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Ligamentotaxis versus Open Reduction and Internal Fixation for Distal Radius Intra-Articular Fractures

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Abstract

Objectives: This study compared the clinical and radiological outcomes of two different methods for the treatment of distal radial intra-articular fractures. **Patients and Methods:** Forty-six patients with distal radius intra-articular fractures were divided into two groups. Group I included 24 patients with type C fracture treated by external fixator augmented by percutaneous K-wires. Group II included 22 patients with type C fracture treated by volar locked distal radial plate augmented by K-wires. Two patients had complex injuries necessitating double plating (sandwich). All patients were evaluated clinically by Mayo Wrist Score and radiologically by Sarmiento's radiological score. **Results**: Both groups reported good personal satisfaction according to Mayo Wrist Score, and the results were not statistically different between the two groups. In Group I, 19 patients (79.2%) had excellent radiological outcome and five patients (20.9%) had good radiological outcome according to Sarmiento's radiological score. In Group II, 20 patients (90.9%) had excellent outcome, and two (9.1%) had good radiological outcome; there was no or insignificant deformity. **Conclusions:** Complex distal radial fractures can be treated either by external fixation (ligamentotaxis) or by locked pre-contoured plating. The clinical outcome of plating and external fixator in our study did not show any statistically significant difference. The radiological outcome had no correlation with the clinical outcome.

Keywords

Distal Radial Fracture, Complex Fracture of Distal Radius, External Fixator, Locked Volar Plate

1. Introduction

Intra-articular fractures of the distal radius represent a therapeutic challenge compared to unstable extra-articular fractures [1]. These fractures can be managed either by external fixation with Kirschner wire (K-wire) [2] or by open reduction and internal fixation (ORIF) using volar fixed angle locked plate, which is also used for treating unstable fractures [3] [4]. Clinical outcome of the distal radius fractures (limited range of motion, reduced grip strength, and radiographic abnormalities) does not always reflect the pain and disability of the injured wrist [5] [6].

The purpose of this study was to compare the clinical and radiological outcomes of the treatment of intra-articular distal radial fractures by external fixator with K-wire versus open reduction and internal fixation using distal radius locked plate.

2. Patients and Methods

All patients included in this study had signed consent to be enrolled in this study and ethical committee of our institution had an agreement for this work

This multicentre, retrospective study included 46 patients aged below 50 years, who had intra-articular distal radial fractures. All patients are active working and have no chronic diseases (Hypertension, Diabetes, renal or liver diseases). All patients had been treated either by external fixator (ligamentotaxis) augmented by percutaneous K-wires or by ORIF using distal radius locked plate. Twenty-four patients (52.2%) were treated by external fixator (ligamentotaxis) using K-wires (Group I) and 22 patients (47.8%) were treated by ORIF using distal radius locked plate (Group II).

Group I included 24 patients (52.2%); 20 were male patients (83.3%) and four were female patients (16.7%); their age ranged from 23 to 47 years, with a mean age of 32.1 years. Fractures were classified according to Müller (AO) classification as type C2 (n = 3, 12.5%), and type C3 (n = 21, 87.5%). Reasons for fracture were motor vehicle accident in 19 patients (79.2%), and fall from height in five patients (20.8%). There were 23 dominant hand fractures (95.8%) and one bilateral hand fracture (4.2%). Distal Radio Ulnar Joint (DRUJ) dissociation was observed in 11 patients (45.8%), and was more frequently sustained by those involved in high velocity motor vehicle accidents. Associated injuries were recorded in the form of spinal fracture and lower limb fracture in five patients (20.8%), and were managed by the same medical team at the same study center (**Table 1**).

Group II included 22 patients (47.8%); their age ranged from 21 to 47 years, with a mean age of 35.8 years. There were 19 male patients (86.4%) and three female patients (13.6%). Eighteen fractures (81.8%) were type C3 and four fractures (18.2%) were type C2. Reasons for injury were fall from height in three patients (13.6%) and motor vehicle accident in 19 patients (86.4%). All patients had dominant hand fracture, with no bilateral fractures or associated injuries. DRUJ injuries were observed in 14 patients (63.6%).

Table 1. Demographic data for both groups.

Pt. Group I	Age	Sex	Dom. Hand	Type of fracture	Group	Age	Sex	Fracture type	Dom. Hand
1	22	Male	Rt.	C3		43	Male	C2	Rt.
2	24	Male	Rt.	C3		28	Male	C3	Rt.
3	36	Male	Rt.	C2		34	Male	C3	Rt.
4	27	Male	Rt.	C3		21	Male	C3	Rt.
5	34	Male	Rt.	C3		35	Female	C3	Rt.
6	26	Male	Rt.	C3		39	Male	C3	Rt.
7	33	Male	Rt.	C3		26	Male	C2	Rt.
8	44	Male	Rt.	C2		36	Male	C3	Rt.
9	39	Male	Rt.	C3		22	Male	C2	Rt.
10	37	Female	Rt.	C3		28	Male	C3	Rt.
11	25	Male	Rt.	C3		34	Male	C3	Rt.
12	36	Male	Rt.	C2	Group II = 22 pts	42	Male	C3	Rt.
13	47	Female	Rt.	C3		46	Female	C3	Lt.
14	28	Male	Rt.	C3		47	Male	C3	Rt.
15	36	Male	Rt.	C3		39	Male	C3	Rt.
16	28	Male	Rt.	C3		39	Male	C3	Rt.
17	40	Male	Rt.	C3		40	Male	C2	Rt.
18	23	Male	Bilat.	C3		28	Male	C3	Rt.
19	20	Female	Rt.	C3		44	Female	C2	Rt.
20	43	Male	Rt.	C3		30	Male	C3	Rt.
21	27	Male	Rt.	C3		45	Male	C3	Rt.
22	29	Female	Rt.	C2		41	Male	C3	Rt.
23	31	Male	Rt.	C3					
24	36	Male	Rt.	C2					

2. Methods

Group I: The surgical technique for all the patients of this group was the same and was performed by the same surgical team. All fractures were characterized by disfigurement of the articular surface, bone loss, and shortening of the affected radius. After reduction, the application of the fixators was in the dorsal plane. Pins were inserted through small incisions, two proximal to the fracture in the distal radius and two distal in the shaft of the second metacarpal bone. These pins were inserted at an angle of 60˚ to the horizontal plane. Augmentation with K-wires was required in majority of the cases in order to hold the provisionally restored articular fragments. The reduction was monitored and confirmed by fluoroscopy (Figure 1). DRUJ instability (DRUJI) was checked intra-

operatively by manual testing after completion of the surgery in all cases. We reduced radioulnar joint injury for 11 patients (45.8%) by using medial K-wire, and if the joint was still instable, the transfixing wire through DRUJ was retained for 6 weeks. The external fixator frames were removed after 6 to 8 weeks for all patients; however K-wires were not removed until complete consolidation of the fractures occurred. Wrist joint mobilization was allowed after removal of the external fixator frame, regardless of the removal of the wire or its retention until 2 weeks. Group II: The patients of this group were treated by ORIF using distal volar radial locked plate. After reduction, K-wires were placed through the radial styloid provisionally, if required. An anterior locking plate was then positioned. All the plates were precontoured for anterior flare of the distal radius. The plate position was adjusted based on intra-operative fluoroscopy finding. The plate position was verified in both anteroposterior (AP) and lateral planes before the distal screws were placed. Among the cases where the distal fragment was severely comminuted, the plate was adjusted as far as possible, but not farther beyond the watershed line of the radius. Double plating was used in two cases, as the screw caused disfigurement of the dorsal articular surface, which necessitated buttressing from the dorsal surface (Figure 2). DRUJ was checked manually after the surgery. After fixation of the distal radius, the distal end of the radius was grasped with the forearm in a neutral position, and the distal end of the ulna was grasped by the contra-lateral hand by moving distal ulna from the dorsal to the palmar direction. If there was a translation of 5 to 10 mm as compared with the uninjured wrist, it was considered as DRUJI. Transverse wire through the DRUJ was inserted in 12 patients (54.5%) who had significant DRUJI after plate fixation.

Figure 1. Intra-articular comminuted fracture distal radius treated by external fixator augmented by K-wire.

Figure 2. Intra-articular comminuted fracture distal radius treated by sandwich double plating.

Post-operative care for the external fixator group was recommended to control pain and edema and to maintain the range of motion in the fingers, elbow, and shoulder. All patients were encouraged to perform their routine activities by themselves, to the extent possible.

For internal fixation plate group, the splint below the elbow was retained for at least 6 weeks post-operatively. These patients were treated with medication to control pain and edema for 2 weeks. After the removal of the splint, they were encouraged to move the elbow and shoulder with passive motion of the wrist. After 8 weeks, the patients were encouraged to perform their daily activities entirely by themselves.

3. Results

All the patients were followed up clinically and radiologically 12 - 26 months with average 17.4 months (Table 2). Mayo Wrist Scoring System was used for clinical evaluation of both groups (Table 3); Sarmiento's radiological score was used for radiological evaluation [7]. All patients were followed up from 12 - 24 months (average 17.3 months).

Statistical Analysis

Statistical analyses of data were performed using SPSS 15 and PASTA software.

Group I: The mean score for pain at the last follow-up was 23.9 ± 2.0; the mean score for satisfaction was 23.1 ± 2.4; the mean grip strength was 17.29 ± 4.6; the mean value for the range of motion (ROM) was 16.8 ± 4.3; the mean score representing the final outcome was 82.2 ± 9.2.

Group II: The mean score for pain at the last follow-up was 24.09 ± 1.9; the mean score for satisfaction was 23.6 ± 2.2; the mean grip strength was 20.4 ± 5.9; the mean value for ROM was 18.6 ± 4.9; the mean score for the final outcome was 87.04 ± 6.6.

The final clinical outcome, according to Mayo wrist Score, is classified as follows: 90 - 100 = Excellent, 80 - 89 = Good, 65 - 79 = Fair, and less than 65 = Poor (Table 4).

T-test was used to compare the two groups and there were no significant differences for pain (P = 0.74), satisfaction (P = 0.076), ROM (P = 0.856), and the grip strength (P = 0.805). Correlation analysis showed that personal satisfaction was not correlated with final outcome among patients of both groups (Table 5),

Table 2. Follow up at different periods for both groups.

Group I N* = 24	Mean Follow Up			Group II N* = 22	Mean Follow Up		
	Min	max	Mean ± SD		Min	max	Mean ± SD
F-up at 6 ms	35	70	53.3 ± SD 9.3		22	65	95 ± SD 7.4
F-up at 12 ms	55	90	71.4 ± SD 10.1		22	75	100 ± SD 7.2
F-up at 24 ms	60	100	82.9 ± SD 10.5		22	75	100 ± SD 8.2

Table 3. Mayo Wrist scoring for the two groups.

ID	External Fixator (Group I), n = 24					ORIF (Group II), n = 22				
	Pain	Satisfaction	ROM*	Grip Strength	Final outcome	Pain	Satisfaction	ROM	Grip Strength	Final outcome
1	20	20	15	15	65 - 79	20	20	15	25	80 - 89
2	25	25	25	15	90 - 100	25	25	25	15	90 - 100
3	25	20	15	15	65 - 79	25	20	15	25	80 - 89
4	25	25	15	15	80 - 89	25	25	25	15	90 - 100
5	25	25	15	15	80 - 89	25	25	15	25	90 - 100
6	20	20	15	15	65 - 79	25	25	25	25	90 - 100
7	25	25	15	15	80 - 89	25	20	15	15	65 - 79
8	25	25	15	25	90 - 100	25	25	15	25	90 - 100
9	25	25	25	25	90 - 100	25	25	15	15	80 - 89
10	25	25	15	25	90 - 100	25	25	15	25	90 - 100
11	25	25	15	25	90 - 100	25	25	25	15	90 - 100
12	20	20	15	15	65 - 79	20	25	15	25	80 - 89
13	25	25	25	15	90 - 100	25	20	15	15	65 - 79
14	25	20	25	15	80 - 89	20	20	25	25	90 - 100
15	25	25	15	15	80 - 89	25	25	15	25	90 - 100
16	25	20	15	15	65 - 79	25	20	15	25	80 - 89
17	25	25	15	25	90 - 100	25	25	25	25	90 - 100
18	25	20	15	15	65 - 79	20	25	15	25	80 - 89
19	25	25	15	15	80 - 89	25	25	15	15	80 - 89
20	25	25	15	25	90 - 100	25	25	25	15	90 - 100
21	25	25	25	15	90 - 100	25	25	15	15	80 - 89
22	20	20	15	15	65 - 79	25	25	25	15	90 - 100
23	25	25	15	15	80 - 89					
24	20	20	10	10	<65					

*ROM = Range of motion.

Table 4. Mayo wrist score.

Group I (n = 24)	Patients	Group II (n = 22)	Patients
Excellent (90 - 100)	9	Excellent (90 - 100)	12
Good (80 - 89)	7	Good (80 - 89)	8
Fair (65 - 79)	7	Fair (65 - 79)	2
Poor (<65)	1	Poor (<65)	0

Table 5. Results of correlation analysis for Mayo Wrist Score for the two groups.

Item	n	Correlation coefficient	Sig.	n	Correlation coefficient	Sig.
Pain		0.389	0.074		−1.000	0.329
Satisfaction		0.386	0.076		0.386	0.076
ROM	24	0.041	0.856	22	−1.821	0.083
Grip Strength		−0.056	0.805		1.516	0.144
Final outcome		−0.133	0.554		−0.133	0.554

and the difference between the two groups was not statistically significant.

Analysis of Sarmiento's radiological score indicated that Group I had excellent radiological results in 19 cases (79.1%), with 13 cases demonstrating no or insignificant deformity (54.1%) and six cases (25%) exhibiting either dorsal angulations or shortening <3 mm. Five cases (20.8%) had good radiological outcome (two cases had slight deformity, two cases had dorsal angulations of 1 - 10˚, and one case had shortening of 5 mm.). Only one case (4.1%) reported poor radiological outcome (average radial deviation of 23˚) in this group.

In Group II, 20 cases (90.9%) had excellent outcome, four cases (18.1%) exhibited shortening of <3 mm, 11 cases (50%) exhibited no or insignificant deformity, two cases (9.1%) demonstrated dorsal angulation of 0˚, and two cases (9.05%) had shown a loss of radial deviation of <4˚. Two cases (9.05%) had good radiological outcome, one case (4.5%) had loss of radial deviation of 5 - 9˚, and one case (4.5%) had dorsal angulations of 9˚.

4. Discussion

Distal intra-articular radial fractures are very common fractures that represent a therapeutic challenge when compared to unstable extra-articular fractures, and there is no clear consensus regarding their appropriate treatment. Patients' outcome may differ according to method of evaluation. To ensure comprehensive treatment of these fractures, medical attention should be extended beyond physical impairment and radiography, since the final outcome may also depend on the post fracture rehabilitation.

In this study, we treated two groups with intra-articular fractures either by external fixator augmented by K-wires (Group I) or by ORIF by using volar

locked plates and K-wires (Group II). The decision for treatment depended on the surgeons' preferences and equipment availability at each study center.

According to the Mayo Wrist Scoring System used for evaluating the clinical outcome, significant differences did not exist for pain between the two groups in our study at the final follow-up (P = 0.006).

McQueen [8] in his randomized, prospective study compared the effectiveness of non-bridging and bridging external fixator in restoring the normal anatomy, carpal alignment, and hand function for the treatment of intra articular distal radial fractures. He had conducted the evaluations immediately after the surgery and showed that non-bridging external fixation achieved significantly better radial length compared to bridging fixation. It was reported that the pain outcome measures between the bridging and non-bridging fixator were similar during the initial analysis and after 1 year of follow-up. There were no significant differences between both groups for the carpal pain at the final follow-up.

In evidence based medicine (EBM), the amount of pain among patients treated with external fixation compared to that among patients treated by closed reduction and casting did not show significant difference until the first year [9]. A consensus remains to be reached regarding the choice of bridging or non-bridging methods in the external fixator treatment for distal radial fractures. Atroshi *et al.* in 2006 reported that non-bridging external fixation had no clinically relevant advantage over wrist-bridging fixation, but was more effective in maintaining radial length [10].

Huang *et al.* [11] in their study, treated 70 cases of intra-articular fractures of the distal radius by closed reduction and external fixation using small AO external fixators. They recommended that bridging external fixation is a more suitable and reliable method for the management of intra-articular distal radial fractures than non-bridging fixation. They concluded that meticulous reduction and rigid fixation, achieved on treatment with small AO external fixator, are the key factors that contributed to the good final clinical outcomes observed in their study.

A prospective cohort study tried to predict the association of pain with age, gender, co-morbidity, level of education, and claim of compensation. This study also analyzed the correlation of clinical outcome to that of radiological outcome. The authors reported that the baseline characteristics of the patients and the injuries in extra-articular distal radial fractures had a minor role in predicting the patients likely to develop pain and disability after 1 year [12].

In the present study, we did not find any significant difference in the final outcome between the two groups, while evaluating the correlation of different parameters with the final outcome. This is in agreement with the results of the prospective, randomized study by Rosental *et al.* [13], where the final outcome of unstable comminuted distal radial fractures treated by open reduction and internal fixation using volar plates was compared with outcomes of using percutaneous K-Wires fixation. They found that there was no significant difference for

the final outcome according to the DASH score. On the contrary, they concluded that the volar plate for the distal intra-articular radial fractures offered faster recovery for patients requiring a faster return to function after injury.

We did not observe any significant correlation between the radiological and clinical outcomes among patients in this study. The information regarding the factors influencing the final outcome among patients with intra-articular distal radial fractures is conflicting in the existing literature. This also implies that neither limitations to the fracture construct nor reliability of radiographic measurements were responsible for the limited prediction of the final outcome in the previous studies.

Kasapinova and Kamiloski [14] found no significant statistical correlation between the radiographic parameters and the patient-rated outcome (disability).

Some authors have studied whether factors such as age and sex would affect the final outcomes, as these factors play a major role in determining the bone mineral density (BMD) [12] [15]. Hollevoet *et al.* studied the correlation of clinical parameters with the bone mineral density to a greater extent compared to the radiological parameters. They suggested that osteoporosis may be one of the factors affecting the outcome of comminuted intra-articular distal radial fractures. In contrast, Dhainaut *et al.* did not observe any significant association between the reduced BMD of the cortical bone of the hand analyzed by digital radiography (DXR) and the risk of having an intra-articular or extra-articular fragility fracture in the distal radius. They concluded that the use of glucocorticoids may be responsible for the increase in the risk of having an intra-articular fracture, more than BMD, which can cause more severe fractures [16].

In our study, routine evaluation of the DRUJ and transfixing wire was performed for the cases that required attention in both groups. Reduction of the joints with transfixing wires improved the outcome, as it reduces the complications. DRUJ reduction is considered the cornerstone for the reduction of comminuted distal radial fracture. Injury of the DRUJ has been classified into high energy or low energy trauma according to Fernandez and Jupiter [17] classification Fernandez and Jupiter based their classification on two main parameters; they considered soft tissue injury and DRUJ injury as the main factors which affect the outcomes of treatment for intra-articular fractures of distal radius.

De la Torra *et al.* [18] studied 12 cases with type 1 DRCJI and reported that the surgically treated DRCJI cases did not have better outcome than non-surgically treated cases.

In our study, 10% of the ORIF group was treated with double plating (sandwich plate). Ring *et al.* [19] studied 25 patients who had complex comminution of both the articular surface and the metaphysis (Type C3.2) associated with distal radial fractures. They were treated by double plating method, and 96% of the cases reported either good or excellent results according to the rating system of Gartland and Werley.

Day *et al.* [20] reported the results of 12 patients who were treated by double plating, whose functional outcome were evaluated by DASH questionnaire and

Gartland and Werley scoring system. They reported that 70% of the patients had good or excellent outcome. The need for the removal of plates or tendon rupture among these patients until the final follow up was not observed.

Farhan *et al.* [21] reviewing data of 24 patients with severe comminuted fracture of distal radius treated by double plating, reported complications such as tendon rupture, carpal tunnel syndrome, infection and non-union, in addition to the early removal of dorsal plate among four patients. Besides, they concluded that double plating has the advantages of early motion and good outcome.

We did not notice any clinical complications that necessitate more interventions among our study patients. On the contrary, radiological outcome showed no correlation to the clinical outcome in our study.

5. Conclusion

Complex distal intra-articular radial fractures can be treated either by external fixator or by locked pre-contoured plating. Surgical techniques are demanding and should be performed by skilled surgeons. Restoring the articular surface is essential for normal function of the wrist. The clinical outcome of plating versus external fixator treatment did not show significant difference in our study. The radiological outcome did not correlate with the clinical outcome. Further studies are needed to clarify the existing conflict in the treatment of complex distal intra-articular radial fractures.

Conflicts of Interest

The authors declare no conflicts of interest.

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