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Original Article

Comparison between Volar Plating and External Fixation in Distal Radial Fractures

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ABSTRACT

Background: Distal radius fractures are of the commonest fractures in the middle-aged and elderly population. Thus, it represented a special concern for medical professionals.

Aim of the work: This study aimed to compare the functional outcome in distal radial fractures especially comminuted type in internal fixation by volar plate or external fixators, regarding restoring hand function and reducing complication rate, and early returning to work.

Methods: In the period between April 2022 and November 2022, a prospective comparative study was performed. It involved 30 patients, presented with distal radial fractures. Participants were coded from 1 to 30, then, they were categorized into two equal groups (each had 15 patients): Group (A): included patients with Odd numbers and were submitted to open reduction and internal fixation (ORIF) by volar plate. Group (B) included patients with even numbers, and there were submitted to external fixation augmented by K-wires.

Results: Patients in group (B) (treated by fixation augmented by k-wires) has union time range (5-10 weeks) while patients treated with volar plating has union time range (5-8 weeks). There were no significant clinical differences between the two groups (p= 0.324).

Conclusion: ORIF by volar plating provided a comparable outcome to external fixation augmented by k-wires for treatment of distal radius fractures.

Keywords: **Volar Plating; External Fixation; Distal Radial Fractures.**

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INTRODUCTION

Distal radius fractures account for up to 8%−15% of all adult bony and up to 20% of all fractures treated surgically. It is commonly due to a fall on the outstretched hand while the wrist is in a dorsiflexion position. The fracture type and severity is totally depending on the wrist position at the moment of hitting the ground [(1)]. Middle aged and elderly population are the commonest affected age groups by the distal radius fractures [(2)]. Thus the medical importance of these fractures. The distal radius fractures witnessed a sharp increase among women older than 40 years of age. This raised the possible effects of estrogen withdrawal leading to loss of bone density, as a risk factor for distal radial fractures [(3)]. Unfortunately, the treatment of distal radius fracture is a challenging task as the fracture reduction and stabilization is a difficult process. Thus, these fractures are highly prone to malunion [(4)].

The value of volar locked plating over the external fixation for treatment of distal fractures are reported in randomized controlled and cohort studies. The better outcome was marked in the early postoperative period [(5)]. The treatment results are heterogeneous and even were contradictory for AO types C2 and C3, either treated by the volar locked plates, external fixation or by a combination of two approaches [(6)]. However, the clinical and radiographic outcome for treatment of such fractures yielded favorable results [(7)].

The current work was designed to address the outcome (functional) for distal radial factures (with special attention to comminuted type). It aimed to compare between the internal fixation by volar plates and external fixators, as regards the hand function, complication rate and early returning to the work.

PATIENTS AND METHODS

Between April 2022 and November 2022, this prospective study was conducted. It included 30 patients, who were presented with acute distal radial fractures. For grouping, patients were arranged from 1 to 30, the numbers were kept in a closed envelope that opened before surgery. Patients with odd numbers were the participants of group A (n=15). They were treated by open reduction and internal fixation (ORIF) by volar locked plates. On the other side, patients with even numbers were the participants of the group B (n=15), and were treated by external fixation augmented by k-wires.

Inclusion criteria: Unilateral Isolated Closed Distal Radius Fractures, surgically fit patients and <14 days since trauma.

Exclusion criteria: chronic **(**old) fractures, concomitant fracture of the same limb, surgically unfit patients, open fractures, pathological fractures, patients with associated vascular injury or compartmental syndrome and patients with incomplete data or lost to follow-up.

Methods:

Preoperative assessment

Each participant was evaluated in a systematic manner by history taking (age, work, mode of trauma, chronic disease, time lapse between injury and operation and special habits), clinical examination of the hand (condition of the skin, muscle functions, deformity, function of the nerves and tendons). In addition, the laboratory investigations included routine workup (e.g., complete blood count, liver and renal function tests, and coagulation profile).

The radiological investigations were in the form of X-rays or CT scans. The X-ray scanning was performed by AP and lateral views of the affected wrist (aiming to determine the site of the fracture, articular extensions, comminution degree, associated fractures, and disrupted distal joints). In addition, elbow X-ray was performed to recognize higher level fractures or dislocations. The CT scan was performed aiming to detect the site and degree of articular comminution (scaphoid and lunate fossae). The CT scans were routinely ordered for all participants.

Each patient signed an informed consent for participation in the study and give his/her permission to obtain images. AO classification was used to classify injuries.

Clinical Photographs: Photographs of the patient hands were obtained after surgical intervention for follow up.

Surgical technique

Anesthesia: The general anesthesia or ultrasound-guided supraclavicular brachial plexus block Anesthesia were used.

Position (Figure 1): The operation was performed while the patient was in the supine decubitus position, and the forearm was placed on a radiolucent side table. By abducting the shoulder, it is possible for the surgeon and his assistant to sit on either side of the table.

I- Group (A): The modified Henry method was used. First we identified the plane between flexor carpi radialis tendon and the radial artery. Before proceeding to the skin incision, the flexor carpi radialis tendon was palpated. Longitudinal incision was then made over the flexor carpi radialis (FCR) tendon (Figures 2 and 3).

Reduction: After exposure of the fracture site, it was refreshed and the reduction process was performed and proper fixation under the C-arm by K-wires was performed. If intra-articular fractures, the large pieces were managed, reduced and fixed by wires (Figure 4). A fluorescein die was injected and images were obtained to assess the plate size and location. A satisfactory result must be recognized.

Plate position: The plate was positioned on the distal radius proximal to the watershed line. With proper placing, the K-wires were inserted to insure the position. The position of the plate was confirmed by the image intensifier (Figure 5).

Post-operative rehabilitation: Post-operatively, anti-edematous, analgesic when indicated only and antibiotic were prescribed. Hand elevation and early active fingers and metacarpophalangeal (MP) exercises were encouraged. First follow up visit after 1 weak for wound care and reassurance, second visit after two weeks postoperatively for

stitches removal then monthly for 6 months. Standard AP & lateral radiograph was obtained after 6 weeks postoperatively and every visit with clinical assessment to exclude infection and tendon injuries.

Group (B): External fixation: We used external fixator either static external fixator in 7 patients or dynamic external fixator in rest 8 patients with pinning (by K-wires) to maintain reduced position of distal radius.

Fracture reduction and fixation: Adequate reduction of the distal radius fracture by manual traction was performed. It aimed to restore the radial height. Some ulnar deviation was done to reduce the radial displacement together with volar tilt to reduce the dorsal deviation. These process was guided by the image intensifier (volar tilt can be assisted by putting a sterile pad under the radius proximal to fracture site). Per-cutaneous K-wires were inserted (while an assistant maintaining the reduction) (figure 7).

Postoperative rehabilitation: As early as possible, the active movement of the hand was encouraged. Patients was instructed to hold things (e.g., a pen or a cup within 1 week of surgery) and felt comfortable with frames. In addition, patients were instructed to clean pin tracts with saline daily and to perform shoulder and elbow mobilization exercises. Four weeks' post-operative distraction released to permit better hand function.

Post-operative assessment of both groups: After 6 weeks, clinical and radiological evaluation of union were assessed & physiotherapist instructed the patients regarding the standard ROM exercises for the wrist and fingers & patients were permitted to carry out non-loaded activities of daily living. This included eating and personal care activities. At 3 months, full evaluation (ROM, grip strength, scoring & radiological parameters) was obtained and repeated at 6 months as a final evaluation after full fracture consolidation which was used for statistical analysis.

Figure (1): Position of the patient and the forearm on a hand table.

Figure (2): Longitudinal incision was made over FCR tendon

Figure (3): Identification of flexor carpi radialis tendon.

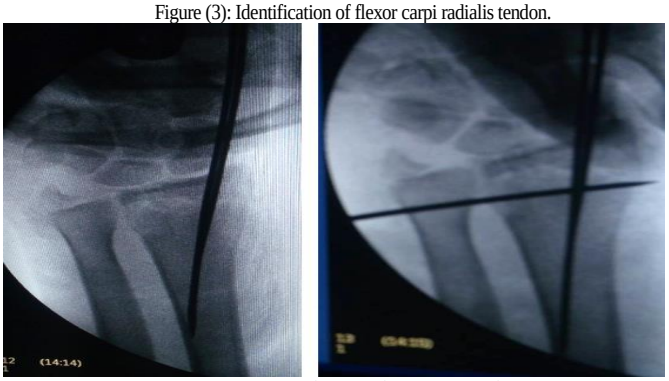


Figure (4): Preliminary fixation of large articular fragments

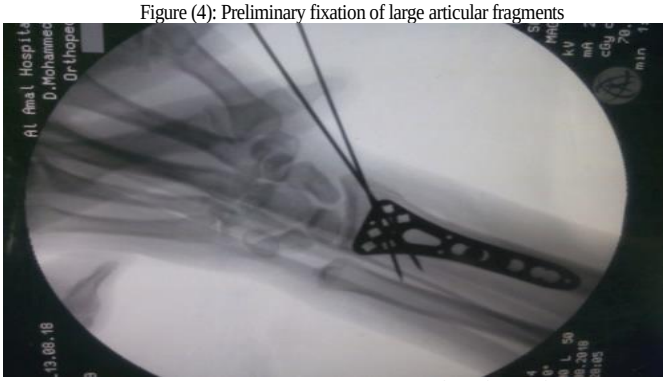


Figure (5): Plate adjustment on the volar surface of lunate facet.

Figure (6): A) Uniaxial plate, B) uniaxial plate augmented with multiple K-wires.

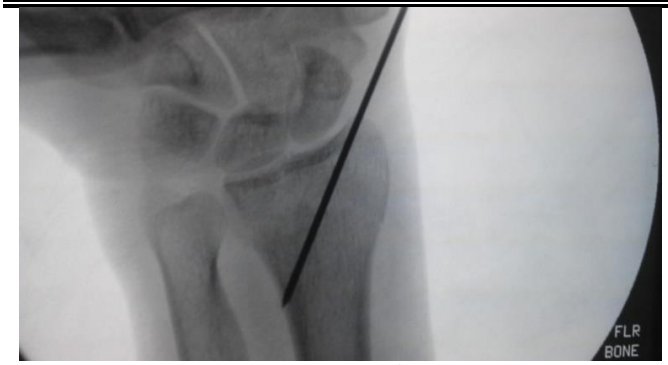


Figure (7): K-wire inserted from radial styloid

Follow up: QDASH score: Quick Disability of Arm, Shoulder and Hand Score, Gartland-Werley score, Grip strength measurement and range of motion were calculated and documented. The range of motion (ROM) describe a measurement of the distance and direction a joint can move to its full potential.

Radiological follow up: Radiological parameters of distal radius for the operated side of both groups (polyaxial & uniaxial).

Statistical analysis of study data: Data were collected, revised, coded and fed to a software computer package for calculation of all statistical testes. This was the Statistical Package for Social Science (IBM SPSS, USA) version 23. Quantitative variables were summarized by their arithmetic mean, standard deviations (SDs) and ranges (maximum – minimum) when parametric. Otherwise the median and inter-quartile range (IQR) were calculated for non-parametric data. The categorical (qualitative) variables were summarized by relative frequencies (numbers) and percentages. Appropriate statistical tests were used for comparison between groups (e.g., independent samples student test for comparison between means, Chi-square test and/or Fisher exact test when the expected count in any cell found less than 5, for categorical variables. Repeated ANOVA test was used to evaluate outcome overtime. P value < 0.05 was considered significant.

RESULTS

Both groups A (volar plate) and group P (external fixation augmented) were comparable regarding patient age, age group, patient sex, occupation, special habits, medical history and hand dominance (detailed results were in table 1). Ten patients were operated in the same day of surgery (33.3%), 4 patients in group (A) and 6 patients in group (B). Others postponed till resolve of posttraumatic edema. Nineteen patients (11 patients in group A and 8 patients in group B) were operated during the first week (63.3%) and one patient in group (B) was operated in the second week (3.3%). (Figure 8). Patients were classified according AO classification. In group (A), type C2, C3 and A 3 were reported for 8, 7 and 0 patients respectively. On the other side, the classification was C2, C3 and A 3 for 7, 7 and 1 patients, respectively (Figure 9 depicts the percentage of patients in each group according to OA classification). The operative time ranged between 30 and 90 minutes, with significant increase of operative time in group A than group B (54.0±12.28 vs 36.33±5.16 minutes, respectively) (Table 2). Both groups were comparable regarding postoperative range of motion, except significant increase of ROM in the extension in the B than A group (74.00 ± 12.28 vs 60.00 ± 22.83, p = 0.046). In addition, no significant differences were observed between groups regarding radiological outcome (Table 2).

Grip strength, QDASH score, and Gartland-Werley score were used to evaluate functional outcomes. In group A, there was highly significant correction and progressive improvement overtime in these three parameters showed by repeated ANOVA test. (Table 3). This was also noted in group B, where final results showed significant correction in the three parameters as shown in Figure (10). Mann-Whitney test and Kruskal-Wallis test revealed that the Quick-DASH score had negative correlation with age groups, Occupation, Smoking & Diabetes Mellitus in **Group (A).** This negative correlation was not statistically significant**.** This correlation was also not statistically significant in **Group (B) (Table 4).** Statistical analysis of complications between volar plating (group A) and external fixation augmented by k-wires (group B) show no significant difference identified between 2 groups. Figure (11).

Table (1): Relation output of demographic results between two groups

		Volar Plate group	Ext Fix group	Test value	P-value
		No. = 15	No. = 15		
Age	Mean ±SD	37.33 ± 10.43	42.33 ± 16.60	0.988	0.332
	Min. – max.	23 – 54	22 – 75		
Age groups	Young age	5 (33.3%)	4 (26.7%)	2.164	0.339
	Middle age	10 (66.7%)	9 (60.0%)		
	Old age	0 (0.0%)	2 (13.3%)		
Sex	Female	3 (20.0%)	5 (33.3%)	0.682	0.409
	Male	12 (80.0%)	10 (66.7%)		
Occupation	Active	13 (86.7%)	9 (60.0%)	2.727	0.099
	Sedentary	2 (13.3%)	6 (40.0%)		
Smoking		9 (60.0%)	8 (53.3%)	0.136	0.713
Positive Medical history		2 (13.3%)	4 (26.7%)	0.833	0.361
DM		1 (6.7%)	1 (6.7%)	0.000	1.000
HTN		2 (13.3%)	4 (26.7%)	0.833	0.361
Previous operation		0 (0.0%)	0 (0.0%)	–	–
Dominance	Right	15 (100.0%)	14 (93.3%)	1.034	0.309
	Left	0 (0.0%)	1 (6.7%)		

Table (2): Comparison of mean operative time, ROM and radiological outcome between study groups

			Volar Plate group	Ext Fix group	Test value	P-value
			No. = 15	No. = 15		
Operative Time (min.)		Mean ± SD	54.00 ± 12.28	36.33 ± 5.16	5.137	<0.001*
		Min. – Max.	40 – 90	30 – 45		
ROM	Flexion	Mean ± SD	62.00 ± 22.58	73.00 ± 7.97	1.779	0.086
		Min. – Max.	10 – 85	60 – 85		
	Extension	Mean ± SD	60.00 ± 22.83	74.00 ± 12.28	2.091	0.046*
		Min. – Max.	10 – 85	45 – 85		
	Pronation	Mean ± SD	75.33 ± 6.67	74.67 ± 5.81	0.292	0.773
		Min. – Max.	65 – 85	65 – 85		
	Supination	Mean ± SD	76.33 ± 7.90	74.33 ± 7.29	0.721	0.477
		Min. – Max.	60 – 85	60 – 85		
	Radial deviation	Mean ± SD	16.00 ± 6.87	17.07 ± 6.09	0.450	0.656
		Min. – Max.	5 – 30	10 – 28		
	Ulnar deviation	Mean ± SD	32.00 ± 8.41	28.53 ± 5.60	1.329	0.195
		Min. – Max.	20 – 40	20 – 35		
Radiological Outcome	Volar tilt	Median (IQR)	9 (3 – 10)	2.8 (-0.5 – 8)	1.624	0.104
		Min. – Max.	-7 – 12	-12.3 – 15		
	Radial inclination	Mean ± SD	21.19 ± 3.16	21.94 ± 2.78	0.687	0.498
		Min. – Max.	13.5 – 24.4	18 – 28.2		
	Radial height	Mean ± SD	9.17 ± 3.08	10.87 ± 2.59	1.637	0.113
		Min. – Max.	2 – 14	7 – 15		
	Articular step off (mm)	Median (IQR)	0.5 (0 – 0.7)	0 (0 – 1)	0.428	0.669
		Min. – Max.	0 – 1.5	0 – 2		
		Fair	1 (6.7%)	1 (6.7%)		
	Union (weeks)	Mean ± SD	6.73 ± 1.03	7.20 ± 1.47	1.004	0.324
		Min. – Max.	5 – 8	5 – 10		

Table (3): Functional outcomes on 1, 3, and 6 months follow up in group (A):

Group A		1 month	3 month	6 month	Test value•	P- value
		No.= 15	No.= 15	No.= 15		
Grip strength	Mean±SD	6.47 ± 3.64	14.23 ± 5.77	19.20 ± 6.77	98.364	< 0.001
	Range	1 – 12	5.5 – 23	8 – 27		
Q DASH	Mean±SD	51.20 ± 10.14	24.08 ± 8.59	24.08 ± 8.59	260.329	< 0.001
	Range	36.25 – 70	11.5 – 45.5	11.5 – 45.5		
Gartland-Werly	Mean±SD	13.60 ± 2.13	7.00 ± 1.73	3.13 ± 2.33	250.187	< 0.001
	Range	11 – 19	5 – 10	0 – 9		

Table (4): Association between the QUICK-DASH score with age groups, Occupation, Smoking & Diabetes Mellitus in groups (A and B)

			DASH		Test value	P-value
			Median (IQR)	Range		
Group A	Age groups	Young age	6.8 (4.5 – 6.8)	2.5 – 6.8	1.021	0.307
		Middle age	6.8 (4.5 – 11.5)	4.5 – 27.3		
	Occupation	Active	6.8 (4.5 – 6.8)	2.5 – 11.5	1.415	0.157
		Sedentary	17.05 (6.8 – 27.3)	6.8 – 27.3		
	Smoking	No	5.65 (4.5 – 11.5)	2.5 – 27.3	0.246	0.806
		Yes	6.8 (4.5 – 6.8)	4.5 – 11.5		
	DM	No	6.8 (4.5 – 6.8)	2.5 – 11.5	1.688	0.091
		Yes	27.3 (27.3 – 27.3)	27.3 – 27.3		
Group B	Age groups	Young age	10.3 (8.7 – 13.25)	8.3 – 15	0.896	0.639
		Middle age	6.8 (4.5 – 12.5)	2.5 – 22.5		
		Old age	15 (5 – 25)	5 – 25		
	Occupation	Active	11.5 (9.1 – 15)	4.5 – 22.5	1.712	0.087
		Sedentary	5.9 (4.5 – 6.8)	2.5 – 25		
	Smoking	No	6.8 (4.5 – 12.5)	2.5 – 25	1.159	0.246
		Yes	10.75 (7.95 – 17.75)	4.5 – 22.5		
	DM	No	9.55 (6.8 – 15)	4.5 – 25	1.623	0.105
		Yes	2.5 (2.5 – 2.5)	2.5 – 2.5		

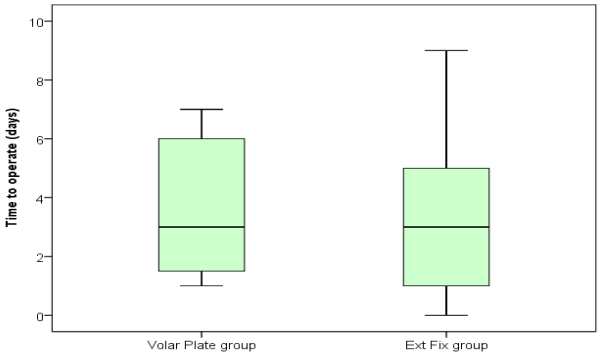


Figure (8): Box plot illustrating injury to treatment interval in the two studied groups.

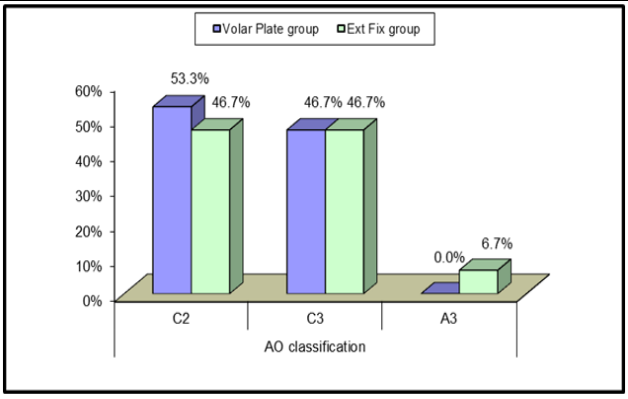


Figure (9): Distribution of the patients regarding to AO classification.

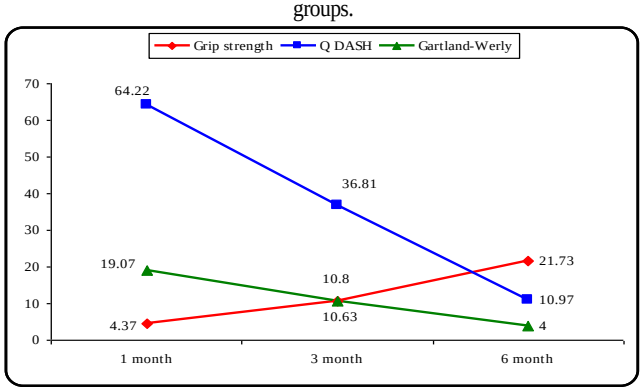


Figure (1): Line chart illustrating Functional outcomes on 1, 3, and 6 months follow up in group (B)

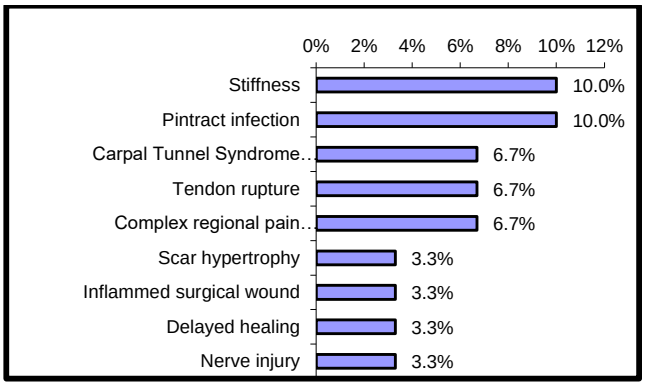
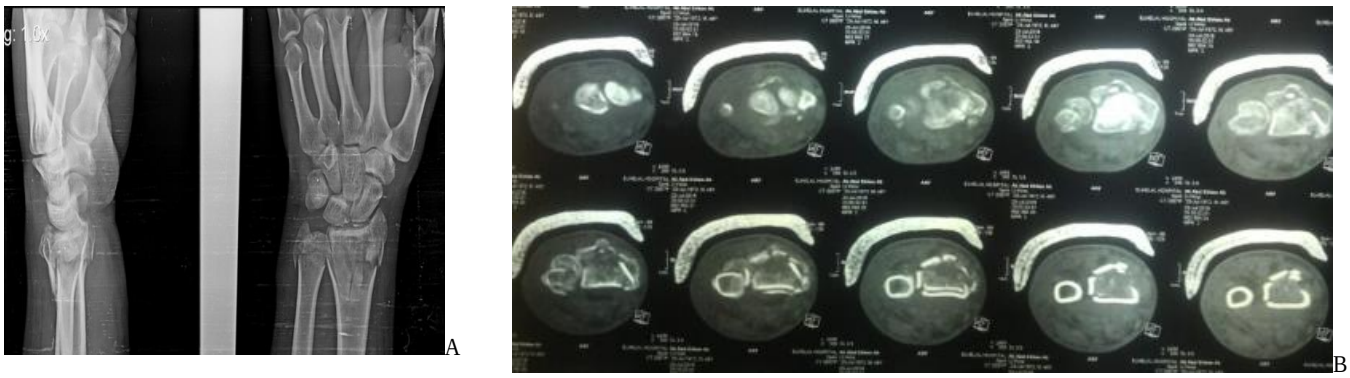


Figure (11): Distribution of the studied patients in both groups according to complications

Case Presentation

Patients with volar plating: The next case for a 45 years old right-handed male patient. He worked as a carpenter, a smoker and presented with fracture distal radius of right dominant hand with ulnar styloid fracture due to road traffic accident (RTA). Fracture was AO/OTA type 2R3C3, Frykman type (VIII). He was managed with a polyaxial volar plate after 7 days of injury (Figures 12 and 13).



A B

Figure (12) A: preoperative x-ray & CT, B: Immediate postoperative

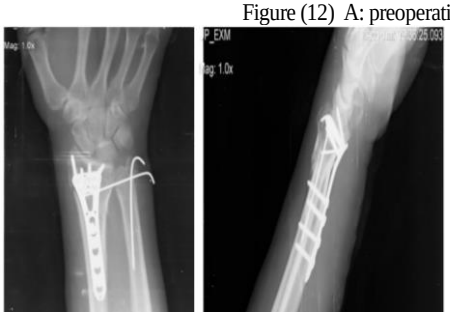


Figure (12C): Post-operative x ray: 1 week after operation

Figure (12D): Follow up after 6 months

Figure (13): Range of motion A: Dorsiflexion, B: Palmar flexion, and C: Ulnar deviation. D: radial deviation, E: supination, F: Pronation, G: Grip strength. **Clinical scores:** Flexion: 50 & Extension: 40 ; Radial deviation: 10 & ulnar deviation: 40; Supination: 80 &pronation: 80 ; Grip strength: 18; Radial inclination: 24 ; Radial height: 11; Volar tilt: 12 ; Articular step off: 0.9; QDASH: 4.5; Gartland-Werley score: Good (6)

The next case for 75 years old right-handed female patient, housewife, hypertensive, non-smoker presented with fracture distal radius of right dominant hand with ulnar styloid fracture due to falling of outstretched hand. Fracture was AO/OTA type 2R3A3, Frykman type (II). He was managed with external fixator and k-wires after 5 days of injury (figure 14).

Figure (14A): A: pre-reduction X-rays AP and lateral wrist views.

Figure (14b): Preoperative C.T scan cuts

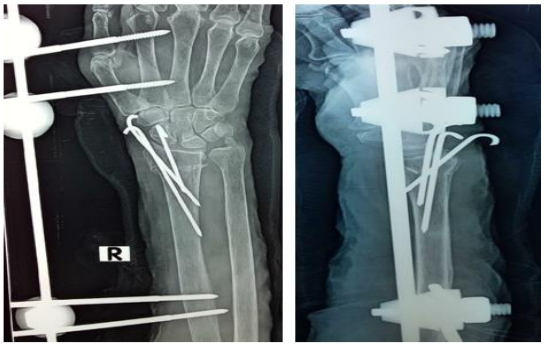


Figure (14c): Post-operative X-rays AP and lateral wrist views

Figure (14d): Post-operative X- rays after removal of external fixator &

Figure (14E): wrist range of motion after 6 months.; Clinical scores: Flexion: 75 & Extension: 85; Radial deviation: 25 & Ulnar deviation: 33; Supination: 80 &pronation: 75; Grip strength: 22.5; Radial inclination: 22; Radial height: 9; Volar tilt: 15; Articular stepoff: 0 ; QDASH: 5 ;Gartland-Werley score: Excellent (2).

DISCUSSION

The distal radial fractures are usually due to high-energy trauma in young, middle aged and elderly. No standard treatment option is available and no-consensus is not build for the treatment. We studied two treatment options, open reduction with internal fixation by volar plate and the second was the external fixation augmented by k-wire (each for 15 patient). The age of patient ranged between 22 and 75 years, and the minimum follow up duration was 6 months. The majority of patients regained their grip strength with acceptable range of motion in this duration. These results agree with **Yu *et al.*** [8].

In the current work, there was a male-sex predominance (66.7% and 80% of groups A and B, respectively, were males). This is comparable to **Duramaz *et al.*** [9] who reported that, males represented 65.5% and 60.7% of external fixator and volar plate groups respectively.

The mean age in the current work was 42.33 and 37.33 in the external fixator and volar groups respectively, with no significant differences between groups. These results are comparable to **Kreder *et al.*** [10] study. They reported that, the mean age was 39 and 40 years in the external fixator and volar groups, respectively. In addition, **Xu *et al.*** [11] reported that, the mean age was 41.8 and 45.3% in external fixation and volar plate groups respectively. Furthermore, **Phandis *et al.*** [12] reported that, no significant differences between groups were recorded for age or gender. The results of the current work come in agreement with this study.

We recorded objective ROM in each direction. The results showed that, the external fixation had a significant improvement of perforce in wrist extension, when compared to volar plating (p = 0.046). However, other directions showed non-significant differences between groups. This may be related to the permission of early exercises (either by stress ball or other special exercises at home) directly on the second postoperative week in patients of the external fixation group. In addition, the nature of the study (as a prospective study) permits the evaluation of ROM at the end of the minimum follow up period (6 months as described before). Thus, nearly all patients regained their normal range of motion. These results agree with **Wei *et al.*** [13], and **Shukla *et al.*** [14].

The results of the current work showed non-significant increase of the average grip strength in External fixation (21.73) than volar plating (19.20). These findings are supported by some studies. For example, **Grewal *et al.*** [15] study, in which 53 patients were included and randomized to ORIF (27 patients) or augmented external fixation (26 patients).

In our study, the radiological results showed non-significant differences between study groups. The previous literature reported a comparable result. For example, **Duramaz *et al.*** [9] showed that, the differences in the radiological results were insignificant. The radial length and inclination were better corrected with external fixation. However, these results not to have any effect on functional outcomes during the follow up period of 2 years.

In our study, Volar plate group had better functional outcomes than external fixation in Quick DASH score (6.8 vs 9.1). In addition, Gartland-Werley score results are better in Volar plate (53.3% excellent and 40% were good) than external fixation (33.3% excellent and 60% were good) but the difference did not reach statistical significance (P value>0.05). These results are in line with the retrospective study carried out by **Richard *et al.*** [16]. They included 115 patients with AO type C2/C3 fractures and demonstrated better DASH score and more improvement in pronation/supination arc in volar plate group at postoperative 12 months

In our study, volar plating was associated with an overall reduced incidence of complications than the external fixation. Generally, 7 patients had complication in the volar plating, compared to 9 in the external fixation group. These results are agreeing with previous literature, where less complications were associated with ORIF. For example, **Abramo *et al.*** [17] reported 14 out of 26 patients treated with ORIF had complications compared to 20 out of 24 patients in the external fixation group. However, all complications were of mild nature and treated conservatively, with no need for further surgical intervention.

The prospective nature and homogeneity (all had comminuted distal radial fractures, and matched for age and sex distribution) of patients are the strength points of the current work. In addition, a subjective and objective measures of outcome were used. This was associated with a clear view about the improvement. However, the small sample size in each group representing a major limiting step that prevent globalization of

results. Thus, a wide scale, future studies are highly recommended.

We are able to conclude that, volar plating and augmented external fixations are comparable choices for treatment of distal radial comminuted fractures.

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