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Original Article

Comparison of open reduction volar locking plate fixation and closed reduction percutaneous K-wire fixation in the treatment of AO type C1 distal radius fractures

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Abstract: *Objective:* We aimed to compare both functional and radiological outcomes of AO classification type C1 distal radial fractures managed using volar locking plates and percutaneous K-wire fixation. *Materials and methods:* In total, 15 patients were included in group 1, in which open reduction and internal fixation using volar locking plates were performed, whereas 15 patients were included in group 2, in which closed reduction and percutaneous K-wire fixation were utilized. In both groups, the functional outcomes were evaluated according to the Gartland-Werley scoring system. The Knirk and Jupiter scoring system was used to classify arthritic changes. Stewart's radiological assessment criteria were used in angular assessments. Grip strength measurement was performed. *Results:* At the end of the follow-up, a significant difference was detected between the groups in volar tilt value ($P<0.05$) but not in radial inclination and radial length ($P>0.05$). Significant differences were detected in the Gartland-Werley score and the mean Knirk and Jupiter score between the two groups ($P<0.05$). No significant difference was found in the mean Stewart score between the groups ($P>0.05$). *Conclusion:* It was concluded that K-wire fixation seems insufficient in distal radius fractures of the complex intra-articular type.

Keywords: Distal radius fractures, volar locking plates, pinning, K-wires, intra-articular fractures

Introduction

Distal radius fracture is the most commonly encountered fracture of the upper extremity [1-3]. In management, the primary goal is to restore the anatomical integrity and function of the joint [4].

Simple stable fracture patterns are best treated with a period of immobilisation [1, 5]. However, there is no established treatment method for unstable fractures [1, 3, 5]. There are numerous surgical options for the management of distal radial fractures, which include the use of percutaneous K-wire fixation, external fixation and open reduction internal fixation with volar and dorsal plates, both locking and non-locking [2, 5, 6]. Two commonly used methods of fixation are open reduction with internal fixation using plates and percutaneous pin fixation [1, 2, 7].

K-wire fixation allows for simple, rapid, minimally invasive and low-cost fixation of fractures [1, 3, 5]. K-wire fixation cannot protect against radial collapse in osteoporotic bone as K-wires are not load-bearing devices [2, 5]. Internal fixation provides fixation while allowing early active movement; however, it requires maximal soft-tissue dissection [8-11]. Volar locking plates are also biomechanically superior, with an implant stiffness that will support the physiological load placed on the wrist joint [2, 8-11]. Studies have reported tendon problems despite carefully performed internal fixation [1, 5, 8-11].

In this study, we aimed to compare both the functional and radiological outcomes of AO

Table 1. Demographic characteristics and clinical outcomes

	Group 1 (n=15)	Group 2 (n=15)	*P* Value
Mean age, years, (range)	50 (34-67)	45 (18-77)	0.350
Sex			
Female	4	7	0.256
Male	11	8	
AO classification			
C1	15	15	
Side of involvement			
Right	6	8	0.464
Left	9	7	
Dominant extremity injury	12	13	0.718
Followup, months	17.5 (12-50)	18.1 (12-38)	0.418
Time from injury to surgery, days, (range)	2.87 (1-7)	2.6 (0-9)	0.781
Mean length of hospitalisation, days	5.33 (2-8)	4.4 (1-11)	0.104

Table 2. Functional outcomes of two techniques [mean (range)]

	Group 1 n=15	Group 2 n=15	*P* value
Grip strength (kg)	46 (25-60)	44 (10-55)	0.748
Flexion (°)	73 (65-80)	72 (60-80)	0.704
Extension (°)	76 (70-80)	74 (60-80)	0.462
Pronation (°)	88 (85-90)	86 (60-90)	0.830
Supination (°)	87 (75-90)	86 (50-90)	0.979
Ulnar deviation (°)	31 (25-40)	30 (15-40)	0.795
Radial deviation (°)	26 (20-30)	25 (15-30)	0.877
Gartland-Werley score	1.2 (0-3)	2.8 (0-10)	0.042

Abbreviations: kg, kilogram.

classification type C1 intra-articular distal radial fractures managed by open reduction and internal fixation using volar locking plates with closed reduction and percutaneous K-wire fixation.

Materials and methods

We retrospectively evaluated 30 patients who underwent surgical treatment due to AO type C1 distal radial fractures between 2008 and 2012. Patients were separated into two groups according to surgical technique. In total, 15 patients (11 males, 4 females; 6 right, 9 left; mean age 50 years; range 34-67 years) were included in group 1, in which open reduction and internal fixation using volar locking plates was employed, whereas 15 patients (8 males, 7 females; 8 right, 7 left; mean age 45 years; range 18-77 years) were included in group 2, in which closed reduction and percutaneous K-wire fixation was the method used.

Demographic characteristics were recorded for all patients. In both groups, functional outcomes after treatment were rated according to the Gartland-Werley clinical scoring system [12].

In radiological assessments, radial inclination, volar tilt and radial length were measured in a comparative manner with a contralateral side. The system described by Knirk and Jupiter was used to classify arthritic changes [13], whereas Stewart's radiological assessment criteria were used in angular assessments [14]. Wrist range of motion (ROM) was measured using a standard goniometer. The grip strength measurement was performed using a standard Jamar dynamometer (Sammsons Preston Inc. Bolingbrook, IL, USA, 60440-4989).

Statistical analysis

All statistical analyses were performed in SPSS version 19.0 (IBM, Chicago, IL, USA). The Kolmogorov-Smirnov test was used to assess the normality of data, whereas the Levene's test was used to assess the homogeneity of quantitative data. Among groups, an independent sample t-test was used for binary comparisons of parametric variables, whereas the Mann-Whitney U test was used for non-parametric variables. Pearson's chi-square test was used to compare categorical variables. $P<0.05$ was considered to indicate a statistically significant result.

Ethics statement

The protocol was reviewed and approved by the institutional review board of İzmir Bozyaka Training and Research Hospital, İzmir, Turkey (No. 25.04.2012/8-4). Written informed consent was obtained from all participating patients.

Table 3. Radiographic outcomes of two techniques

	Group 1 n=15	Group 2 n=15	*P* value
Radial inclination (°)	22.5 (15-31)	23.5 (14-32)	0.57
Volar tilt (°)	+7.1 (-4 to +11)	1.62 (-10 to +17)	0.038
Radial length (mm)	9.2 (3-15)	8.09 (3-13)	0.339
Mean Knirkand Jupiter score	0.2 (0-1)	0.67 (0-1)	0.011
Stewart score	0.53 (0-4)	1 (0-3)	0.092

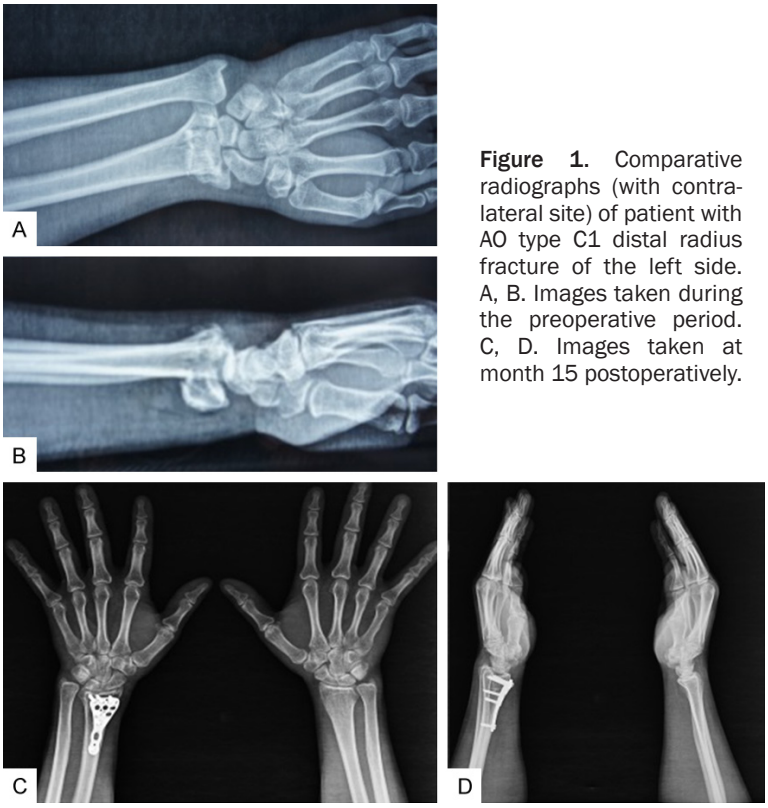

Figure 1. Comparative radiographs (with contralateral site) of patient with AO type C1 distal radius fracture of the left side. A, B. Images taken during the preoperative period. C, D. Images taken at month 15 postoperatively.

Results

The patient characteristics and clinical outcomes are presented in **Table 1**. In cases of trauma, hand trauma was dominant in 12 (80%) and 13 (86.6%) of the patients in group 1 and group 2, respectively.

The causes of injury in the study population were as follows: traffic accident in 3 patients (10%), fall from height in 5 patients (16.6%), occupational injury in 1 patient (3.3%) and simple fall in 21 patients (70%).

The mean time from injury to surgery was 2.87 days (range, 1-7) in group 1 and 2.6 days (0-9) in group 2 (P=0.781). The mean duration of follow up was 17.5 months (range, 12-50) and 18.1 months (range, 12-38) in groups 1 and 2, respectively (P=0.418).

The mean length of hospitalisation was 5.33 (range, 2-8) and 4.40 (range, 1-11) days in groups 1 and 2, respectively (P=0.104).

Table 2 presents functional outcomes in each of the participant groups. Grip strength measured at the involved and contralateral sites was 46 ± 0.04 kg and 62 ± 0.04 kg in group 1, respectively (P=0.008), and 44 ± 0.06 and 61 ± 0.06 kg in group 2, respectively (P=0.043). No significant difference was detected between the groups when the grip strength values obtained at the final control visit postoperatively were compared (P=0.748).

In group 1, the radiological values measured at the involved and contralateral sites were as follows: radial inclination 22.5 ± 1.07° and 24.5 ± 0.74° (P=0.132); volar tilt 7.15 ± 1.21° and 9.4 ± 0.64° (P=0.114); and radial length 9.2 ± 0.9 mm and 10.9 ± 0.5 mm (P=0.396), respectively. In group 2, radiological values measured at the involved and contralateral site were as follows: radial inclination 23.5 ± 1.3° and 24.4 ± 0.5° (P=0.520); volar tilt 1.62 ± 2.23° and 11.29 ± 0.29° (P=0.001); and radial length 8.09 ± 0.7 mm and 9.83 ± 0.6 mm (P=0.79), respectively. In the final control visit postoperatively, a significant difference was detected between groups in the volar tilt value (P=0.038) but not in the radial inclination (*P*=0.57) or radial length (P=0.339) (**Table 3**).

The mean ROM values at final follow-up in group 1 and 2 were 73 ± 0.95° (range, 65-80) and 72 ± 1.3° (range, 60-80) for flexion angles (P=0.704); 76.3 ± 1.4° (range, 70-80) and 74.6 ± 1.5° (range, 60-80) for extension angles (P=0.462); 87 ± 1.1° (range, 75-90) and 86 ±

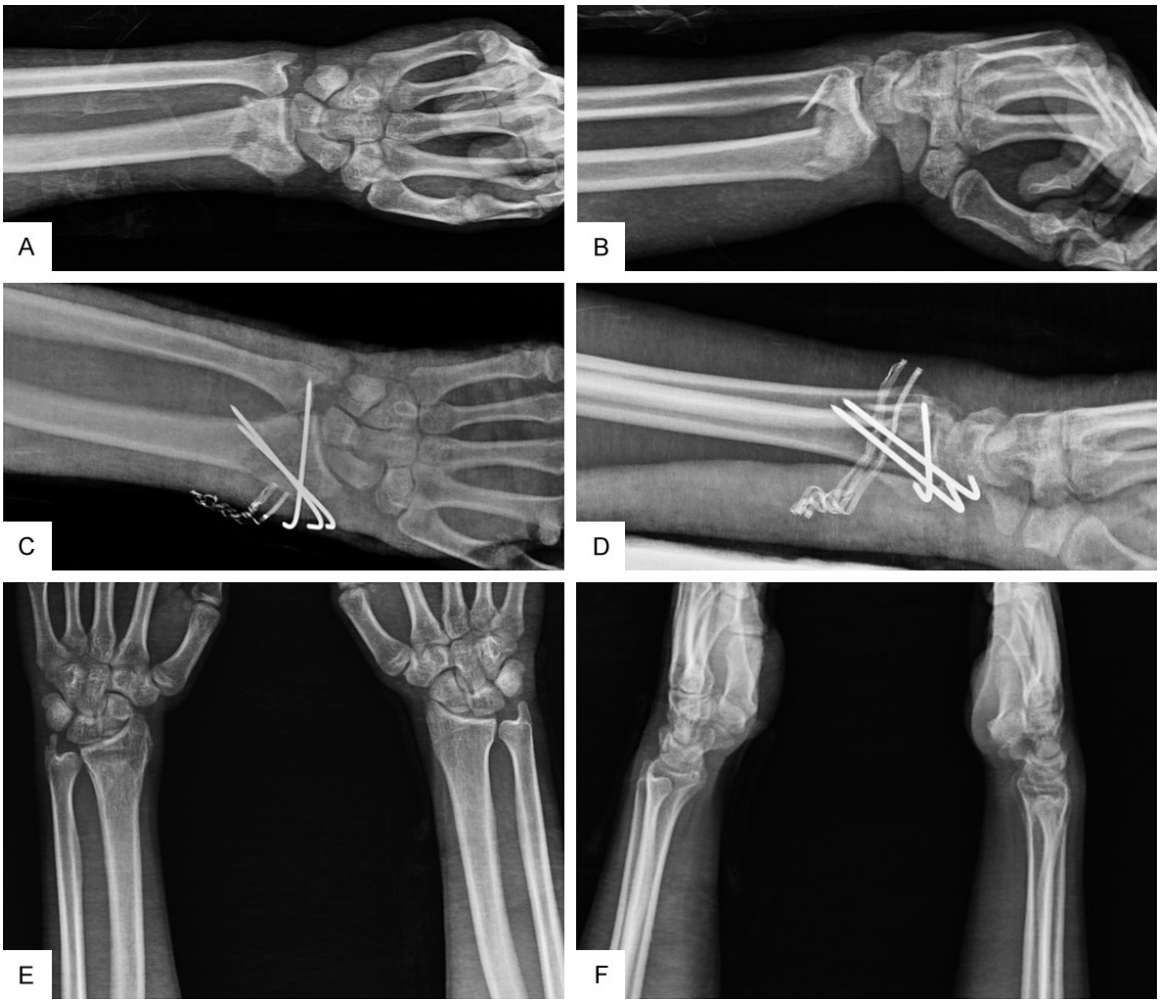

Figure 2. Comparative radiographs (with contralateral site) of patient with AO type C1 distal radius fracture of the left side. A, B. Images taken during the preoperative period. C, D. Early postoperative period. E, F. Images taken at month 14 postoperatively.

2.6 (range, 50-90) for supination angles (P=0.979); 88.6 ± 0.5° (range, 85-80) and 86.6 ± 2.0° (range, 60-90) for pronation angles (P=0.830); 31.6 ± 1.35° (range, 25-40) and 30.6 ± 1.5° (range, 15-40) for ulnar deviation angles (P=0.795); and 26.0 ± 1.1° (range, 20-30) and 25.6 ± 1.1° (range, 15-30) for radial deviation angles (P=0.877), respectively.

The Gartland-Werley score was found to be 1.2 ± 0.3 (range, 0-3) in the group that underwent volar locking plate fixation. The outcome was found to be excellent in 11 patients (73.3%) and good in 4 patients (26.7%). The Gartland-Werley score was 2.8 ± 2.1 (range, 0-10) in the group that underwent K-wire fixation. The outcome was found to be excellent in seven patients (46.6%), good in seven patients (46.6%) and moderate in one patient (6.8%). A significant difference was detected in the Gartland-Werley score between groups (P= 0.042). The mean Knirkand Jupiter score was 0.2 ± 0.1 (range, 0-1) and 0.67 ± 0.1 (range, 0-1) days in groups 1 and 2, respectively (P=0.011).

Stewart's score was 0.53 ± 0.29 (range, 0-4) in the group that underwent volar locking plate fixation. The outcome was found to be excellent in 11 patients (73.3%), good in 3 patients (20%) and moderate in 1 patient (6.8%). Stewart's score was 1.0 ± 0.2 (range, 0-3) in the group that underwent K-wire fixation. The outcome was found to be excellent in 6 patients (40%) and good in 9 patients (60%). No significant difference was found in the mean Stewart score between groups (P=0.092) (**Figures 1** and **2**).

Discussion

Numerous conservative and operative methods have been described for the treatment of distal radial fractures [1-7]. The primary goal in all methods of treatment is the restoration of the joint with maximum recovery of function [1, 4]. Although many studies have presented the results of surgical methods, limited studies have compared managed percutaneous pinning with locked plate fixation in the treatment of complex intra-articular fracture types, such asdistal radial fractures [1, 2, 7, 15]. In our study, there were significantly more volar tilt losses and arthritic changes at the end of follow-up in patients who underwent K-wire fixation. In addition, there was no significant difference in ROM between the groups; however, it was found that functional outcomes differed significantly between methods.

Distal radius fractures classified as AO type C are treated with a surgical approach because of unstable structures. Locking plates are used widely and offer successful outcomes at the distal radius [1, 5, 8-11]. The technique is effective in the provision of anatomical alignment and allows early mobilization of the joint due to its higher durability in fixation [1, 5, 8-11]. Its biomechanical advantages include the ability to insert screws in different planes and close implementation to the articular surface. Therefore, locking plates are frequently preferred in osteoporotic or comminuted fractures [6, 8-11]. A lower incidence of flexor and extensor tendon problems due to fixation that is more compatible with the surrounding tissues is an advantage of volar locking plate interventions [8-11]. Nevertheless, tendon problems and loss of alignment at the articular surface and inflammation in tissues surrounding the fixation material can develop despite meticulous procedures [5, 8-11].

Percutaneous K-wire fixation allows for low-cost fixation of unstable fractures with biological osteosynthesis as a less invasive procedure [3, 5, 16]. In addition, K-wire fixation allows for a shorter operation time, ease of hardware removal and excellent cosmetic outcomes [1, 2, 16]. However, this type of fixation is not rigid [1, 5]. K-wire fixation may not be sufficient to provide anatomical continuity in displaced, comminuted fractures [1, 2, 5]. Loss of fixation, pin-site infection and injury in the sensorial branch of the radial nerve are additional complications reported in K-wire fixation [3]. However, the total number of complications is lower in volar locking plate when compared with K-wire fixation [3]. In our study, no complications were observed in either group.

Although K-wire is a feasible and inexpensive method for simple fractures, locking plate seems to be appropriate for complicated fractures, especially when closed reduction is not possible [7]. More recently, in a study in which radiographic and functional outcomes were compared in patients with distal radius fractures who underwent volar locking plate or K-wire fixation, Brennan *et al*. reported that functional outcomes in volar locking plate werenot superior to those of K-wire, although good results were achieved by volar locking plate [17].

In a study, comparing K-wire and volar locking plate fixation in intra-articular distal radius fracture, Hull *et al*. reported that there was no difference in terms of outcome measures for all patients, rated using either the PRWE scores or DASH scores [1].

In a study with a 26-month follow-up comparing K-wire and volar locking plate in patients aged 60 years or older, it was reported that the Gartland-Werley and Castaing scores did not reveal any significant differences between the groups. However, there was a significantly earlier return to activities of daily living in the volar plate group [15].

In a randomized study comparing K-wire and volar locking plate fixation, no difference in functional outcome was reported in patient wrist evaluation in the 12 months after Kirschner wire fixation versus volar locking plate fixation. Kirschner wire fixation was less costly and faster to perform [7].

In conclusion, it could be concluded that K-wire fixation seem insufficient in distal radius fractures of the complex intra-articular type due to higher volar tilt loss and more arthritic changes during the postoperative period when compared with volar locking plate, in addition to significant differences in functional outcomes, as rated by the Gartland-Werley score between these methods.

Disclosure of conflict of interest

None.

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