ORIGINAL ARTICLE

Comparison of two surgical methods in the treatment of intra-articular distal radius fractures: Volar locking plate and K-wire augmented bridging external fixator

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ABSTRACT

BACKGROUND: In this study, we aimed to compare the radiological, clinical and functional results of volar radius locking plate, and K-wire augmented bridging external fixator (BEF) treatments that applied in intra-articular distal radius fractures.

METHODS: Between May 2016 and January 2019, 162 patients who met the inclusion criteria of 23–C2 and 23–C3 according to the AO/OTA classification who operated in our clinic were evaluated retrospectively. 78 patients (37 males, 41 females, mean age 49.92) were fixated with K wire augmented BEF and 84 patients (41 males, 43 females, mean age 46.81) were fixated with volar locking plate (VLP). Demographic (age, gender, type of trauma, and follow-up time), radiological (radial inclination, radial height, volar tilt, and fracture healing time), and clinical and functional (range of motion [ROM], grip strength, Quick Dash, Green O'Brien and Mayo scores) data of the patient groups were recorded and compared statistically.

RESULTS: There was no significant difference between the patient groups in terms of functional scoring systems. Radiologically, radial inclination, and radial length were significantly better in the volar plate group. In terms of joint ROM, flexion, extension, pronation, and supination movements were significantly better in the VLP group. Sudek atrophy incidence and loss of grip strength were higher in BEF group. Mean time of union was significantly shorter in the BEF group.

CONCLUSION: Successful results can be obtained in both treatment methods. However, VLP treatment provides better joint ROM and lower complication rates compared to BEF treatment.

Keywords: Bridging external fixator; distal radius fracture; functional result; volar locking plate.

INTRODUCTION

Distal radius fractures are common fractures among skeletal system fractures. One in six patients presenting to emergency department with bone fracture have distal radius fracture.[1,2] It is the third most common fracture in osteoporotic fractures.[3] Intra-articular distal radius fractures occur especially in young patients after high-energy traumas. About 20% of these fractures are unstable. Surgical treatment is indicated in these fractures. Anatomical restoration of the joint surface is important in improving functional results and increasing patient satisfaction.[4,5]

In treatment of distal radius fractures, surgical treatment methods such as volar and dorsal locking plating, fixation with percutaneous K-wires, and fixation with external fixator are applied.[6,7] Our aim in treatment; anatomical restoration of distal radius joint surface, radial length, radial, and palmar inclination.[8–10] Although there are various treatment methods, a gold standard treatment method has not been defined in the literature.[6,11]

In this study, we compared clinically and radiologically the volar radial locking plate (VLP) and the K-wire augmented bridging external fixator (BEF) treatments, which are the two

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most commonly, used methods in intra-articular distal radius fractures.

MATERIALS AND METHODS

Corporate ethics committee approval was received for this study. The study was conducted in accordance with the principles of the declaration of Helsinki. (Informed consent form was obtained from each patient). Between May 2016 and January 2019, patients who were treated VLP or K-wire augmented BEF due to intra-articular distal radius fractures were retrospectively evaluated.

23–C2 and 23-–C3 type fractures according to the AO/OTA classification were included in this study. Patients over 18 years of age, with a VLP or BEF, fully retrospective records, and at least 1 year of follow-up were included in the study.

Patients with bilateral fracture or multitrauma, patients with a fracture other than 23–C2 and 23–C3 fracture type according to AO/OTA classification, with additional injury in the same extremity, with an open fracture, with a distal radioulnar joint (DRUJ) pathology, neurovascular injury, with insufficient cognitive functioning, patients who were treated with plaster due to comorbidities and performed surgery due to reduction loss in follow-up, whose data were not fully available or were not followed were excluded from the study.

All patients were operated within 2 days after trauma. Patients in both groups were followed up for 2 days. Age, gender, type of trauma, and duration of follow-up were recorded in all patients.

Categorical variables (age, gender, side, and type of fracture) between groups were evaluated using the Chi-square test.

K-wire Augmented BEF

All operations were performed under regional or general anesthesia. The same type of hinged BEF was applied to all patients. Two Schanz screws were sent percutaneously under the scope from proximal of the fracture to the radius and from distal of the fracture to the second metacarpal. Then, external fixator was locked following closed reduction under scope. Reduction was checked under the scope. The fixation

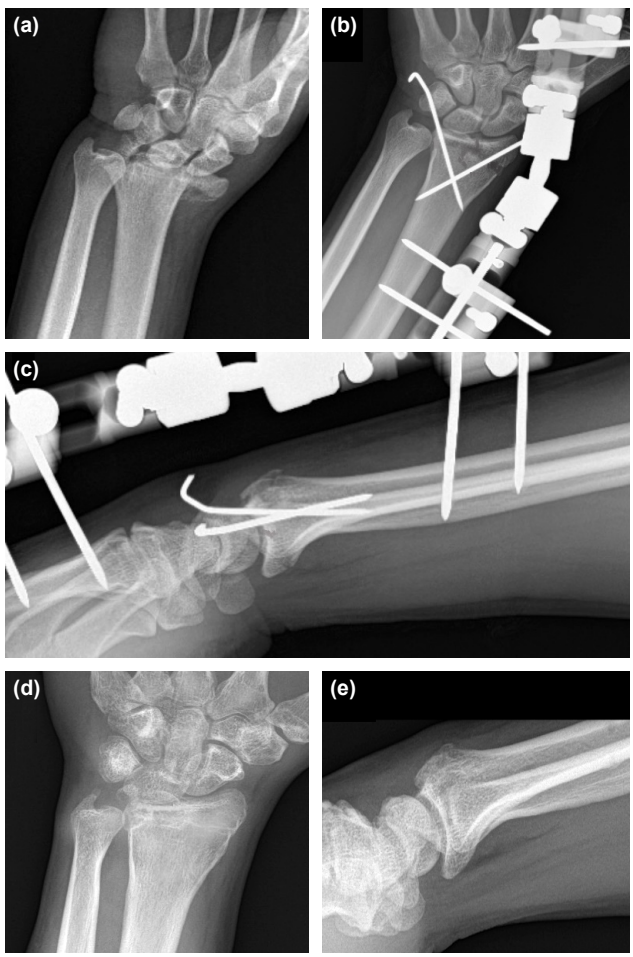

Figure 1. (a) Intra-articular displaced distal radius fracture pre-operative antero-posterior (ap) image. **(b, c)** Early post-operative ap and lateral view of K-wire augmented bridging external fixator fixation. **(d, e)** Post-operative 1st year ap and lateral view

Figure 2. (a, b) Intra-articular distal radius fracture pre-operative antero-posterior (ap) and lateral view. **(c, d)** Early post-operative ap and lateral view fixated by volar locking plate. **(e, f)** Ap and lateral view in the first operative year

was augmented with one k-wire through the radius styloid and one through the dorsal cortex adjacent to DRUJ. Additional wires were added if necessary (Fig. 1). The same procedure was applied to 12 patients (15.38%), where proper reduction was not achieved, through open reduction through a dorsal mini incision. Finger and elbow movements were started immediately after operation. The patients were called for wound control in the 2nd week. Controlled range of motion (ROM) exercises were started in all patients by loosening the hinge of the fixator in the 3rd week. In the 6th week, K-wires and external fixators were removed and the exercises were gradually increased. Radiological and clinical controls of patients were repeated week 6, week 9, week 12, month 6, and year 1.

Volar Plate

All operations were performed under regional or general anesthesia. The same type of VLP was applied to all patients. The fracture was reached with the Henry volar approach and reduction was achieved and the fracture was fixated with the locking plate-screw system (Fig. 2). Reduction was evaluated under scope. The quadratus muscle was sutured again. Bleeding was controlled and wound was closed. A short arm splint was applied. All patients were discharged within 2 days postoperatively. The patients were called for wound control in the 2nd week and after the splint was terminated in the 3rd week, controlled ROM exercises were started. Radiological and clinical controls of patients were repeated week 6, week 9, week 12, month 6, and year 1.

Clinical and functional evaluation was done in the end of the 1st post-operative year. The joint ROM was measured with a standard goniometer. Percentage of grip strength was evaluated according to the opposite limb. Force measurement was performed with the hand dynamometer (Hydraulic Hand Dynamometer Model SH 5001, Saehan corporation, Masan Korea), while the patient was sitting, the arm was placed at 90 degrees flexed, the forearm at neutral position. Three measurements were taken and the mean was recorded. In antero-posterior and lateral radiographs, union was evaluated in at least 3 of 4 cortices according to bone continuity. Radiographic results were calculated according to various radiological parameters (Radial inclination, volar tilt, and radial height) on X-ray images taken at the end of the 1st year of patient follow-up. All patients were evaluated with Gren O 'Brien, Mayo Modified wrist score and Quick Disabilities of the Arm, Shoulder and Hand (QuickDash) scores in the 1st post-operative year.

Statistical Analysis

The data obtained were entered into the packet statistics program (Jasp version 0.12.2, University of Amsterdam). First of all, descriptive statistics of all data were done. Then, extreme value analyzes and normality tests (Kolmogorov–Simirnov test) were performed. It was determined that the data were not normally distributed in the groups. Thereupon, the Mann–Whitney U-test, which is one of the non-parametric tests, was used to evaluate the differences between the groups.

RESULTS

All of the 162 patients meeting the current criteria were evaluated. 78 patients (37 males and 41 females) had BEF, 84 patients (41 males and 43 females) had VLPs treatments applied.

Table 1. Functional and radiological results

	Group 1 (BEF) (n=78)	Group 2 (VLP) (n=84)	p-value*
	Mean (Standard deviation)	Mean (Standard deviation)	
Volar tilt (degree)	12.35 (2.149)	12.52 (2.279)	0.594
Radial inclination (mm)	10.78 (3.039)	14.19 (2.959)	0.001
Radial lenght (mm)	7.85 (2.439)	10.50 (2.068)	0.001
Flexion (degree)	59.10 (12.054)	70.48 (7.55)	0.001
Extension (degree)	51.03 (6.711)	62.8 (7.814)	0.001
Pronation (degree)	60.64 (10.971)	64.40 (9.262)	0.026
Supination (degree)	58.97 (10.67)	71.73 (9.647)	0.001
Radial deviation (degree)	16.67 (5.202)	16.55 (5.32)	0.871
Ulnar deviation (degree)	19.04 (7.165)	19.11 (6.729)	0.903
Loss of grip strenght (%)	13.65 (3.837)	10.24 (3.95)	0.001
Green O'Brien score	74.42 (9.5)	77.14 (10.009)	0.12
Mayo score	73.97 (8.841)	76.55 (10.921)	0.117
Quick Dash score	5.41 (3.802)	4.94 (3.12)	0.548
Union time (week)	6.86 (0.849)	7.63 (1.297)	0.001

*Mann-Whitney U test, $p<0.05$. BEF: Bridging external fixator; VLP: Volar radial locking plate.

The mean age in the BEF group was 49.92 (19–70). In the VLP group, it was 46.81 (19–70). The mean follow-up period was 18 months in the BEF group and 16 months in the VLP group. There was no significant difference mean follow-up duration and categorical variables between the groups.

Of the patients, 58 (35.8%) simple fall, 41 (25.3%) fall from height, 27 (16.7%) occupational accident, 22 (13.6%) in-vehicle traffic accident, and 14 (8.6%) applied for non-vehicle traffic accident.

When the radiological data were examined, radial inclination was found to be significantly better in the radial length in volar plate group ($p<0.05$). There was no significant difference between groups in terms of volar tilt. In terms of joint movements, the volar plate group was significantly superior in flexion, extension, pronation, and supination movements ($p<0.05$). There was no significant difference between the groups in the radial and ulnar deviation. The fracture healing time was significantly shorter in the BEF group. There was no significant difference between the two groups in terms of Green O 'Brien, Quick Dash, and Mayo scoring systems (Table 1).

Sudek atrophy was developed in 11 patients in the BEF group. All patients fully recovered with physiotherapy. There arethree patients had superficial pin tract infection and they were treated with antibiotherapy without requiring surgical intervention. Nine of the patients experienced discomfort and adjustment problems due to external fixator. One patient had hypoesthesia on the dorsal hand. The radial nerve was evaluated in favor of dorsal sensory branch damage and there was no improvement in follow-up. In the VLP group, Sudek atrophy was observed in two patients. All patients fully recovered with physiotherapy.

DISCUSSION

K wire augmented bridging external fixation and VLP fixation are common treatment methods for the treatment of distal radius intra-articular fractures.[12–20] Variable radiological and functional results related to these two methods have been reported in the literature.[17–20] In this study, we aimed to contribute to the literature by comparing the functional and radiological results of the two surgical methods.

Looking at the data in the literature, there is no clear evidence as to which method is the most ideal treatment. BEF treatment has advantages such as being relatively easy to apply, requiring less soft-tissue dissection, and being able to correct alignment closed with the ligamentotaxis method.[21] However, there are complications such as Sudek atrophy, pin tract infection, radial nerve sensory branch paralysis, and loss of grip strength.[22] In the volar plating method, although more tissue dissection is required, anatomical reduction of the joint surface is provided with direct vision. At the same time, volar locked plate therapy provides rigid fixation, allowing early movement of the joint. However, complications such as flexor pollicis longus rupture and carpal tunnel syndrome have been reported.[23–25] When we look at the complications in our study, sudek atrophy between the two groups was significantly more common in the BEF group. We thought that the reason for this is that the bridge external fixator is a method that stabilizes in the distracted position, although a little, and does not allow early movement. However, fracture healing time was significantly shorter in the BEF group than in the VLP group. We attribute this to the fact that BEF treatment is a closed method and protects the fracture hematoma.

In their study, Navarro et al.[26] found that grip strength and radial deviation were significantly higher in the VLP group than in the BEF group. However, they did not find any significant difference in other joints' ROM. In their study, Saving et al.[27] stated that there was no difference between the two groups in terms of functional results. Duramaz et al.[28] In their study, showed that flexion, extension, pronation, supination and radial deviation ROM were significantly better in the VLP group. They found the ulnar deviation ROM significantly better in the BEF group. In our study, similar to Duramaz et al.'s findings, we found that flexion, extension, pronation, supination ROM, and grip strength were significantly better in the VLP group. We did not find any significant difference between the two groups in radial deviation and ulnar deviation ROM.

Kumbaraci et al.[29] showed in their study that radial inclination was significantly better in the VLP group and that there were no significant differences between the two groups in terms of other radiological criteria. Similarly, Li et al.[30] found that there was no difference between the two groups in terms of radiological criteria. In our study, we found radial inclination and radial length were significantly better in the VLP group. In terms of volar tilt, there was no significant difference between the two groups. Although external fixator treatment provides closed reduction and good alignment with the ligamentotaxis method, we can say that open reduction and rigid fixation under direct vision through VLP treatment is a more effective method for achieving radiological targets.

While Williksen et al.[31] did not find a significant difference between the two groups in Quick Dash scoring, they found the Mayo scoring significantly higher in the VLP group. Yu et al.[32] did not find any significant difference between the groups in the Quick Dash scores. Talmaç et al.[33] stated that Quick Dash, Mayo, and Green O'Brien scores were significantly better in the VLP group. In our study, we did not find any significant difference between the groups in Quick Dash, Green O'Brien and Mayo scoring systems. Having no difference in scoring systems both treatment methods and both methods achieving good scores show that both methods can be used safely in treatment.

Gereli et al.[34] stated that in the presence of free fragments involve the articular surface or do not respond to ligamen-

totaxis, excessive distraction cannot provide reduction and increase complications. In these cases, they stated that open reduction augmented with K-wire should be tried. In our study, we provided anatomical reduction by applying open reduction dorsally to 12 patients in similar situations.

The limitations of this study are that it is a retrospective study, the follow-up times are relatively short, and comorbidities and smoking status that would affect fracture union and functional outcomes were not determined.

Conclusion

Although VLP treatment is superior to BEF treatment in providing ROM and radiological targets, there is no difference between them in terms of functional scoring. Due to the high complications in the BEF group, VLP is a safer method for the primary treatment of intra-articular distal radius fractures.

Ethics Committee Approval: This study was approved by the Yozgat Bozok University Ethics Committee (Date: 25.12.2019, Decision No: 2017-KAEK-189).

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Conflict of Interest: None declared.

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ORİJİNAL ÇALIŞMA - *ÖZ*

Eklem içi distal radius kırıklarının tedavisinde iki cerrahi yöntemin karşılaştırılması: Volar kilitli plaklama ve K-teli ile güçlendirilmiş köprü eksternal fiksatör

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AMAÇ: Biz bu çalışmamızda eklem içi distal radius kırıklarında uygulanan volar radius kilitli plak ve K-teli ile güçlendirilmiş köprü eksternal fiksatör (BEF) tedavilerinin radyolojik, klinik ve fonksiyonel sonuçlarını karşılaştırmayı amaçladık.
GEREÇ VE YÖNTEM: Mayıs 2016 ve Ocak 2019 tarihleri arasında kliniğimizde ameliyat edilen AO/OTA sınıflamasına göre 23-C2 ve 23-C3 tipi kırığı olup dahil edilme kriterlerini sağlayan 162 hasta geriye dönük olarak değerlendirildi. Hastaların 78'ine (37 erkek, 41 kadın, ortalama yaş 49.92) K-teli ile güçlendirilmiş köprü eksternal fiksatör (BEF), 84'üne (41 erkek, 43 kadın, ortalama yaş 46.81) ise volar kilitli plak (VLP) ile tespit uygulanmıştır. Hasta gruplarının demografik (yaş, cinsiyet, travma şekli, takip süresi) radyolojik (radial inklinasyon, radial yükseklik, volar tilt, kaynama zamanı) klinik ve fonksiyonel (eklem hareket açıklıkları, kavrama kuvveti, QuickDash, GreenO'Brien ve Mayo skorlamaları) verileri kaydedilerek istatistiksel olarak karşılaştırıldı.
BULGULAR: Hasta grupları arasında fonksiyonel skorlama sistemleri açısından anlamlı farklılık bulunamadı. Radyolojik olarak radial inklinasyon ve radial uzunluk volar plak grubunda anlamlı olarak daha iyiydi. Eklem hareket açıklıkları açısından fleksiyon, ekstansiyon, pronasyon, supinasyon hareketleri VLP grubunda anlamlı olarak daha iyiydi. BEF grubunda Sudek atrofisi görülme oranı ve sıkma kuvveti kaybı daha fazlaydı. Ortalama kaynama süresi ise BEF grubunda anlamlı olarak daha kısaydı.
TARTIŞMA: Her iki tedavi yönteminde de başarılı sonuçlar alınabilir. Ancak VLP tedavisi BEF tedavisine göre daha iyi eklem hareket açıklığı sağlamaktadır ve komplikasyon oranları daha azdır.
Anahtar sözcükler: Distal radius kırığı; fonksiyonel sonuçlar; köprü eksternal fiksatör; volar kilitli plak.

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