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ORIGINAL ARTICLE

Retrospective comparison of external fixation versus volar locking plate in the treatment of unstable intra-articular distal radius fractures

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Abstract The aim of this study is to compare the radiological and functional outcomes of open reduction and volar locking plates versus external fixation (EF) in the treatment of unstable intra-articular distal radius fractures. In this retrospective comparative study, 69 of 80 patients who underwent an operation for AO/ASIF C1, C2 and C3 distal radius fractures were assessed. Functional evaluation was performed using the Gartland–Werley scoring system and the PRWE scale, and wrist range of motion and grip strength was also measured. For the radiological assessment, radial inclination, volar tilt, radial length, ulnar variance, and articular step-off were compared. The range of movement was better for all parameters in the volar plate group, but only wrist flexion and pronation range differed significantly between the groups ($p = 0.037$ and $p = 0.014$, respectively). With the exception of better subjective functional results in the volar plate group, the differences were not significant. With respect to radiological evaluation, all parameters were better in the volar plate group, but only radial inclination and articular step-off were significantly better ($p = 0.018$ and $p = 0.029$, respectively). In the volar plate group, two patients had carpal tunnel syndrome and one patient had regional pain syndrome. In the external fixator group, six patients had superficial pin tract infection, two patients had sensory branch injury, and four patients had regional pain syndrome. Volar locking plate fixation appeared as a dependable method for the treatment of intra-articular distal radius, with lower complication rates. On the other hand, EF remains a suitable surgical alternative for these fractures, with easy application and acceptable results.

Keywords Volar locking plate · External fixation · Distal radius fractures · Intra-articular · Wrist injuries

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Introduction

Distal radial fractures are the most common fractures of the human skeleton [1]. The optimal management of distal radius fractures has changed dramatically over the previous two decades from the almost universal use of cast immobilization to a variety of highly sophisticated operative interventions [2]. Although various methods have demonstrated good results, the choice of the best option still remains controversial [3–11]. Twenty to fifty percent of distal radius fractures are considered unstable and require additional fixation. In general, these fracture types will require a combination of longitudinal traction or multiplanar ligamentotaxis for the reduction in the metaphyseal fracture, open reduction for restoration of joint congruity, bone grafting of the defect, and some form of internal or external fixation (EF) [3]. EF has been used in the treatment of unstable distal radius fractures. This technique has proven to be successful but is also associated with complications such as the stiffness of fingers, loss of reduction, problems with the radial sensory nerve, and pin-track infections [12]. A recent trend in internal fixation has been a move toward using locking screw implants, which can rigidly stabilize cancellous and fragmented bone that is normally not amenable to screw fixation [13]. Potential advantages of this new technique include stable subchondral fixation, early postsurgical active wrist motion, and the restoration of articular and extra-articular alignment.

The purpose of this study is to compare the radiological and functional outcomes of bridging EF or a volar locking plate for treating unstable intra-articular distal radius fractures.

Materials and methods

The study group consisted of 80 patients with an unstable distal radius fracture treated either with bridging EF or a volar locking plate. Patients with open fractures and/or accompanying injuries were not included for creation of uniform treatment groups. Eleven patients were excluded from the study due to loss of follow-up evaluation and/or address changes. An unstable distal radius fracture was defined as a fracture with greater than 10° dorsal angulation, extensive dorsal comminution, ≥5 mm loss of height relative to the contralateral side, or ≥2-mm articular step-off. According to the AO/ASIF classification system, only C1, C2, and C3 fractures were included in the study. Thirty-four patients (18 men, 16 women; mean age, 48 ± 16.2 years) were treated with open reduction and internal fixation using distal volar radius plates (Hand Innovations, Miami, FL) and 2.4-mm volar locking plates (Synthes, Solothurn, Switzerland) with the modified Henry approach. These patients constituted the volar plating (VP) group. The VP group patients were operated by two different surgeons at Tepecik training and research hospital. In the VP group, the fracture types included C1 ($n = 11$), C2 ($n = 13$), and C3 ($n = 10$) fractures. Two patients had median nerve neurapraxia secondary to fracture compression. In volar plate fixation, the skin was incised longitudinally along the course of the flexor carpi radialis (FCR) tendon. The FCR tendon and flexor pollicis longus tendon were retracted ulnarly, and the pronator quadratus muscle was also elevated from its radial origin and reflected ulnarly to expose the distal radius. Each fracture fragment was identified and reduced. After applying the plate and screws, if possible, the pronator quadratus was sutured. Postoperatively, all wrists were placed in a volar plaster splint. Active finger exercises were started the day after surgery. Dressings and sutures were removed in the fifteenth postoperative day. The patients were placed in a removable splint for an additional 15 days. Rehabilitation began with active and passive exercises after suture removal.

Thirty-five patients (17 men, 18 women; mean age 52.7 ± 12.2 years) were treated with closed reduction under fluoroscopy and fixation with an external fixator by a single surgeon in Ege University hospital. The surgeon of external fixator group put the EF first place because he believes that results of EF are better than plate fixation.

In the EF group, the fracture types included C1 ($n = 10$), C2 ($n = 13$), and C3 ($n = 12$) fractures.

In the EF group, we applied continuous mild traction to maintain alignment after the initial reduction maneuver. We used 4-mm Schanz pins for the radius and 3-mm pins for the second metacarpal. Initially, two pins were set into the radius after proper drilling. While keeping the wrist ulnar deviated at 15°, we inserted the metacarpal pins and applied the fixation device. After the fluoroscopic control, we inserted additional K wires if needed. The reduction, radial height, radial inclination, and volar tilt were checked under fluoroscopic control. Overdistraction was checked with the range of motion of second metacarpophalangeal joint. Any degree under 90° points was accepted as overdistraction.

Finger motion was permitted on the first operative day, and wrist rehabilitation was begun after fixator removal in the sixth postoperative week.

The type of the treatment was determined by treating surgeons without any attempt to form two different, randomized treatment groups. The patients were evaluated at the last control visit. Wrist range of motion and grip strength were assessed to serve as functional outcomes. Flexion–extension, radial-ulnar deviation, and forearm supination-pronation were determined with a goniometer, and grip strength was measured using a Jamar dynamometer (Jamar, Preston, USA). The average of three trials for both hands was recorded for measurement of grip strength. Subjective functional assessment was performed using the patient rated wrist evaluation (PRWE) score and the Gartland–Werley scale [14].

Radiographic evaluations were performed using standard posteroanterior and lateral radiographs for measurement of volar tilt, radial inclination, radial length, ulnar variance, and articular step-off. The presence of arthritic changes was evaluated according to the Jupiter criteria on the final radiographs. All radiographs were digitized, and measurements were made with an image viewer utilizing drawing software. At each visit, the patients were evaluated for any postoperative complications including infection, neuropathy, tendon injury, loss of reduction, malunion, nonunion, chronic regional pain syndrome, and plate and screw loosening. The follow-up period was at least 1 year, and the mean follow-up period was 24.5 ± 8 months (range 12–45 months) in the VP group and 49.6 ± 20 months (range, 12–72 months) in the EF group.

All data were analyzed using SPSS for Windows 15.0 statistical software (SPSS Inc., Chicago, IL, USA). Statistical analyses were performed using Student's t test, and significance was set at $p < 0.05$ (Fig. 1).

Fig. 1 **a**, **b** Preoperative anteroposterior and lateral radiographs show an intra-articular displaced distal radius fracture. **c**, **d** Postoperative anteroposterior and lateral radiographs performed after volar plating

Results

The demographic data of the groups are displayed in Table 1. The groups had similar mean ages and fracture types. The range of movement, for all parameters, was better in the VP group compared to the other group, but this difference was only significant for wrist flexion and pronation ($p = 0.037$ and $p = 0.014$, respectively) (Table 2).

Radiographic measurements of the groups at the final follow-up are shown in Table 2. The mean palmar tilt, radial length, and radial inclination degrees were higher in the VP group than in the EF group, but this difference was only significant for radial inclination ($p = 0.018$). The mean ulnar variance was 0.7 mm (range 0–2 mm) for the VP group versus 0.7 mm (range 0–3 mm) for the EF group ($p > 0.05$). Articular step-off was 0.2 ± 0.4 in the VP group and 0.5 ± 0.6 in the EF group, which was a statistically significant difference ($p = 0.029$). Any patient did not be re-operated because of loss of reduction (Table 3).

According to the Jupiter criteria for osteoarthrosis, 2 patients in the volar plate group had stage 1 osteoarthrosis versus 5 patients in the EF group.

Table 1 Demographic data of two groups

	External fixation (n = 35)	Volar locking plate (n = 34)
Sex (M/F)	17/18	18/16
Average age (years)	52.6 ± 12	48 ± 16
Fracture classification (*AO-ASIF*)		
C1	10	11
C2	13	13
C3	12	10
Average follow-up (months)	24.5 ± 8 (12–45)	49.6 ± 20 (12–72)

Table 2 Comparison of functional and radiological outcomes between volar locked plate and external fixation

	External fixation ($n = 35$)	Volar locked plate ($n = 34$)	p value
Flexion (degree)	60.7 ± 6.8	64.7 ± 8.4	**0.037**
Extension (degree)	57.8 ± 7.6	58.8 ± 6.7	0.578
Pronation (degree)	76.4 ± 7.8	80.6 ± 5.7	**0.014**
Supination (degree)	80.1 ± 6.2	82.3 ± 6.2	0.144
Radial deviation (degree)	20.6 ± 3.1	21.3 ± 3.6	0.339
Ulnar deviation (degree)	31.8 ± 4	32.3 ± 6.9	0.717
Grip strength (kg)			
(% contralateral)	29.6 (92)	28.4 (93)	0.243
PRWE	18.2 ± 10.3	14.6 ± 6.3	0.081
Gartland–Werley	6.7 ± 4.1	6 ± 2.2	0.398
Radial inclination (degree)	20 ± 1.2	21 ± 2.1	**0.018**
Volar tilt (degree)	4.9 ± 2.7	5.8 ± 3.6	0.256
Radial length (mm)	10.2 ± 1.3	10.2 ± 1.2	0.886
Ulnar variance (mm)	0.7 ± 0.9	0.7 ± 0.8	0.924
Articular step-off (mm)	0.5 ± 0.6	0.2 ± 0.4	**0.029**

Significant p values are in bold

The mean Gartland–Werley score was 6 ± 2.2 in the VP group and 6.7 ± 4.1 in the EF group. Twenty-five (73 %) of the patients in the VP group had either an excellent or a good result according to the Gartland and Werley scoring system compared to 22 (68 %) in the EF group. Mean Gartland–Werley scores did not differ significantly between the two groups ($p > 0.05$). The mean PRWE was 14.6 ± 6.3 in the VP group and 18.2 ± 10.3 in the EF

Table 3 Complications

Type of complication	External fixation ($n = 35$)	Volar locked plate ($n = 34$)
Pin-track infection and wound infection	6	0
Carpal tunnel syndrome	0	2
Radial sensory nerve damage	2	0
Complex regional pain syndrome	4	1
Nonunion	0	0

group, which was not a statistically significant difference ($p > 0.05$).

The grip strength was 29.6 kg (92 % contralateral) in the VP group and 28.4 kg (93 % contralateral) in the EF group ($p > 0.05$).

In the EF group, six patients developed superficial pin tract infections, all of which were treated with antibiotics. Two patients had a sensory branch injury that resolved simultaneously. Four patients in EF group and one patient in VP group developed regional pain syndrome required long-term physiotherapy. In the VP group, two patients developed carpal tunnel syndrome, both of which resolved with splinting and physiotherapy.

Discussion

Different surgical strategies are available for treating unstable intra-articular distal radius fractures, including EF, open reduction, and internal fixation with locking or non-locking palmar plates. EF is versatile in managing both intra- and extra-articular fractures with acceptable functional results [3, 4, 7–9]. The reasons to use external fixators include the continuity of reduction under fluoroscopic control, improved reduction by ligamentotaxis, and the ability to protect the reduction until healing occurs. The advantages of EF are the relative ease of application, minimal surgical exposure, and reduced surgical trauma [10]. EF neutralizes the axial load imparted by the physiologic load of the forearm musculature. The restoration of the articular surfaces cannot be accomplished using ligamentotaxis, as there is an impaction between the metaphysis and cancellous bone. In these cases, open reduction with mini-incision helps in the restoration of joint surfaces [7]. The use of a percutaneous pin has also been introduced to improve the stability of EF and to the prevent loss of bone reduction. It is critical to understand that certain fracture patterns will require more invasive techniques. For example, if the lunate facet is split into palmar and dorsal fragments, traction alone may not reduce the critical volar ulnar corner. If indirect reduction in this fragment does not occur with traction, then direct reduction will be required [2].

Reported complication rates for EF in the treatment of distal radial fractures range from 6 to 60 % [7–9]. Overdistraction, superficial radial nerve injury, pin tract infections, and complex regional pain syndrome are among the potential complications of EF. Overdistraction during bridging EF has been implicated in generating poorer digital motion, poorer functional outcomes, and poorer strength and pain scores following fracture treatment [15]. A relatively long duration of traction is needed to maintain the reduction in external fixator applications. These excessive loads and durations of traction often lead to some problems, such as reflex sympathetic dystrophy [9]. These complications are very difficult to manage and usually impair functional outcomes. Four patients in our EF group developed regional pain syndrome and required long-term physiotherapy.

Prolonged fixation with K wires and Schanz screws were the reasons for skin discomfort and infection. In the EF group, 6 patients developed superficial pin tract infections, all of which were treated with antibiotics. One of the complications observed with the use of pins is iatrogenic injury to the superficial radial nerve. This risk may be reduced by making a small 5-mm incision and spreading with a hemostat down to the bone [2]. Although we used this technique, 2 patients had a sensory branch injury that resolved simultaneously.

In some intra-articular fractures, it may be impossible to maintain reduction with EF even with extreme traction. These fractures often necessitate mini-open reduction, additional K wire fixation, and occasionally bone grafting procedures [9]. We applied additional K wires in 6 patients and performed additional open reduction from a mini-incision with K wire fixation in one patient.

The advantages of open reduction and internal fixation include direct visualization and manipulation of the fracture fragments, stable rigid fixation, and the possibility of immediate postoperative motion. Fixed-angle plate designs minimize screw loosening in the distal fragments due to a "toggling effect" and thus reduce the danger of secondary displacement. The subchondral placement of smooth pegs is useful to buttress small articular fragments and successfully control shortening and angular displacement, especially in osteoporotic bone [3]. Most fractures can be managed through a single volar access despite the presence of dorsal fragments, resulting in acceptable outcomes and good implant stability. Multiple studies have demonstrated good clinical results with volar locking plates [15–27]. The potential advantages of the volar fixed-angle devices include fewer complications than with dorsal plating or EF, subchondral support through the fixed-angle tines, the initiation of early wrist motion and early return of hand and upper limb function, potentially less overall pain, and a decreased risk of displacement. Recent publications report up to 12 % flexor pollicis longus (FPL) tendon ruptures despite the low profile heights of the locking volar plates. Distal placement of the plate and the sharp edges of the screws are cited as possible reasons for rupture [2]. We identified no cases of tendon rupture in our volar plate group.

Carpal tunnel syndrome can occur following volar plate fixation. Some authors have reported that intraoperative transverse carpal ligament release reduces the rates of such complications [23]. In the VP group, 2 patients developed carpal tunnel syndrome, both of which resolved with splinting and physiotherapy.

Volar locking plate applications allow faster rehabilitation than EF. Recent prospective randomized trials have reported rapid functional recovery after volar plate application in the early period. On the other hand, at 1 year, there were no significant differences between the volar locking plate and EF groups based on objective and subjective functional assessments [17, 19, 20, 22, 26, 27].

In our study, functional evaluation revealed that wrist flexion and pronation were better in the locking plate fixation group; however, the results of the two groups were similar with regard to the Gartland–Werley score, PRWE, and grip strength, despite the fact that the ORIF population began wrist motion much sooner than the EF patients.

The prognosis and outcome of intra-articular fractures of the distal radius also depend on the presence of associated injuries such as capsular, ligamentous, and cartilaginous lesions of the wrist. Accompanying injuries, such as triangular fibrocartilaginous complex or scapholunate ligament tears, cannot be identified in the primary examination, and these pathologies may affect the functional outcome [15, 22].

The restriction of included patients to three precisely defined fracture types is an advantage of the present study. Moreover, the similar number of patients in each fracture subgroup also aided the assessment. On the other hand, retrospective assessment, non-randomized group formation, and not blinded evaluators are weak points of the present study.

Volar locking plates have gained popularity of the past decade. The major reason for this popularity seems to be surgeon's choice. In addition, patients usually demand early onset physiotherapy and shorter healing periods. In our study, the radiological and functional results of the volar plate group were better than those of the EF group. However, only flexion, pronation, radial inclination, and articular step-off showed significantly better results in the volar plate group compared to the EF group. In conclusion, a volar locking plate is a dependable method for the treatment of intra-articular distal radius fractures, producing good results and lower complication rates. Furthermore, EF has been the traditional mode of treating unstable distal radius fractures and is still used by many as the preferred technique because of its acceptable results and easy application.

Conflict of interest None.

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