Comparison of External Fixator Combined with Plate Compared to Plate Fixation Alone in the Treatment of Intra-Articular Comminuted Distal Radius Fractures

Abstract

Introduction: Distal radius fractures are the most common fractures in the upper limb, and many studies have been conducted on its treatment. There is, as yet, no consensus on which treatment method is preferable. This paper compares the use of plate alone with plate + external fixator in this fracture.

Materials & Methods: In a randomized clinical trial (RCT), patients with type C2 and C3.1(AO/OTA classification) distal radius fracture, were randomly divided into two groups of fixation with locking plate alone (control) and fixation with plate and additional external fixator (intervention). Then patients were evaluated in terms of radiographs and clinical outcomes in first, third and, sixth weeks, and also 6 and 9 months after surgery by Quick Disabilities of the Arm, Shoulder and Hand questionnaire (qDASH) and visual analogue score (VAS). SPSS software was used for data analysis. Informed consent was obtained from the patients.

Results & Discussion: 52 patient (26 in each group) were enrolled in the study. The mean age was 42 years in the control and 41 years in the intervention group. The qDASH score in the control group was 35 and 38 in the intervention group and this difference was not significant between the two groups. No significant difference was observed between the two groups in terms of pain level according to the (VAS) score either. Also, the radiographic criteria including radius height and palmar tilt, did not differ significantly between the two groups ($p<0.05$).

Conclusion: In general, with similar results of plating, and plating with addition of external fixator in fixation of distal radius fracture, the method of "plate alone" is preferred.

Keywords: Distal radius fracture, Fracture Fixation, External Fixators, Internal Fixators.

Accepted: 36 days before printing

Arvin Najafi, MD[1], Milad Behzadi, MD[2], Salman Azarsina, MD[1], Mohammad Sajjad Mirhosseini, MD[1], Mohammad Sheibani, MD[1], Dorsa Hadavi, MD[3], Elahe Khandan, MD[4], Mehdi yaghoobnezhad, MD[1]

1. Department of Orthopedic Surgery, Clinical Research Development Unit of Shahid Madani Hospital, School of Medicine, Alborz University of Medical Sciences, Karaj, Iran.
2. Student Research Committee, School of Medicine, Clinical Research Development Unit of Shahid Madani Hospital, Alborz University of Medical Sciences, Karaj, Iran.
3. Clinical Research Development Unit of Shahid Madani Hospital, School of Medicine, Alborz University of Medical Sciences, Karaj, Iran.
4. Student Research Committee, Faculty of Medicine, Iran University of Medical Sciences, Tehran, Iran.

Corresponding Author:
Mohammad Sajjad Mirhoseini, MD
Email address:
smirortho@gmail.com

Introduction

Often, the anatomical restoration of the joint surface is the main reason for surgical treatment. Many studies have shown an association of non-uniform articular surface of even 1 mm with worse outcomes, however other reports have noted no association between radiographic arthrosis and outcomes. Bone quality is also a fundamental variable in choosing the type of treatment and is related to the ability to obtain and maintain reduction in the future[(1)].

Clinical and biomechanical studies have determined that Palmar tilt and Radial height are the most important radiological factors impacting the outcomes[(2)]. It seems that the external fixator neutralizes the axial force on the distal radius by ligamentotaxis and thus prevents depression of the articular surface and subsequent shortening, especially in crushed cases[(3)]. Comparing external fixator and open & internal fixation, fist power, better range of motion and less nausea have been seen with the internal fixation[(4)]. A comparative meta-analysis of clinical trials concluded that open & internal fixation was associated with better forearm supination, recovery of velar tilt and better outcomes at the bedside while better fist strength and wrist flexion were seen with external fixator[(5)]. In cases of articular surface involvement with comminuted patterns, it is difficult to achieve an optimal articular surface restoration using external fixator alone. For this reason, the use of expandable plate fixation is increasing, with overall good short-term results. But in the long-term run, they have suffered from depression of the joint surface and short radius[(6)].

So, we decided to evaluate this hypothesis that the use of an external fixator and a plate combination could achieve the desired uniformity at the joint level by means of the plate and prevent depression and subsequent shortening og radius. Also, if this hypothesis is rejected, we could prevent from imposing an additional cost of an external fixator for this kind of fracture.

Materials & Methods

In this RCT, Patients with intra-articular and comminuted fractures of the distal radius who referred to the emergency department of Shahid Madani Hospital in Karaj from March 2023 to 2024 were eligible to enter the study. Inclusion criteria include acute intra-articular and comminuted fractures of the distal radius type C2 and C3.1 according to AO/OTA classification, mastery of speech and understanding of Persian language, informed consent to participate in the study and age between 18 and 60 years. Exclusion criteria include the presence of contra-indications for surgery, pathological fracture, premature osteoporosis, substance and alcohol abuse, Gastillo-Anderson type 2 and 3 open fracture, concomitant fracture (except ulna styloid fracture), patients who are unlikely to cooperate and accept all planned follow-up visits and multiple trauma.

Selected patients were randomized into two groups, the first group (control) underwent surgical treatment with locking plate (T or anatomical) and the second group (intervention) underwent fixation with unilateral external fixator in addition to locking plate. All surgeries were performed by two surgeons who are members of the academic staff of Shahid Madani Medical Training Center or their senior assistants. The modified Henry approach was used for all the performed procedures and acceptable reduction and fixation criteria including the restoration of the articular surface and the tilt of the distal radius and the appropriate height of the radius according to the mentioned numbers was obtained.

Patients then were followed-up one week and again in third week, sixth week, sixth month, and ninth month after the surgery. In each post-operative visit, patient were evaluated in terms of radiological and clinical outcomes. Radiological examinations to examin th non-union and malunion (with Palmar tilt and Radial height criteria) were performed in the first, third, and sixth week visit and in the 9th month visit, which is the same as the routine protocol of the center's surgeons, and therefore, no extra cost was imposed on the patient.

non-union diagnosis was based on the radiology and examination at the sixth month, and also the criteria of malunion in the radiology at the ninth month was our measurement and analysis criteria.

Evidence of infection in the path of the pin and infection of the surgical site (infection of the incision site for plaque placement) and the occurrence of complex regional pain syndrome (CRPS) were checked in all visits after surgery.

The basic variables including age, gender and body mass index (BMI) were extracted from patient's file and entered into the statistical models and adjusted to eliminate their confounding effect. Functional assessment of patients was done using qDASH questionnaire in the ninth month visit and pain assessment was done by VAS questionnaire in the sixth month. If the patient did not have sufficient literacy, the questionnaire questions were asked orally. The questionnaire was anonymous, and the participants were told to participate in this research if they wanted to.

The data analyzer was blinded so that the analyst did not know which of the study groups the patients belonged to. Block randomization method was used for sampling. Initially blocks were prepared as (AA,BB),(BB,AA),(AB,BA),(BA,AB),(AB,AB),(BA,BA) in the Excel software as A confirmed the intervention group and B confirmed the control group. Then one of these blocks was randomly selected and based on the sequence of letters A and B in the selected block and then the eligible patients were assigned to each groups. This random process of selecting blocks and assignment continued until the desired sample size was reached.

Results

A total of 52 people including 36 (69.2%) men and 16 (30.8%) women were included in the study(Table 1 and 2; Figure 1 and 2). The mean age of the patients in the control group (plate) was equal to 42.27 ± 12.920 years and 41.15 ± 14.181 years in the intervention group (plate + external fixator). The mean BMI of patients in the control group (plate) was 24.919 ± 4.3672 and 24.750 ± 14.181 in the intervention group (plate + external fixator). 33 fractures, including 18 in the control group and 15 in the intervention group, were type C2 and 19

fractures, including 8 in the control group and 11 in the intervention group, were type C3.1 according to the AO/OTA classification. Non-union after 6 months and surgical site infection (SSI) did not occur in any of the patients. Two of the patients in the intervention group had an infection of the pin tract, and they were treated with oral antibiotics and washing the pin site and did not need the removal of the pin. Also, one of patients in the intervention group developed CRPS, who finally recovered with oral medication and physiotherapy. The difference in the frequency of SSI and CRPS was not significant between the two study groups. Radial height in the control group was 10.62 milimeter (mm) with a standard deviation (SD) of 2.858 and 9.81 mm with a standard deviation of 2.154 in the intervention group. Also, palmar/dorsal tilt in the control group was 12.08 degree with a standard deviation of 9.629 and 12.15 degree with a standard deviation of 8.633 in the intervention group. The difference in the mean of radial height and palmar/dorsal tilt was not significant between the two study groups.

The mean qDASH score in the control group (plate) was 35.750 ± 13.0673 and 38.335 ± 14.4556 in the intervention group (plate + external fixator) and this difference did not reach the significant level (p= 0.502). The level of dysfunction was graded based on the qDASH score as normal (<20), mild functional impairment (20-39), moderate functional impairment (40-60) and severe functional impairment (>60). There was also no statistically significant difference been the two study groups in terms of functional impairment level. In addition, the largest number of patients from both groups and the mean score of both groups were in the spectrum of mild functional impairment (20-39 points).

The mean VAS score in the control group (plaque) was equal to 2.08 ± 1.129 and 2.19 ± 1.234 in the intervention group (plaque + external fixator) and this difference did not reach the significant level (p= 0.726). In both intervention (plate + external fixator) and control (plate) groups, the functional score and level and pain level in type C2 fractures was significantly better than C3.1 type fractures (p< 0.05).

Table 1: comparison of basic and clinical data between two study groups

Variables		Group		P value
		Control (plate)	Intervention (plate+ExFix)	
Age (years)		42.27 ± 12.92	41.15 ± 14.18	
BMI (kg/m^2)		24.91 ± 4.36	24.75 ± 3.61	
Fracture type	C2	18 (69.2 %)	15 (57.7 %)	
	C3.1	8 (30.8 %)	11 (42.3 %)	
Non-union		0	0	-
Infection		0	2	1.000
CRPS		0	1	1.000
Radial height (mm)		10.62 ± 2.85	9.81 ± 2.15	0.255
Palmar/Dorsal tilt (°)		12.08 ± 9.62	12.15 ± 8.63	0.976
qDASH score		35.75 ± 13.06	38.33 ± 14.45	0.502
Functional impairment	Normal	3 (11.5 %)	3 (11.5 %)	
	Mild	15 (57.7 %)	13 (50 %)	
	Moderate	7 (26.9 %)	8 (30.6 %)	
	Severe	1 (2.8 %)	2 (7.7 %)	
VAS		2.08 ± 1.12	2.19 ± 1.23	0.726

Table 2: Comparison of functional and pain score based on fracture type in each study groups

Groups	variables	AO/OTA classification		P value
		C3.1 (n=8)	C2 (n=18)	
Control (plate)	q-DASH score	42.83 ± 17.15	32.60 ± 9.76	
	VAS	2.38 ± 1.40	1.94 ± 0.99	
Intervention (plate+ExFix)	q-DASH score	47.55 ± 12.59	31.57 ± 12.00	
	VAS	2.91 ± 0.83	1.67 ± 1.23	

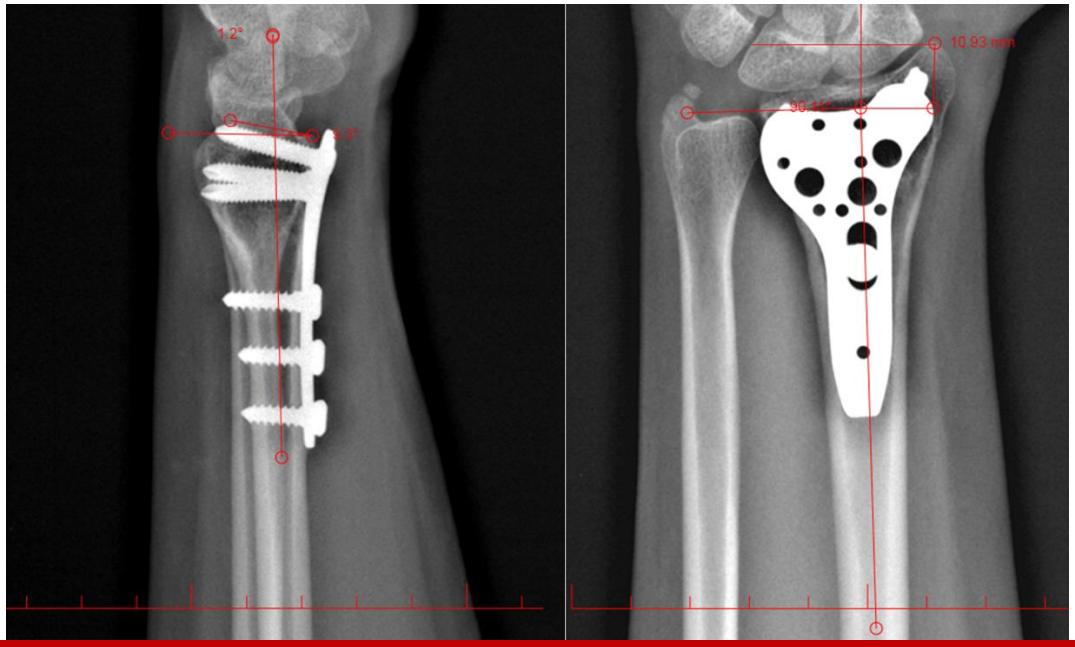

Figure 1: Radial Height (right) and Palmar Tilt (left) in the radiograph of a 31-year-old patient with a C2 type fracture, 9 months after surgery (equivalent to 10.9 mm and 9 degrees, respectively)

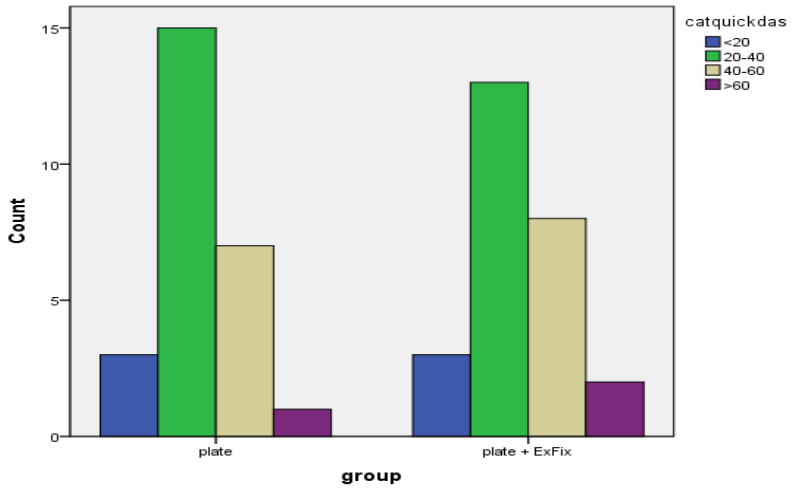

Figure 2: The level of functional impairment based on the qDASH score in each study groups

Discussion

Fracture of the distal radius is the most common fracture of the upper limb, and it incurs a huge cost to the health care system and to the people every year. Despite the many studies that have been conducted in this regard, there is still no general agreement on how to manage these fractures, and none of the available treatment choices has a high recommendation power[7].

In this study, we have dealt with specific types of distal radius fractures (type C2 and C3.1). In intra-articular fractures that are accompanied by comminuted metaphyseum, it is sometimes difficult to achieve a favorable outcome. Most authors have come to the conclusion that intra-articular fractures with displacement are better managed with open reduction and fixation with a locking plate so that both a more suitable reduction and a stronger fixation can be obtained which results in quicker start to movements after the operation and sooner return to daily activities[8,9].

Of course, it should be noted that in cases of severe comminuted fractures, we cannot naturally use a locking plate and fix the small parts with screws;

Therefore, in these cases (C3.2 and C3.3 types), alternative treatments such as external fixator or spanning plate are used[10]. In our study, these severely comminuted fractures were excluded. One of the issues that affects the clinical outcomes of intra-articular fractures with distal radius comminution is the shortness of the radius in the long term after the treatment of the surgery. "Auxiliary use of external fixator" in combination with anatomical plates (which should be used in displaced intra-articular fractures) can prevent this shortening in the future by establishing length and alignment through ligamentotaxis[3] and this issue was one of the our hypotheses in this study. On the other hand, if this hypothesis is rejected, the cost of the patient's surgery can be reduced by abandoning the use of this device.

In this randomized clinical trial, the post-operative hand function level (which was our most important variable) that was evaluated in the 9th month after surgery, did not show a significant difference between the group treated with plaque only (control) and the group treated with plaque plus external fixator (intervention). The clinical outcomes in the control group were even numerically slightly better (although not significant) and this could be because the patient's movements started earlier and patients returned to activities sooner in this group. The control group also did not have complications related to the external fixator, such as infection of pin tract and CRPS (of course, this difference was not significant) and lack of comfort due to the presence of an external device.

The results related to pain level were not significantly different between the two groups. Therefore, it can be concluded that considering the costs and comfort of the patients, the plate only surgical technique should be recommended to fix distal radius fractures.

Regarding the functional level of patients, the results of our study are in contrast with Pradhan et al.'s study in 2010. They found that the best outcomes are obtained in the combined use of external and internal fixator. It seems that this difference in the results is due to the small statistical population of his study (22 people in total)[11].

We believe that the more important and fundamental role than the clinical and radiological outcomes (including the depression of the articular surface and as a result the shortening of the radius), in addition to the restoration of the appropriate articular surface and height of the radius and tilt suitable palmar at the time of surgery, is to provide proper support in the subchondral area during surgery (using bone graft if needed) due to the comminuted nature and presence of metaphyseal impaction and restore bony defects; In fact, it is similar to what is said in proximal tibial fractures. Another basic point, which is probably more important in the treatment of these fractures, is the accurate placement of the distal screws and to try to achieve compression between the fracture parts as much as possible, because these screws, with their locking mechanism, prevent from post-operative movement to some extent. Contrary to most of the studies that evluated less variables, In our study, an attempt has been made to examine most of the common complications associated with these fractures, which affect the patient's satisfaction level, in order to provide a comprehensive view of different treatment angles.

Non-union was not observed in the patients, but due to the metaphyseal nature of the bone, the occurrence of this non-union is naturally less likely. CRPS that occurred in the intervention group could be due to excessive stretching by the external fixator which is also mentioned in the study of Kaempffe FA et al.[12]. The radiological criteria of the study, including radius height and palmar tilt, had no significant difference between the two groups. The issue that the radiological criteria of malunion are not necessarily related to the clinical outcomes of the patient is a point of controversy among studies, such as the study by Chen YR et al. that have confirmed that small changes in these criteria are associated with poorer clinical outcomes[13]. other studies, such as Synn AJ et al.'s have shown that excellent outcomes are possible even with severe deformities[14]. The radiological outcome of our study were in contrast with the results of Han et al.'s study which concluded that this therapeutic combination reduces the probability of re-displacement after surgery and shortening of the radius. Although, in some results, such as the function of the wrist, no difference was seen in the mentioned study like in our study. It seems that the discrepancy between radiological and clinical outcomes that have been presented in some studies is the justification for this issue[15].

There was also some limitation in our study. The AO/OTA classification was used, in which the initial displacement is not considered that can affect the results. Also, the patient's occupation and demand

have an effect on his satisfaction with the treatment, which was not considered in the study. One of the most common concomitants of this fracture is the triangular fibrocartilage complex injury. Since we do not have a specific indication for its repair in distal radius fracture, this injury also can affect the clinical outcomes.

Conclusion

The clinical outcomes of patients with intra-articular fractures with comminution (C2 and C3.1 types) in the group treated with plaque alone were not significantly different from the group treated with plaque plus external fixator. Therefore, due to the cheaper cost, higher comfort of the patient and the absence of complications specific to the external fixator, it seems that it is better to use only the plate and avoid imposing additional treatments without clinical justification.

Ethical approval

This study was approved by the Ethics Committee of Alborz university of medical science and conducted according to the declaration of Helsinki.

Informed consent

Informed consent was obtained from all patients. All authors gave their consentment for paper publication.

Acknowledgment

The authors would like to thank the professional team of the Clinical Research Development Unit of Shahid Madani Hospital, Karaj, who helped us in this research.

References

1 Azar FM, Canale ST, Beaty JH. Campbell's Operative Orthopaedics, E-Book: Elsevier Health Sciences; 2020.
2 Stirling E, Jeffery J, Johnson N, Dias J. Are radiographic measurements of the displacement of a distal radial fracture reliable and reproducible? The bone & joint journal. 2016;98(8):1069-1073. https://doi.org/10.1302/0301-620X.98B8.37469
3 Vidal J, Buscayret C, Fischbach C, Brahin B, Paran M, Escare P. New method of treatment of comminuted fractures of the lower end of the radius:" ligamentary taxis". Acta orthopaedica Belgica. 1977;43(6):781-789. PMID: 613725
4 Huang T-L, Huang C-K, Yu J-K, Chiu F-Y, Liu H-T, Liu C-L, et al. Operative treatment of intra-articular distal radius fractures using the small AO external fixation device. Journal of the Chinese Medical Association. 2005;68(10):474-478. https://doi.org/10.1016/S1726-4901(09)70077-2
5 Wei DH, Poolman RW, Bhandari M, Wolfe VM, Rosenwasser MP. External fixation versus internal fixation for unstable distal radius fractures: a systematic review and meta-analysis of comparative clinical trials. Journal of orthopaedic trauma. 2012;26(7):386-394. DOI: 10.1097/BOT.0b013e318225f63c
6 Han L, Jin C, Yan J, Han S, He X, Yang X. Effectiveness of external fixator combined with T-plate internal fixation for the treatment of comminuted distal radius fractures. Genet Mol Res. 2015;14(1):2912-2919.
7 Lichtman DM, Bindra RR, Boyer MI, Putnam MD, Ring D, Slutsky DJ, et al. Treatment of distal radius fractures. JAAOS-Journal of the American Academy of Orthopaedic Surgeons. 2010;18(3):180-189.
8 Rozental TD, Blazar PE, Franko OI, Chacko AT, Earp BE, Day CS. Functional outcomes for unstable distal radial fractures treated with open reduction and internal fixation or closed reduction and percutaneous fixation: a prospective randomized trial. JBJS. 2009;91(8):1837-1846. DOI: 10.2106/JBJS.H.01478
9 Rockwood CA. Rockwood and Green's fractures in adults: Lippincott; 1991;2.
10 Ginn TA, Ruch DS, Yang CC, Hanel DP. Use of a distraction plate for distal radial fractures with metaphyseal and diaphyseal comminution. JBJS. 2006;88(1):29-36. DOI: 10.2106/JBJS.E.01094
11 Pradhan R, Lakhey S, Pandey B, Manandhar R, Rijal K, Sharma S. External and internal fixation for comminuted intra-articular fractures of distal radius. Kathmandu University Medical Journal. 2009;7(4):369-373.
12 Kaempffe FA, Walker KM. External fixation for distal radius fractures: effect of distraction on outcome.Clinical Orthopaedics and Related Research(1976-2007).2000;380:220-225.
13 Chen Y, Xie R, Tang J. In vivo changes in the lengths of carpal ligaments after mild dorsal angulation of distal radius fractures. Journal of Hand Surgery (European Volume). 2015;40(5):494-501. https://doi.org/10.1177/1753193413517070
14 Synn AJ, Makhni EC, Makhni MC, Rozental TD, Day CS. Distal radius fractures in older patients: is anatomic reduction necessary? Clinical Orthopaedics and Related Research®. 2009;467(6):1612-1620. https://doi.org/10.1007/s11999-008-0660-2
15 Chung KC, Kim HM, Haase SC, Lawton J, Ozer K, Waljee JF, et al. Reflections 1 year into the 21-center national institutes of health-funded wrist study: a primer on conducting a multicenter clinical trial. Journal of Hand Surgery. 2013;38(6):1194-1201.