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Original Article

Comparison of the Clinical and Radiological Results of Volar Locking Plate and External Fixation Treatment of Intra-Articular Fractures of the Distal Radius

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ABSTRACT

Objective: The aim of this study was to compare the mid-term results of patients who underwent open reduction and internal fixation with closed reduction and external fixation in the surgical treatment of distal radius intra-articular fractures.

Methods: The data were retrospectively analyzed of 95 patients who underwent internal fixation with volar plate after open reduction or application of external fixator after closed reduction due to distal radius intra-articular fracture between April 2019 and October 2022 in our clinic. All patients who agreed to participate in the study were clinically evaluated using the MAYO wrist score at the final follow-up examination. Palmar angulation loss, radial length loss, and radial tilt loss were investigated by comparing the radiographs taken at the final follow-up visit with the healthy side.

Results: Evaluation was made of a total of 47 patients, as group 1 comprising 24 patients applied with volar plate and group 2 comprising 23 patients applied with external fixator. A statistically significant difference was determined between the groups in terms of operation time ($P=.002$), duration of follow-up ($P=.031$), wrist extension range of motion ($P=.001$), and volar angulation ($P=.010$).

Conclusion: Some clinical and radiological differences were detected between volar plate fixation and external fixator fixation in the surgical treatment of intra-articular radius distal fractures. However, the MAYO wrist score showed no significant difference between the groups. It is most important that the patient returns to normal life as soon as possible and is able to maintain that. Therefore, these methods can be used interchangeably when necessary.

Keywords: External fixation, intra-articular fractures, radius, volar locking plate

INTRODUCTION

Radius distal fractures are the most common fracture type among all bone fractures of the body[1] and constitute 44% of all hand and forearm fractures.[2] Distal radius fractures are more common in the elderly with a diagnosis of osteoporosis, occurring as a result of a simple fall or low-energy trauma, whereas in younger people, these fractures are usually a result of serious trauma.[3] The prognosis of intra-articular fractures is worse due to the rate of development of arthrosis, accompanying ligament injuries and instability.[4] While non-surgical treatment methods are used for stable radius distal fractures, surgical methods are preferred for unstable fractures with a tendency to slip. Although various surgical intervention methods and fixation materials have been described in the treatment of unstable fractures, no standard treatment method has been established to date.[5] The aim of all these treatment methods is to obtain the anatomy closest to the pre-fracture anatomy and to minimize the loss of function.

The short-, medium-, and long-term clinical results of internal fixation with volar plate after open reduction and external fixator (EF) after closed reduction methods have been evaluated in many studies.[2, 6-13] It has been emphasized that short-term clinical results of volar plate fixation are better after open reduction in distal radius

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intra-articular fractures.[2,6,14,15] However, when the mid-term and long-term results are compared, there are studies suggesting that either the internal or external fixation method is better[9-11] or that these surgical approaches are not superior to each other.[12, 13,16]

The aim of this study was to compare the mid-term results of patients who underwent open reduction and internal fixation with closed reduction and external fixation in the surgical treatment of distal radius intra-articular fractures.

METHODS

This study was approved by Gaziantep University Faculty of Medicine Clinical Research Ethics Committee (No: 2023/116, Date: April 12, 2023). The authors have no conflict of interests to declare. A retrospective analysis was made of the data of 95 patients who underwent internal fixation with volar plate after open reduction or were applied with an EF after closed reduction due to distal radius intra-articular fracture between April 2019 and October 2022 in our clinic. The study included a total of 47 patients who presented at the outpatient clinic for the final follow-up examination. Patients were excluded from the study if they had bilateral fractures, did not attend follow-up examinations, could not be contacted for the final appointment, or were aged <18 years. All the patients provided informed consent for participation in the study.

A record was made for each patient of demographic data (age, gender), fracture side, intra-articular fracture classification of the distal radius, duration of surgery, length of hospital stay, follow-up period, complications, and revisions, if made. Fracture classification was made according to the Arbeitsgemeinschaft für Osteosynthesefragen (AO) classification. The joint range of motion (ROM) at the final follow-up examination was measured with a goniometer. Wrist flexion, extension, supination, and pronation spans were recorded and compared with the healthy side.

Bidirectional (antero-posterior [AP] + lateral) x-ray radiographs of both wrists were taken at the final follow-up examination of all the patients in the study. Radial inclination, radial length, and volar angulation were measured on both sides on the radiographs and recorded. Then, the difference was determined by comparing the operated side with the healthy side.

All the patients who agreed to participate in the study were clinically evaluated using the MAYO wrist score at the final follow-up examination. This scoring system is used to evaluate pain, functional status (working status), ROM, and grip strength. A subjective evaluation was also made of residual deformities of the patients and pain. The ROM and development of complications were evaluated using the Gartland & Werley Demerit rating scale (Sarmiento modification). Loss of palmar angulation, radial length, and radial tilt were investigated by comparing the radiographs taken at the final follow-up examination with the healthy side.

Surgical Method

In the volar plate application, all the patients were operated on in the supine position using a pneumatic tourniquet with a volar Henry incision. A soft resting splint, which did not extend beyond the metacarpophalangeal joints and came up to the elbow, was applied to the wrist postoperatively. Active finger exercises were started the day after the surgery. After 4 weeks, the splint was removed and active and passive wrist exercises were started. At the end of the eighth week, an exercise program for muscle strengthening was started according to the union status. Weight bearing and heavy work were not permitted until the acceptable bone union was observed radiographically (Figure 1).

For the cases undergoing external fixation, the fracture was identified with percutaneous K-wires after closed reduction performed under fluoroscopy guidance. Two 2-3 mm screws were placed on the second metacarpal shaft. The pins placed on the radius shaft were placed in such a way that they would pass between the adductor pollicis longus and extensor pollicis brevis muscles and would not penetrate these structures. A half-ring was fixed with K-wires at the fracture line, and then connected to the fixator. Distraction was then applied using the traction unit distal to the fixator. The operation was

MAIN POINTS

- When the wrist range of motion results of the volar plate (VPL) and external fixator (EF) groups of this study were compared for all parameters, a significant difference was observed in favor of VPL only in extension at the end of the follow-up period.
- No significant difference was determined between the groups according to the MAYO and Gartland & Werley scores.
- Volar plate was found to be superior in terms of shorter operation time and shorter follow-up period.
- Plate fixation can be recommended for cases with suspected osteoporosis.
- A significant difference was observed in the VPL group in terms of preventing palmar tilt loss.
- In conclusion, no clinical and radiological differences were detected between VPL fixation and EF fixation in the surgical treatment of intra-articular radius distal fractures.

Figure 1. Preoperative, postoperative, post-implant removal, and final follow-up direct x-ray images of a case with volar plate applied for the diagnosis of radius distal intra-articular fracture.

terminated by dressing the bottom of the pins. Finger exercises were started in the EF group on the first postoperative day. Wire ends were checked weekly for infection. When findings of bone union were observed radiographically between 6 and 8 weeks, the EF was removed under sedation and the K-wires were left in place. Rehabilitation was started with active and passive exercises, and then the K-wires were removed when acceptable consolidated bone union findings were observed radiographically (Figure 2). According to the union status, an exercise program for muscle strengthening was started at the end of the 12th week at the latest.

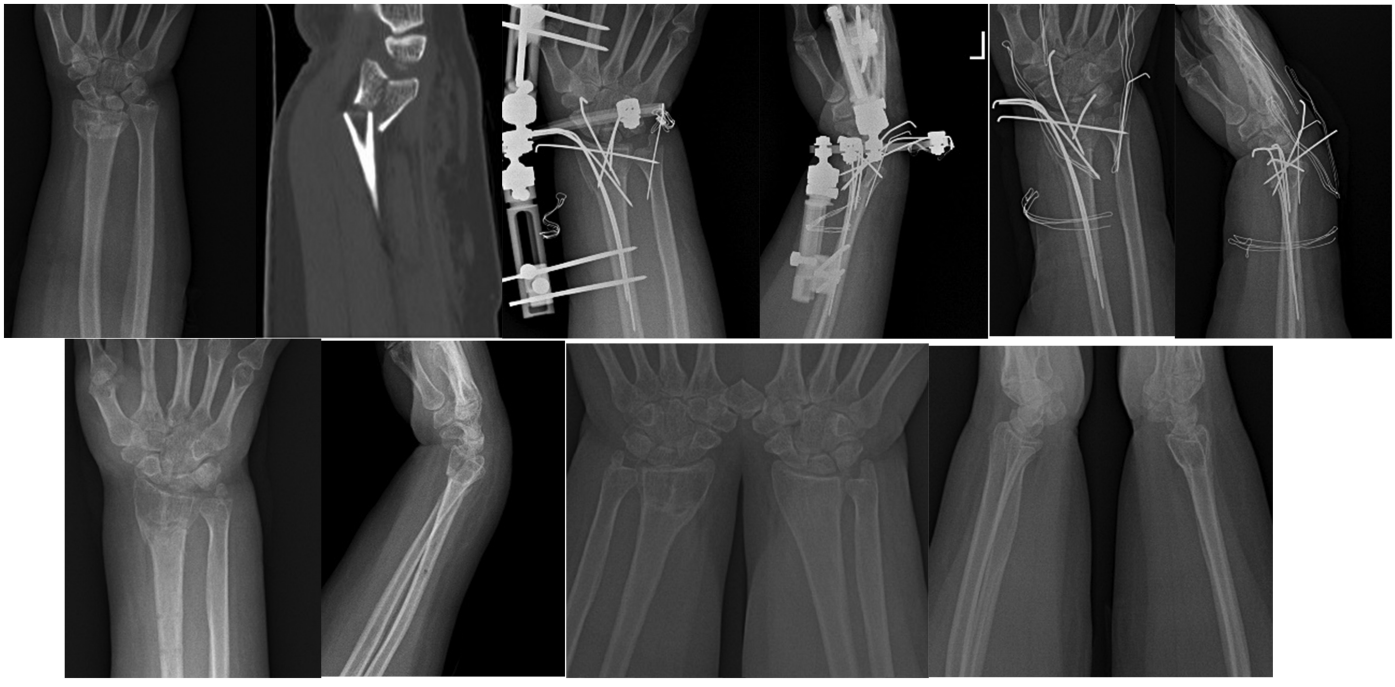

Figure 2. Preoperative, postoperative, post-implant removal, and final follow-up direct x-ray images of a case with a diagnosis of radius distal intra-articular fracture who was applied with an external fixator.

Table 1. Comparison of Demographic Characteristics of Patients

		Implant Used		
		Group 1 (Volar Plate)	Group 2 (External Fixator)	
		(n=24)	(n=23)	*P*
Age (years)		43.5 (18-70)	45.7 (18-92)	.681
Gender	Male	15 (62.5%)	18 (78%)	.245
	Female	9 (37.5%)	5 (22%)	
Side	Right	14 (58%)	11 (47.8%)	.520
	Left	10 (42%)	12 (52.2%)	
Length of hospitalization (days)		1.8 (1-8)	1.5 (1-8)	.459
Operation time (minutes)		101.8 (20-195)	64.3 (29-110)	**.002**
Follow-up time (months)		26.6 (8-49)	34.5 (8-49)	**.031**

Statistical Analyses

Data obtained in the study were analyzed statistically using Statistical Package for the Social Sciences version 27 (IBM SPSS Corp., Armonk, NY, USA) software. Quantitative variables were given as mean (minimum-maximum) and qualitative variables as number (n) and percentage (%). Quantitative variables conforming to normal distribution were analyzed with the independent samples *t*-test, and quantitative variables not showing normal distribution with the Mann–Whitney *U*-test. The chi-square test was used in the analysis of qualitative variables. A value of $P < .05$ was considered statistically significant.

RESULTS

Evaluation was made of a total of 47 patients, as group 1 comprising 24 patients applied with volar plate, and group 2 comprising 23 patients applied with an EF. There was no statistically significant difference between the groups in terms of age ($P=.681$), gender, fracture site, and hospital stay ($P=.459$). A statistically significant difference was observed in respect of operation time ($P=.002$) and duration of follow-up ($P=.031$) (Table 1).

According to the AO classification, 37.5% of the patients were 23-B and 62.5% were 23-C in group 1, and in group 2, 30.5% of the patients were 23-B ($P=.706$) and 69.5% were 23-C ($P=.11$). There was no statistically significant difference between the groups in terms of the distribution of fracture type.

Postoperative complications developed in 46% of the cases in group 1 and in 61% of the cases in group 2. None of the patients in group 1 needed revision, but 1 patient in group 2 needed revision and wrist arthrodesis was performed. There was no statistically significant difference between the groups in terms of postoperative complications ($P=.328$).

According to the Gartland & Werley Demerit rating scale (Sarmiento modification), excellent/good results were obtained in 70.6% of the patients in group 1 and in 82% of group 2. According to the MAYO wrist assessment score, excellent/good results were obtained in 66.6% of group 1 patients and in 73% of group 2 patients. There was no statistically significant difference between the groups according to the MAYO wrist evaluation score ($P=.329$) and the Gartland & Werley Demerit evaluation scale ($P=.463$) (Table 2).

At the final outpatient visit, the joint ROM was measured using a goniometer and the operated side was compared with the healthy side. There was no statistically significant difference between the groups in terms of both wrist flexion range ($P=.488$), forearm supination ($P=.452$), and pronation ($P=.133$). There was a statistically significant difference between the groups in terms of wrist extension ROM ($P=.001$).

Radiographically, no statistically significant difference was determined between the groups in terms of radial inclination ($P=.498$) and radial length ($P=.194$) when compared to the healthy contralateral side. A statistically significant difference was observed between the groups in terms of volar angulation ($P=.010$) (Table 3).

DISCUSSION

This study was conducted to determine the most appropriate treatment approach to distal radius fractures extending to the joint, in terms of the functional results of open reduction and internal fixation with volar plate, and closed reduction and external fixation, which are the 2 most preferred surgical approaches. In contrast to some studies in the literature, the results of this study showed that no clinical and radiological differences were observed between volar plate fixation (VPL) and EF fixation in the surgical treatment of intra-articular radius distal fractures.

Table 2. Comparisons of Clinical Outcomes Between the Groups

		Implant Used		
		Group 1 (Volar Plate)	Group 2 (External Fixator)	
		(n=24)	(n=23)	*P*
Revision		0	1 (2%)	.328
Complication	Radioulnar pain	2 (8%)	6 (26%)	.105
	Reflex sympathetic dystrophy	0	2 (9%)	.302
	Joint stiffness	7 (29%)	3 (13%)	.177
	Infection	2 (8%)	3 (13%)	.610
	Total	11 (46%)	14 (61%)	.122
Gartland and Werley Demerit rating scale		4.8 (1-11)	5.8 (1-26)	.463
MAYO wrist evaluation score		77 (50-100)	78 (20-95)	.817
	Excellent	4 (16.6%)	7 (30%)	.577
	Good	12 (50%)	10 (43%)	
	Fair	5 (20.8%)	5 (21%)	
	Poor	3 (12.5%)	1 (4%)	

Table 3. Comparisons of Radiological Results Between the Groups

		Implant Used		
		Group 1 (Volar Plate)	Group 2 (External Fixator)	
		(n=24)	(n=23)	*P*
Flexion	Operated side	66° (40°-80°)	63° (50°-80°)	.533
	Intact side	80° (70°-90°)	78° (70°-85°)	
	Difference	14.6° (5°-20°)	14.7° (0°-70°)	.488
Extension	Operated side	57° (45°-70°)	60° (50°-83°)	.076
	Intact side	69° (60°-70°)	80° (70°-90°)	
	Difference	13.3° (0°-30°)	20° (3°-75°)	**.001**
Supination	Operated side	62° (10°-80°)	59° (40°-85°)	.527
	Intact side	82° (70°-90°)	80° (70°-90°)	
	Difference	20.6° (5°-70°)	21.4° (3°-60°)	.452
Pronation	Operated side	67° (20°-90°)	64° (35°-86°)	.508
	Intact side	85° (75°-90°)	86° (75°-90°)	
	Difference	18.5° (0°-70°)	22° (3°-60°)	.133
Radial slope	Operated side	19° (9°-22°)	18° (8°-23°)	.493
	Intact side	23° (20°-30°)	21° (13°-35°)	
	Difference	–4.45° (–10°/+1°)	–3.1° (–16°/+14°)	.498
Radial length	Operated side	10 mm (5 mm-14 mm)	10 mm (4 mm-14 mm)	.490
	Intact side	13 mm (10 mm-17 mm)	12 mm (7 mm-15 mm)	
	Difference	–2.1 mm (–8 mm/+4 mm)	–2.8 mm (–14/+7 mm)	.194
Volar angulation	Operated side	8° (2°-22°)	7° (0°-13°)	.062
	Intact side	13° (10°-18°)	11° (5°-14°)	
	Difference	–4.5° (–12°/+7°)	–3.7° (–14°/+2°)	**.010**

While the operation time was shorter in the EF group, the postoperative follow-up period was significantly longer in the VPL group. In the light of this information, EF was found to be superior in terms of shorter operation time.

Although a significant difference was detected in the follow-up period in this study, the average follow-up period of these cases was observed to be 8 months with no significant difference between the groups. The overall difference emerged as the date when the cases were called to the outpatient clinic was accepted as the final follow-up date.

In the long-term treatment with the EF, loss of palmar angulation may persist even after removal of the fixator. Palmar tilt can be corrected better with the volar plate, as the fixation can be made directly and visually. The distal screws of the VPL placed subchondrally provide support against loss of palmar angulation and prevent fracture collapse in the long term.[5]

Contrary to this expectation, palmar tilt loss was found to be significantly less in the EF group than in the VPL group in the current study. This may have been due to bias in patient selection. When acceptable reduction could be obtained with closed reduction in post-traumatic fractures, EF treatment may have been applied first to those patients. The VPL treatment may have been applied to patients who could not achieve adequate reduction with closed reduction, had large displacement, or had extensive soft tissue damage to the bone surrounding the fracture. Further prospective randomized controlled studies are needed to prove the validity of this determination, which is contrary to the literature and scientific data.

Many studies in the literature have compared plate-screw and EFs in the surgical treatment of intra-articular radius distal fractures. In a meta-analysis by Margaliot et al,[16] plate fixation and external fixation in the treatment of radius distal fractures were compared, and there was found to be no clinically or statistically significant difference according to grip strength, wrist ROM, and radiological alignment. Consequently, no concrete data could be obtained to prove the superiority of internal fixation over external fixation in unstable distal radius fractures.

In a randomized controlled study of 179 adult patients with displaced intra-articular radius fractures, Kreder et al[17] compared patients who underwent indirect percutaneous reduction and external fixation with those who underwent open reduction internal fixation. No significant statistical difference was found between the 2 groups in terms of radiological and functional aspects.

In a recent, comprehensive meta-analysis, Wang et al[14] examined studies comparing volar plate and external fixation applications in distal radius fractures and reported that volar plate was superior in respect of disability, ulnar variance, radial tilt, and volar tilt, and the incidence of pin site infection. In a similar meta-analysis,[15] although better results were obtained in the volar plate internal fixation group at 3 months, the results were similar to those of external fixation at the 12-month evaluations. Li-hai et al[18] also showed that both methods had similar outcomes at 12 months in another meta-analysis examining randomized controlled studies on this subject.

Egol et al[19] reported that wrist ROM was better in the short term in patients in the VPL group, but only pronation was better preserved during the follow-up period. In the current study, when the wrist ROM results of the VPL and EF groups were compared for all parameters, a significant difference was observed in favor of VPL only in extension at the end of the follow-up period. While less volar angulation loss was detected in the EF group, there was seen to be less extension loss in the VPL group. This was attributed to the fixator bridging the wrist in the EF group and keeping the wrist in flexion for a while, whereas the early start to exercises in the VPL group could have caused less loss of wrist flexibility.

In this study, the MAYO wrist scoring system and the Gartland & Werley Demerit rating scale (Sarmiento modification) were used in the follow-up of the cases. The MAYO wrist scoring system evaluates pain, satisfaction levels, ROM, and grip strength. The Gartland & Werley Demerit rating scale (Sarmiento modification) evaluates residual deformities, a subjective assessment of pain, and objective assessment of ROM and complications. Of the studies in the literature comparing VPL and EF, some have reported that the results of VPL were better according to the MAYO scoring system[10,11,20], some have reported that the results of EF were better[11,13,21-23], and some have shown a significant difference between the results of EF and VPL studies.[14,15] Likewise, there are studies showing that VPL is better according to the Gartland & Werley Demerit evaluation scale[6] and there is no significant difference between the 2 methods.[11] The results of the current study showed no significant difference between the groups according to the MAYO and Gartland &Werley scores. While there were differences between the groups according to radiological measurements and ROM measurements taken with a goniometer, there was no difference in the MAYO scores. This may have been due to the fact that the MAYO score is mostly evaluated according to the subjective data of the patients and that the same surgeon operated on all the patients. Thus, they were all informed in the same way by the same surgeon and the trauma process was managed in the same way. Therefore, good subjective results can be obtained if the patients are sufficiently well informed in advance to be able to discount problems that

may emerge later. If this is true, evaluations based on subjective criteria such as the MAYO score are affected by communication with the patient. However, further multicenter and prospective studies are required to be able to verify this.

Loss of reduction seen after the removal of the EF is an important problem. Bradway et al[23] reported a reduction loss of 4%, and Szabo and Weber[1] reported a rate of 7.6%. Radius distal fractures have high complication rates, affected by factors such as the personal characteristics of the patient, the presence of osteoporosis and compliance with treatment. In this study, only 1 patient needed revision and arthrodesis was performed. That patient was a 92-year-old female in the EF group. It is not clear whether the reduction loss in this patient was due to existing osteoporosis or insufficient surgical fixation. Therefore, plate fixation can be recommended for patients with suspected osteoporosis.

The EF has some potential complications in the treatment of distal radius fractures, such as nail tract infections, joint stiffness, limitation of finger movements, loss of grip strength, and superficial radial nerve injury. Grala et al[24] reported that EFs that bridge the joint cause stiffness in the wrist and fingers as a result of prolonged distraction with the effect of ligamentotaxis and cause reflex sympathetic dystrophy. An EF bridging the wrist was applied to all the patients in this study, but no significant difference was found between the groups in terms of pin site infection, joint stiffness, radio ulnar pain, and reflex sympathetic dystrophy.

This study had some limitations. There were differences in the choice of surgical method applied to fractures caused by trauma. The EF was preferred for patients with soft tissue damage, with a low degree of fragmentation in the metaphyseal region, or without excessive comminuted fractures, where successful closed reduction could be obtained. The VPL was preferred for cases that could not be reduced successfully with closed reduction, had a large displacement, or a large fracture. As the bias is evident in these preferences, it is not possible to conclude that the methods can be alternatives to each other. In order to clarify this situation, there is a need for blinded randomized controlled prospective studies.

All cases were performed in a single center and by a single surgeon. Therefore, surgical experience, which is decisive in surgical applications, could not be evaluated in this study. The cases were not evaluated in terms of treatment compliance, whether they received physical therapy support when necessary, additional pathologies (osteoporosis, diabetes mellitus, renal insufficiency, etc.) and additional drugs used, and variables that may affect long-term surgical results such as physically difficult movements in daily life. In addition, while open surgery allows the surgeon a direct view to be able to decide on adequate reduction, closed methods require imaging after each manipulation. Therefore, more fluoroscopy is needed in the closed method, but since the amount of fluoroscopy used in the operations was not noted, no comparison could be made.

The results of this study demonstrated that there were clinical and radiological differences between VPL and EF fixation in the surgical treatment of intra-articular radius distal fractures. However, no significant difference was determined between the groups according to the MAYO wrist scoring system or the Gartland & Werley Demerit scale, which evaluate subjective data such as pain, satisfaction levels, joint ROM, and grip strength of the patients. Therefore, the most important parameter that determines the outcome of the surgery can be considered to be the patient's ability to return to normal life and be satisfied. In light of this information, these methods can be used interchangeably when necessary. However, there is a need for multicenter, prospective randomized controlled studies to be able to obtain more robust data.

Ethics Committee Approval: The study started after obtaining permission from Gaziantep University Faculty of Medicine Clinical Research Ethics Committee (Date: April 12, 2023, No: 2023/116).

Informed Consent: Written informed consent was obtained from the patients participating in this study.

Peer-review: Externally peer-reviewed.

Declaration of Interests: The author declare that they have no competing interest.

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