

# Management of distal unstable radius fractures with volar locking plates: A retrospective cohort study

## Unstabil radius distal uç kırıklarının volar kilitli plak ile yönetimi: Retrospektif kohort çalışma

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### Abstract

**Aim:** Unstable distal radius fractures are difficult to manage. Volar locking plate screw is a better option than the other treatment methods (external fixator, K pin, etc.). The aim of this study is to present the radiographic and functional clinical results of patients with lower end unstable radius fractures who were treated with volar locking plate screws in our clinic.

**Methods:** A total of 52 patients (29 males, 23 females, mean age 42; the distribution 18-77) who underwent volar locking plate fixation due to an unstable distal radial end fracture were examined. Based on the AO classification, six patients (11.5%) had B2, five patients (9.6%) had B3, four patients (7.6%) had C1, 29 patients (55.7%) had C2 and 8 patients had (15.3%) C3 fractures. Twenty-one (77.8%) of the fractures had dorsal angulation, while six (22.2%) had volar angulation. The fracture was accompanied by an elbow dislocation and/or fracture in four patients (14.8%). Eleven patients (21.1%) had distal radioulnar joint problems. In fifteen patients (28.8%), autogenous crista iliac graft was used in addition to fracture fixation. The patients' range of motion and grip strength were measured. Evaluations were made according to the Stewart criteria. In the functional evaluation, the Quick-DASH-T (Disabilities of the Arm, Shoulder and Hand-Turkish) questionnaire and the Gartland-Werley evaluation form were used. The average duration of follow-up was 15 months (range: 12-34 months).

**Results:** All bones healed smoothly in approximately 7 weeks (range: 6-8 weeks). The average radiographic score was 0.5 (0-3) in the Stewart rating scale. The ulnar variance value was approximately -0.4 (between 0 and -2.5 mm) in 30 patients (57.6%). The average positive ulnar variance level was 0.5 mm (between 0-2.5 mm) in 12 patients (23%). A neutral variance level occurred in ten patients (19.2%). In 32 patients (61.5%) whose radial inclination angles were not equalized, the intact side was 28.5° (the interval 21°-30°) while the average angle for the side that underwent surgery was 22.3° (the interval 18°-27°). The radial inclination angle of fifteen patients (28.8%) gradually equaled the intact side. In other patients, the average radial inclination angle was 5.9° towards the volar direction (dorsal 2°- volar 13°) on the intact side. In twenty-five patients (48%), the loss of radial height was 1.3 mm (0-5 mm) on the side that underwent surgery. The grip strength of the side treated was approximately 69% (18 kg) of the intact side. The average Quick-DASH-T score was found as 8.3 (the distribution being 0-70.5), and the average Gartland-Werley score was found as 4.7 (the distribution 0-16). According to the Gartland-Werley evaluation, the results were excellent in 25 patients (48%), good in 25 (48%) and moderate in 3 (4%).

**Conclusion:** Volar locking plate applications are efficient in correcting and protecting the distal radius end anatomy.

**Keywords:** Open reduction, Locking plate, Unstable fracture, Distal radius fracture

### Öz

**Amaç:** Unstabil distal Radius kırığının tedavi yönetimi zordur. Volar kilitli plak uygulamaları diğer yöntemlere kıyasla (external fiksator, k teli vb.) daha iyi bir yöntemdir. Bu nedenle, bunu göstermek için, merkezimizde Volar yerleşimli kilitli plak vida tespitleri ile tedavi edilen instabil radius alt uç kırıklarının radyografik ve fonksiyonel klinik sonuçları değerlendirildi.

**Yöntemler:** Radius dital uç instabil kırığı nedeniyle volar yerleşimli kilitli plak tespiti uygulanan 52 hasta (29 erkek, 23 kadın, ort. Yaş 42; dağılım 18-77) incelendi. AO sınıflamasına göre altı hastada B2 (%11,5), beş hastada B3 (%9,6), dört hastada C1 (%7,6), yirmi dokuz hastada C2 (%55,7) ve sekiz hastada C3 (%15,3) olarak sınıflandırıldı. Kırıkların 21'inde (%77,8) dorsal, altısında (%22,2) volar açılanma vardı. Dört hastada (%14,8) kırığa dirsek çıkığı ve/veya kırık eşlik etmekteydi. On bir hastada (%21,1) distal radioulnar eklem sorunları vardı. On beş hastada (%28,8) kırık tespitine ek olarak otolog krista iliaka grefti kullanıldı. Hastaların hareket açıklıkları, kavrama kuvvetleri ölçüldü, Stewart ölçütlerine göre radyografik değerlendirmeleri yapıldı. Fonksiyonel değerlendirmede Quick-DASH-T (Disabilities of the Arm, Shoulder and Hand-Türkçe) sorgulaması ve Gartland-Werley değerlendirme formu kullanıldı. Ortalama takip süresi 15 ay (dağılım 12-34 ay) idi.

**Bulgular:** Kırıkların tümü ortalama 7 haftada (dağılım 6-8 hafta) sorunsuz kaynadı. Stewart derecelendirme skalasındaki ortalama radyografik skor 0.5 (0-3) idi. Otuz hastada (%57,6) ulnar varyans değerleri ortalama olarak -0.4 (0 ila -2,5 mm arası) oluştu. On iki hastada (%23) 0.5 mm (0-2,5mm aralığı) ortalama pozitif ulnar varyansı değeri oluştu. On hastada (%19,2) nötral varyans değeri oluştu. Radial inklünasyon açıları eşitlenmemiş olan 32 hastada (%61,5); sağlam taraf 28,5° (Aralık 21 ° -30°) iken ameliyat edilen taraf için ortalama açı 22,3° (Aralık 18°-27°) idi. On beş hastada (%28,8) radyal inklünasyon açısı sağlam tarafa eşitlendi. Diğer hastalarda, sağlam tarafta ortalama radyal inklünasyon açısı volar yönüne (dorsal 2° - volar 13°) doğru 5,9° idi. Yirmi beş hastada (%48) radial yükseklikteki kayıp ameliyat edilen tarafta 1,3 mm (0-5 mm) idi. Tedavi edilen tarafta kavrama gücü, sağlam tarafın ortalama %69'ü (18 kg) idi. Quick-DASH-T skoru ortalaması 8,3 (dağılım 0-70,5), Gartland-Werley puanı ortalaması 4,7 (dağılım 0-16) bulundu. Gartland-Werley değerlendirmesine göre, 25 hastada (%48) mükemmel, 25 (%48) hastada iyi, üç has tada (%4) ise orta sonuç alındı.

**Sonuç:** Volar yerleşimli kilitli plak uygulamaları radius distal uç anatomisinin düzeltilmesinde ve korunmasında etkilidir.

**Anahtar kelimeler:** Açık redüksiyon, Kilitli plak, Unstabil kırık, Distal radius kırığı

## Introduction

Distal radius fractures are frequently seen. The main purpose of treatment is to reestablish the anatomical integrity and functions. In unstable intra-articular fractures, it is usually not possible to reestablish the integrity of the wrist's inner joints and maintain the radial length with closed methods. In these cases, open surgical procedures are required. Various surgical methods and fixation materials can be used [1,2]. Recent studies providing a better understanding of the anatomy of the wrist and its functioning, as well as the increasing expectations of patients, have extended indications for surgical treatment. In addition, the developments in fixation materials have provided new opportunities [3,4].

Due to its intra-articular and unstable structure, distal radius fractures, classified as B and C by AO criteria, were treated surgically. Today, open surgery plate fixation is one of the common methods for these types of fractures [2,5]. Locking plates have replaced conventional support plates. The screws locking into the plate gives the advantage of more biomechanical endurance against forces applied to the fracture surfaces [6,7]. Due to their biomechanical endurance, locking plates are preferred in osteoporotic and multi-fragmented fractures [2,5,8]. On the other hand, there is not a consensus about placing these plates on the distal radius [3,6,9,10]. In recent years, volar approach has become more popular.

In this study, the radiographic and functional results of volar plate fixations on unstable distal radius fractures were evaluated.

## Materials and methods

The ethical approval for our study was obtained from Adana City Hospital ethics committee (date: 11/6/2019, number: 605). Volar locking plate fixation was performed on a total of 52 patients (29 males, 23 females) with a mean age of 42 years, with unstable distal radius fractures between 2018-2019 in our clinic. These patients were followed up for about 15 months. The fracture was on the right side in 38 patients (73%). Based on the AO classification, six patients (11.5%) had B2, five patients (9.6%) had B3, four patients (7.6%) had C1, 29 patients (55.7%) had C2 and 8 patients had (15.3%) C3 fractures. Twenty-one (77.8%) of the fractures had dorsal angulation while six (22.2%) had volar angulation. The fracture was accompanied by an elbow dislocation and/or fracture in four patients (14.8%).

As a first intervention, closed reduction and splinting were performed on the patients in the emergency room. The pre-treatment fracture angulation was approximately 29° (18°-44°). There were comorbid distal radioulnar joint problems in eleven patients (21.1%). A comorbid fracture in the contralateral extremity was present in five patients (9.6%).

Patients who had a comorbid ulnar fracture or a multi-fragmented unstable radius distal fracture as surgical treatment indications were included in our study. Age, occupation, hobbies, the patient's accompanying lesions and active or passive life were evaluated as additional factors in terms of selecting a treatment. Unstable fractures with inner joint cascading were evaluated as one of the open surgery and locking plate fixation

indications. Locking plates were preferred because of their biomechanical advantages and earlier start of movement.

The average pre-operative duration was 3 days (1-7). All surgical interventions were conducted under a tourniquet with the volar Henry approach and radioscopy control was ensured in every surgery.

Grafts were obtained from the crista iliaca autogenously in fifteen patients (28.8%) who required them. A temporary Kirschner wire fixation was performed on six patients who had compatibility problems in the distal radioulnar joint. An additional bone fixation procedure was not performed for patients with an ulnar styloid fracture, who were observed to have a stable distal radioulnar joint during the surgery. A short arm splint was made after the surgery. The splint and sutures were taken off after two weeks and active wrist exercises were started after 20 days. After radiological and clinical union was observed, exercises were started to increase the joint's range of motion and muscle strength. Open fracture treatment protocol was applied to three patients (5.7%) with a Gustilo type I open fracture. Comorbid fractures were also treated surgically.

Post-operative control graphs (anterior-posterior and lateral x-ray) were examined to evaluate the relationship between distal screws and the joint.

In control visits, if there was no pain in the fractured area, bone union was considered to have occurred. Patient follow-ups were performed on the 2<sup>nd</sup> and 6<sup>th</sup> weeks and 6<sup>th</sup> and 12<sup>th</sup> months. The radiographic controls were examined by comparing with the intact side. The radial inclination angle, radial height and ulnar variance were measured. They were evaluated according to the Stewart criteria [11]. Joint movement angles were measured using a standard goniometer. Grip strength was measured using a dynamometer (Saehan Smedley firm, South Korea) and compared with the healthy side. The functional subjective results were evaluated with the Turkish Version of Quick DASH (Disabilities of the Arm, Shoulder and Hand) and the Gartland-Werley evaluation form [12]. The average length of follow-up was 15 months (12-28 months).

### Statistical analysis

Independent samples t test was used for comparison of normally distributed data, and Wilcoxon rank sum test (Mann-Whitney U test) was used for comparing nonparametric data. The Fisher exact test was used for comparison of two proportions. The paired t test and Wilcoxon signed-rank test were used to compare paired data. Kendall  $\tau$ -b was used to measure associations of ranked variables. *P*-value <0.05 was considered significant. Mean values, percentages, and ORs were presented with 95% confidence intervals (CI). Statistical evaluations of the data were performed with SPSS computer software.

## Results

All fractures healed in approximately 7 weeks (between 6-8 weeks). The average radiographic score on the Stewart Rating Scale was found as 0.5 (0-3). The ulnar variance levels were approximately -0.4 (between 0 and -2.5 mm) in thirty patients (57.6%). Twelve patients (23%) had an average positive ulnar variance level of 0.5 mm (between 0-2.5 mm). Ten patients (19.2%) had a neutral variance level. Almost half of the patients' radial tilt angles equalized with the intact side. In 32 patients

(61.5%) whose tilt angles were not equalized, the average angle was 28.5° (the interval 21°-30°) on the intact side and 22.3° (the interval 18°-27°) on the side that underwent surgery. The radial inclination angle equalized with the intact side in fifteen patients (28.8%). In other patients, the average radial inclination angle was 5.9° towards the volar direction (dorsal 2°- volar 13°) on the intact side. In twenty-five patients (48%), the loss of radial height was 1.3 mm (0-5 mm) on the side that underwent surgery.

In their final controls, the range of motion of the patients were as follows: Average flexion angle was 55° (the interval 0°-70°), average extension angle was 40° (the interval 35°-70°), average radial deviation was 18° (the interval 10°-26°), average pronation was 86° (the interval 0°-90°) and average supination angle was 83° (the interval 0° -90°). Synostosis development and loss in forearm rotations were observed in three patients (5.7%).

During the dynamometric evaluations, the average grip strength of the healthy side was measured as 69% (18 kg, 5-30 kg on average). The average Quick DASH-T score was 9.7 (the interval 0-70.5). Twenty-five patients (48%) were excellent, 25 patients (48%) were good and 2 patients (4%) were moderate in the Gartland-Werley evaluation scale. The average Gartland-Werley score was 5.6 (the interval 0-16).

To provide radial height, fifteen (28.8%) metaphyseal gaps were filled by taking grafts from crista ilica, supporting the plate fixation. Supportive (osteoconductive) or uniting stimulant (osteoinductive) instillation was not deemed necessary for the other patients.

There was a statistically significant difference between pre- and post-operative radial inclination angles, volar tilt and radial heights ( $P=0.009$ ); however, these parameters were similar with the healthy sides, except for volar tilt angles ( $P=0.18$ ). The increase in the Stewart radiographic scores was believed to negatively affect Gartland-Werley functional scores ( $r=0.35$ ,  $P=0.006$ ) and cause an increase in the DASH-T scores ( $r=0.53$ ,  $P=0.18$ ). In addition, a significant relationship between Quick DASH-T and Gartland-Werley evaluation scores was observed ( $r=0.827$ ,  $P<0.001$ ) (Table 1).

A statistically significant difference in muscle strength between the intact side and fractured side was found. The difference in joint movements was significantly different from the intact side (Table 2).

Table 1: Clinical outcomes

	3 <sup>rd</sup> month	12 <sup>th</sup> month	P-value
DASH score	21.3	9.7	0.27
VAS score	1.8	0.9	0.18

DASH: Percentage values for limb limitation (low values indicate less limitation), VAS: Visual analogue scale (low values indicate less pain)

Table 2: Mean limitation radiocarpal joint in degrees

	Outcomes	P-value *
3 <sup>rd</sup> month		
Flexion	18.4°	0.16
Extension	29.5°	0.22
Ulnar deviation	9.2°	0.34
Radial deviation	6.3°	0.19
Pronation	18.7°	0.25
Supination	15.5°	0.17
12 <sup>th</sup> month		
Flexion	6.5°	0.25
Extension	3.9°	0.27
Ulnar deviation	2.9°	0.35
Radial deviation	2.2°	0.22
Pronation	3.3°	0.30
Supination	3.6°	0.24

Units of measurement is degrees, \* P-value for the intact side vs. the fractured side

## Discussion

Osteoporosis reduces trabecular thickness and connectivity in bone mass and microarchitecture, leading to increased vertebral fragility and fracture risk [13]. Based on the Stewart criteria, important anatomical restorations were obtained for our study in terms of post-operative evaluation for fractures. After nearly a one-year follow-up, approximately 80% recovery in the wrist's range of motion and approximately 60% recovery in grip strength was observed compared to the healthy side. The Quick DASH-T score used for measuring daily functions was 8.3. In the Gartland-Werley evaluation scale, 25 patients were excellent, 25 patients were good, and 2 patients were moderate. In addition, graft use was not deemed necessary for 71.2% of the patients.

Locking plates provide successful results especially in the treatment of intra-articular unstable fractures [1,5,8,14,10]. The effectiveness of this method in anatomical reduction allows early joint movement through its fixation strength [11,15]. Its biomechanical advantages include ability to screw close to the joint surface and in different directions. The volar approach ensures fixation by creating minimal surgical trauma in the distal radius and adapting better to the surrounding soft tissues [2,5,6,8,9,14,16,17]. In our study, successful anatomical restoration was achieved in our patients with the volar approach, regardless of the direction of the fracture angle. The patients, who were mostly young adults, went back to their daily activities with 90% recovery. The effect of restoration of distal radius joint alignment angles on functional outcomes is controversial. Despite studies showing a direct correlation between anatomical and functional outcomes, it is seen that functional outcomes are satisfactory despite deformity in elderly patients with low functional expectations.

Collapse and loss of reduction on the joint surface is the most frequently seen early stage complication of treatment with plates [3-7,16-18,21,22]. Radiographic evaluations of correction loss revealed that the radiological outcomes of surgical treatment were superior to conservative treatment, even though adequate anatomical restoration can be achieved with closed reduction.

We believe that our study will provide additional information and experience regarding the treatment of unstable distal radius fractures.

## Limitations

Patients with additional complications, pathologies, and multi-trauma were not included in our study. Patients with a bone metabolism disease except for primary osteoporosis, malignant disease, chronic cortisone use, history of wrist fracture or surgery, patients with insufficient improvement (x-ray), and patients with missing data or incomplete follow-up were excluded from the study. The patient exclusion criteria for our study was: Volar angulation not exceeding 10°, radial inclination not being lower than 15°, loss of radial height not exceeding 5 mm, intra-articular cascades not exceeding 2 mm.

## Conclusions

Locking plates are effective in the restoration and protection of the distal radius anatomy. Joint movement and daily functions are regained by using locking plates in distal radius unstable fractures within a shorter period.

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