61.1
	Smoker	14	38.9
	Total	36	100.0

Majority were caused by RTA (66.7%), right and left sides were distributed evenly as well as dominant affection. AO classification B were 50% then C1 38.9% and C2 11.1%. According to the AO classification of distal radius fractures, 9 patients had type B fractures, while7 patients had C1 fractures, and 2 patients had type C2 (Table 2).

Table (2): Fracture characters distribution among studied group

		N	%
Cause	**FFH**	12	33.3
	RTA	24	66.7
Side of fracture	**Left**	18	50.0
	Right	18	50.0
Dominant affection	**No**	18	50.0
	Yes	18	50.0
AO Classification	**B**	18	50.0
	C1	14	38.9
	C2	4	11.1
	Total	36	100.0

Regarding Mayo score, there was significant increase from 6 weeks to 3 months and to 6 months (P=0.00**) (Table 3).

Table (3): Mayo score distribution at different time among studied group

	MAYO_6 week	MAYO_3M	MAYO_6M
Mean ± SD	88.88±19.67	94.44±10.55	98.33±4.85
Median (Range)	95.0 (20-100)	100.0 (60-100)	100.0 (80-100)

There was significant improvement in Mayo score grade (P=0.041*) (Table 4).

Table (4): Mayo score grade distribution at different time among studied group

		N	%
Mayo score 6 weeks	**Excellent**	22	61.1
	Good	8	22.2
	Fair	4	11.1
	Poor	2	5.6
Mayo score 3 months	**Excellent**	26	72.2
	Good	8	22.2
	Fair	0	0.0
	Poor	2	5.6
Mayo score 6 months	**Excellent**	34	94.4
	Good	2	5.6
	Fair	0	0.0
	Poor	0	0.0
	Total	36	100.0

Regarding ROM distribution, there were significant increase from 6 weeks & 3 months to 6 months (P=0.002*) (Table 5).

Table (5): ROM distribution at different time among studied group

	ROM_6week	ROM_3month	ROM_6month
Mean ± SD	113.22±13.21	115.27±13.66	121.66±2.97
Median (Range)	117.5 (75-130)	120.0 (85-130)	120.0 (115-125)

Regarding Grip strength distribution, there were significant increase from 6 weeks & 3 months to 6 months (F=6.12, P=0.018*) (Table 6).

Table (6): Grip strength distribution at different time among studied group

	Grip strength 6week	Grip strength 3month	Grip strength 6month
Mean ± SD	91.0±7.76	95.44±4.48	97.55±2.03
Median (Range)	94.0 (65-98)	96.5 (80-99)	98.0 (92-99)

Concerning outcome, overall complicated cases were 6 cases with 16.7% (Figure 1). Complicated cases were significantly associated with longer union time and significant delayed return to work (Figures 2 & 3).

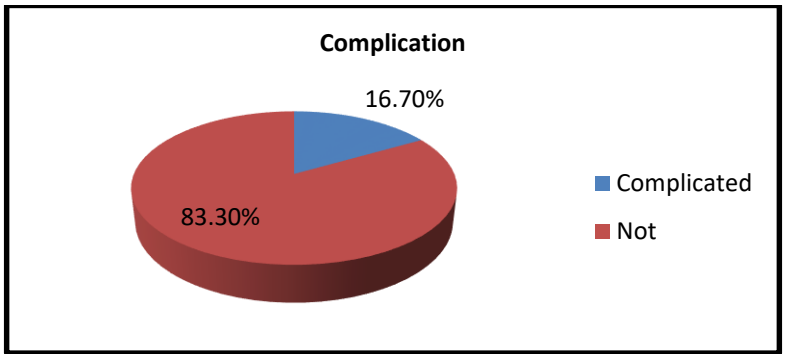

Figure (1): Complicated case among studied group

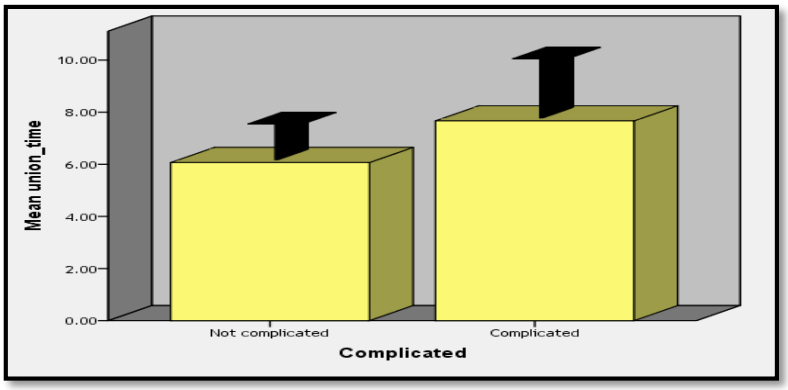

Figure (2): Mean union time of complication and not complication case

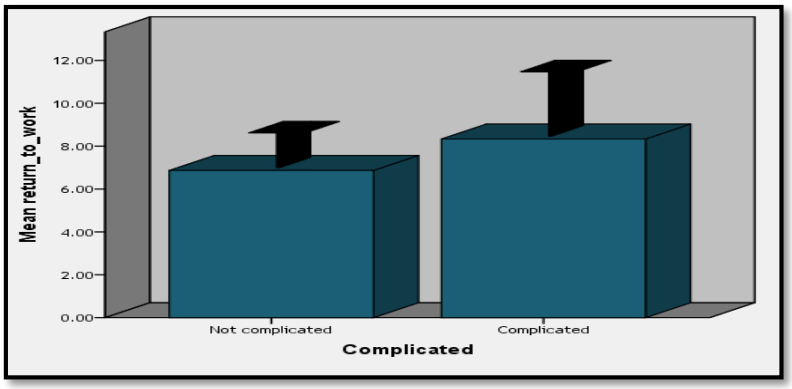

Figure (8): Mean return to work of complication and not complication case

DISCUSSION

Intra-articular radius fractures should be treated with caution to reduce the risk of complications [8]. The primary goal of treating intra-articular radius fractures is to restore the anatomy using a stable fixation mechanism. All step-off and gap distances must be minimized as much as feasible as part of this procedure. The risk of problems is reduced by reducing all step-off and gap distances [9].

We conducted our study on 36 patients with intra-articular distal radial fractures. They were admitted and operated in the Casualty Unit of the Orthopedic department, Zagazig University Hospitals and Zagazig General Hospital. According to the AO classification of intra-articular distal radius fractures, 18 patients had type B fractures, 14 patients had type C1 fractures and 4 patients had type C2 fractures. The follow up period of the cases ranged from 6 to 12 months with average time of 9 months.

Age was distributed as 39.5 ± 9.17 with minimum 23 and maximum 56 years, males were 61.1% and female were 38.9%, dominant right was in 88.9% and left were 11.1%, 77.8% had no Co-morbidity, 16.7% had DM, 5.6% had HTN and 38.9% were smoker. Majority of fractures caused by RTA (66.7%), right and left sides were distributed evenly and also dominant affection. AO classification B was 50% then C1 38.9% and C2 11.1%. In our study we found that Mayo score distribution at different time among studied group showed significant increase from 6 weeks to 3 months and to 6 months. In Mayo score grade distribution at different time among studied group, we found significant improvement. There was significant increase in range of motion distribution from 6 weeks & 3 months to 6 months. There was significant increase in grip strength distribution from 6 weeks & 3 months to 6 months. An overall complicated cases were 6 cases with 16.7%.

Gavaskar *et al.* [10] evaluated the efficacy of 2.4 mm column-specific plating for intra-articular distal radius fractures. In total of 105 patients with AO type C distal radius fractures were operated on using the locking distal radius system and synthes. Follow-up assessments including clinical (wrist and forearm range of motion and grip strength), radiological (articular step, radial length and inclination, volar tilt, and ulnar variance), and functional scores (disabilities of the arm, shoulder, and hand as well as patient-rated wrist evaluation) were made at regular intervals until 1 year. Union was obtained in all patients. Articular surface was anatomically reconstructed in 74 patients (70.5%). Clinical and functional evaluation showed significant continuous improvements over the first year. C1 fractures had a better chance of anatomical reduction compared to C2 and C3 fractures. Fracture type, quality of reduction, and presence of degenerative changes did not show a significant effect on functional outcome scores. Column-specific fixation of the distal radius can achieve satisfactory results in complex intra-articular fractures.

Simic *et al.* [11] evaluated objective functional and radiographic outcomes after open reduction and internal fixation of acute displaced and unstable fractures of the distal aspect of the radius in adults by using a low-profile dorsal plating system. There were 29 type A, 14 type B, and 8 type C fractures (AO classification system). All patients had an excellent (31 patients) or good (19 patients) result according to the scoring system of Gartland and Werley. The mean active range of motion was greater than 80% of that of the contralateral wrist in flexion/extension, pronation/supination, and ulnar/radial deviation. Extensor tendon function was unimpaired in all patients. Grip and pinch strength averaged 90% and 94% of the contralateral sides, respectively. Radiographic evaluation showed no change in fracture reduction or implant position.

According to **Martin *et al.* [12]** who compared the stability of volar locking plates (VLPs) and locking fragment-specific (LFS) dorsal and radial styloid plates for the fixation of dorsal (AO 23-B2) and radial styloid (AO 23-B1) shear fractures of the distal radius, respectively. In the dorsal shear fracture model, the dorsal LFS plate exhibited less displacement than the VLP (0.32 ± 0.04 vs 0.43 ± 0.07 mm, respectively) and showed greater average stiffness. Plate type was responsible for 53.1% of the variation in displacement and 68.6% of the variation in stiffness. In the radial styloid fracture model, variations due to plate type were similar for displacement and stiffness in both groups.

In study conducted by **Benson *et al.* [13]** they assessed the clinical, radiographic, and functional outcomes of treating intra-articular distal radius fractures with fragment-specific fixation. There were 81 patients with 85 intra-articular distal radius fractures who were treated with fragment-specific fixation. Minimum time to follow-up evaluation was 1 year, with a mean time of 32 months. According to Gartland and Werley scoring there were 61 excellent and 24 good results. Flexion and extension of the surgically treated wrist at the final follow-up evaluation averaged 85% and 91%, respectively of the uninjured wrist. Grip strength averaged 92% compared to the uninjured side. The average disabilities of the arm, shoulder, and hand outcome score for the injured wrist was 9. Radiographic alignment was maintained between immediate postoperative and final follow up films. There were no cases of symptomatic arthritis at the final follow up evaluation.

There were some limitations that faced this study. Firstly, the small number of patients included especially those with intraarticular distal radius fractures Type B and C according to AO classification. Secondly the expensive cost of fragment-specific plates and its availability. Lastly, some patients with low educational levels were not cooperative and didn't understand the importance of method of fixation, follow up and physiotherapy. The thing that decreased number of cases included.

CONCLUSION

Fragment-specific fixation is a valuable technique for intra articular distal radius fractures in well planned and selected patients. As it achieves a high rate of union and good functional outcome on follow up and it allows excellent grip strength and range of motion of wrist joint.

Further study should be carried out with larger groups of patients, with longer duration of postoperative follow up and more availability of fragment specific plates that are required for long-term results and to validate the results of this study.

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Author contribution: Authors contributed equally in the study.

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