Is fixation with K-wire sufficient in distal radioulnar joint instability accompanying the distal radius fracture?

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ABSTRACT

Introduction: Distal radius fractures are the most common fractures of the upper extremity. Recently, the tendency towards surgical treatment has increased in distal radius fractures. Distal radioulnar joint instability is thought to negatively affect the results of distal radius fracture. Our aim in this study is to compare the patients with and without distal radioulnar joint instability, who were operated with the diagnosis of distal radius fracture, clinically and radiologically.

Materials and methods: 31 patients who were operated with the diagnosis of distal radius fracture and whose fracture union was completed were included in the study. Patients with an isolated distal radius fracture (19 individuals) were called group 1, while patients with a distal radioulnar joint instability accompanying the distal radius fracture (12 individuals) were called group 2. The groups were compared functionally with DASH and MAYO scores in terms of pain and radiologically with VAS score in terms of radial length, radial slope and volar slope. Joint range of motion was also measured with a standard goniometer and compared between the groups.

Results: In the group with isolated distal radius fractures, 11 (57.9%) patients were male and 8 (42.1%) were female. The mean length of follow-up was 22.5 months. In the group with distal radius fractures and accompanying distal radioulnar joint instability, 9 (75.0%) patients were male and 3 (25.0%) were female. The mean length of follow-up in this group was 27.08 months. There was no difference between MAYO, DASH and VAS scores between the groups (p>0.05). The mean radial length was 9.95 ± 1.96 (6; 14) in group 1 and 10.67 ± 2.71 (4; 15) in group 2. The mean radial slope was 19.53 ± 2.78 (14; 26) in group 1 and 18.92 ± 3.6 (11; 26) in group 2. The mean volar slope was 8.32 ± 3.59 in group 1 and 6.92 ± 4.81 (-2; 14) in group 2. It was understood that there was no significant difference between the groups (p>0.05). While the mean supination angle was 80.53 ± 6.64 (60; 90) in group 1, it was 85.42 ± 5.42 (75; 90) in group 2, and it was found to be significantly higher in group 2 (p<0.05). The mean pronation angle was significantly lower in group 2 (p<0.05).

Conclusions: DRUJ instability after a distal radius fracture is an important factor affecting the functional outcome. Providing distal radioulnar joint stability is important in this sense. In our study, immobilization treatment in full supination and percutaneous transfixion with radioulnar K-wire for 4-6 weeks in patients with distal radioulnar joint instability is associated with good functional outcomes

Key words: Distal radius fracture, radioulnar joint, joint instability

Introduction

Distal radius fractures are the most common fractures of the upper extremity. Distal radius fractures comprise approximately one-sixth of all fractures presenting to the emergency department [1-3]. Regarding the formation of these fractures, two different main injury mechanisms are specified. High-energy traumas such as traffic accidents and sports injuries in young
people occur with low-energy traumas such as simple falls in the elderly. [4,5] Surgical or conservative treatment decisions depend on the type of fracture, bone quality, patient characteristics and the surgeon’s experience [6].

The distal radioulnar joint (DRUJ) is an anatomically and biomechanically complex structure that plays a critical role in forearm function, and DRUJ injuries require special attention due to the complex movement and function of this joint [7]. Since the sigmoid notch is shallow and the radius of curvature is 50% larger than that of the ulnar head, the skeletal structure of the distal radioulnar joint has little contribution to joint stability [8]. The surrounding soft tissue structures are indispensable for DRUJ stability. Various structures have been described, including the joint capsule, pronator quadratus, distal interosseous membrane, ulnocarpal ligaments, extensor carpi ulnaris (ECU), and triangular fibrocartilage complex (TFCC). The primary stabilizer of the distal radioulnar joint is the triangular fibrocartilage complex [9,10]. TFCC tears have been found to be the most common associated soft tissue injury in distal radius fractures. It has been reported that the incidence of TFCC injuries associated with distal radius fractures ranges from 35% to 78% [11]. In a study conducted by Bombaci et al. on patients with distal radius fractures, associated TFCC damage was observed in 45% of the patients [12].

One of the factors that negatively affect the treatment of distal radius fractures is distal radioulnar joint instability. In the literature, DRUJ instability was reported to be a bad prognostic factor for distal radius fractures. Distal radioulnar joint (DRUJ) instability due to distal radius fracture or in combination with it was recognized as a potential complication that can cause long-term pain and limited range of motion. [13,14] Another important point that complicates DRUJ instability is the difficulties in clinical and radiological diagnosis. Clinical determination of the DRUJ instability diagnosis remains a problem due to the low sensitivity, specificity and reproducibility of current clinical tests [15,16]. Despite these deficiencies, stress test and clunk test are generally accepted clinical tests to assess the DRUJ instability [17,18]. Direct radiographs, computerized tomography and magnetic resonance can be used for appropriate radiological diagnosis. While TFCC injury can be detected especially in MRI, sigmoid notch fractures can be detected on CT, and it can be evaluated for instability using methods such as the radioulnar line method [19], subluxation ratio method [20].

The aim of our study is to compare the radiological and functional outcomes of distal radius fractures accompanied by surgically treated DRUJ instability, and the treated surgically isolated distal radius fractures.

**Materials and Methods**

Ethics committee approval was obtained before starting the study. A total of 31 patients who were operated in our clinic with the diagnosis of AO type C distal radius fracture between September 2016 and January 2019 and whose fracture union was completed were included in the study. Inclusion criteria were “radial shortening more than 5 mm, volar or dorsal angulation more than 20 degrees, radial inclination angle less than 10 degrees and intra-articular stepping more than 2 mm”. Exclusion criteria were patients with previous fracture or surgery history on the same side extremity, patients with fractures in the other carpal bones of the hand or wrist or needing additional surgery, patients with wrist deformities, ulnar variance, patients with open fractures and neurovascular injuries, polytraumatized patients, pregnant women, and patients under 18 were not included in the study. 19 patients who underwent open reduction and fixation with volar locking plate due to isolated distal radius fracture were called group 1, while 12 patients who underwent percutaneous ulnarradial K-wire transfixation in full supination in addition to open reduction and fixation with volar locking plate due to distal radius fracture and distal radioulnar joint (DRUJ) instability were called group 2.
Surgical Technique

Volar Henry approach was applied to all patients under general anesthesia in supine position with the help of pneumatic tourniquet. After the fracture was reduced, it was fixed with temporary K-wires. After scopy control, definitive osteosynthesis was performed with a variable-angle LCP Plate (Acu-Loc 2 Volar Distal Plate). (Figure 2) We used the radioulnar stress test for intraoperative assessment of distal radioulnar joint instability in all patients after distal radius fixation [21]. This test is performed by fixing the distal radius with one hand thumb and forefinger while the patient’s forearm is in the neutral position, and by grasping the distal ulna with the other hand’s thumb and index finger and moving it towards the volar and dorsal direction. In the presence of a significant increase in the movement of the ulna compared to the other side, the test was considered positive. In the test-positive patients, pronation movement was restricted by applying fixation with 1.6 mm K-wire transmitted from the ulnar styloid approximately 2-3 cm proximally to the radius transversely with the forearm in full supination (Figure 1)[22,23]. In the group 1, after the postoperative application of short arm splint for 2 weeks, the splint was removed and movement was started. After 4-6 weeks, the splint was removed and percutaneous K-wire was pulled under.
polyclinic conditions and the movement was started. Patients in both groups were referred to our clinic physiotherapists after their splints were terminated, and they were included in the physical therapy program.

Clinical Assessment
Clinical examination was performed at the last controls of our patients with a follow-up period of at least 1 year and in the clinical assessment of the patients, wrist movements were recorded by measuring the flexion, extension, supination, pronation, radial and ulnar deviation angles using a standard goniometer. DASH (Disabilities of Arm, Shoulder and Hand) score and the Modified Mayo Wrist Score (MMWS) were used for functional assessment, while VAS (Visual Analogue Scale) scale was used for pain assessment.

Radiological Evaluation
Radiological assessment was performed using standard wrist posterior anterior (PA) posterior anterior and lateral radiographs obtained at the final controls of the patients. The posteroanterior (PA) view was obtained with the cassette at the level of the wrist, with the shoulder in 90 degrees of abduction, the elbow flexed at 90 degrees and a pronated forearm touching the cassette. Lateral views were obtained by changing only the position of the forearm and wrist into mid-supination. All radiographic measurements were performed by one of the authors.

Radial length, radial slope and volar slope parameters were measured and recorded by one of the authors via the PACS (Picture Archiving and Communication System) system. Radial length was defined as the length between the first line drawn from the distal end of the radial styloid perpendicular to the long axis of the radius and a second parallel line in the most ulnar direction of the lunate facet. Radial slope was defined as the angle between the line drawn perpendicular to the longitudinal axis of the radius, and the line drawn between the most distal end of the radial styloid and the most ulnar direction of the lunate facet. Volar slope was defined as the angle between the line connecting the farthest points of the dorsal and volar cortex of the distal joint surface of the radius and the vertical line drawn on the long axis of the radius.

Statistical Analysis
The normal distribution assumption was examined with the Shapiro-Wilks test. Mean±Standard deviation, median (minimum, maximum) values were used to show descriptive statistics. Categorical variables were summarized with number and percentage. Fisher’s exact chi-square test was used to examine the gender distribution in groups, while the suitable method among the independent samples t-test and Mann-Whitney U test was used to compare the numerical variables.

Statistical analyzes were carried out with IBM SPSS 21.0 (IBM Corp. Released 2012. Armonk) software. Statistical significance level was accepted as p<0.05.

Results
Group 1 patients operated due to the isolated distal radius included 11 (57.9%) male and 8 (42.1%) female individuals, while group 2 patients operated due to DRUJ instability accompanying the distal radius fracture included 9 (75.0%) male and 3 (25.0%) female individuals. There was no statistically significant difference between the groups in terms of gender (Fisher p=0.452). Similarly, the mean age in group 1 was 39.79 ± 13.91 (19; 66) and the mean age in group 2 was 32.50 ± 10.55 (18; 56). The mean length of follow-up was 22.58 ± 8.87 (13; 42) in group 1 and 27.08 ± 8.76 (15; 40) months in group 2. There was no statistically significant difference between the groups in terms of age and length of follow-up.

No complications were encountered in postoperative follow-up of group 1 patients. In 2 of the group 2 patients, superficial pin bottom infection developed in the postoperative fourth week controls, and therefore the pins of the patients were removed in the fourth week. These patients were treated with oral antibiotherapy without sequelae. None of the patients in group 2 developed chronic DRUJ instability. The mean MMWS score in group 1 patients was 88.68
± 8.47 (70; 100), and good-excellent results were obtained in 16 of 19 patients. This rate was 85.42 ± 10.76 (60; 95) in group 2 patients and good-excellent results were seen in 10 of 12 patients. There was no statistically significant difference between the groups (p=0.509). Similarly, no statistically significant difference was found between the groups in terms of DASH and VAS scores (Table 1).

In the radiological assessment, the mean radial length was 9.95 ± 1.96 (6; 14) in group 1 and 10.67 ± 2.71 (4; 15) in group 2. The mean radial slope was 19.53 ± 2.78 (14; 26) in group 1 and 18.92 ± 3.6 (11; 26) in group 2. The mean volar slope was 8.32 ± 3.59 in group 1 and 6.92 ± 4.81 (-2; 14) in group 2. It was understood that there was no statistically significant difference between the groups (Table 2).

In the wrist joint range of motion assessment of the groups, the difference was statistically insignificant in the flexion and extension values, although there was a higher angle mean in group 1. The difference in supination and pronation angles between the groups was significant. While the mean supination angle was 80.53 ± 6.64 (60; 90) in group 1, it was 85.42 ± 5.42 (75; 90) in group 2, and it was found to be significantly higher

### Table 1. Comparison of relevant variable values in groups.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Isolated Distal Radius (Group 1) (n= 19)</th>
<th>Distal Radius + DRUJ Instability (Group 2) (n= 12)</th>
<th>Test statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean±SD (min; max)</td>
<td>Mean±SD (min; max)</td>
<td>t, z, p</td>
</tr>
<tr>
<td>Age (years)</td>
<td>39.79±13.91 (39 (19; 66)</td>
<td>32.50±10.55 (31 (18; 56)</td>
<td>t= 1.552, 0.132</td>
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<tr>
<td>Length of follow-up (months)</td>
<td>22.58±8.87 (21 (13; 42)</td>
<td>27.08±8.76 (29.5 (15; 40)</td>
<td>z= 1.502, 0.141</td>
</tr>
<tr>
<td>MMWS</td>
<td>88.68±8.47 (90 (70; 100)</td>
<td>85.42±10.76 (90 (60; 95)</td>
<td>z= 0.687, 0.509</td>
</tr>
<tr>
<td>DASH</td>
<td>7.99±7.49 (5 (0; 23)</td>
<td>11.12±11.36 (5.45 (2; 39)</td>
<td>z= 0.436, 0.734</td>
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<tr>
<td>VAS</td>
<td>1.89±1.41 (2 (0; 5)</td>
<td>2.50±1.68 (2.5 (0; 6)</td>
<td>z= 1.203, 0.326</td>
</tr>
</tbody>
</table>

Mean±SD: Mean±Standard deviation / (min; max): (minimum; maximum)  
*t: independent samples t-test. z: Mann-Whitney U test.  
MMWS: Modified Mayo Wrist Score, DASH: Disabilities of Arm, Shoulder and Hand, VAS: Visual Analog Scale.

### Table 2. Comparison of relevant variable values in groups.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Isolated Distal Radius (Group 1) (n= 19)</th>
<th>Distal Radius + DRUJ Instability (Group 2) (n= 12)</th>
<th>Test statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean±SD (min; max)</td>
<td>Mean±SD (min; max)</td>
<td>t, z, p</td>
</tr>
<tr>
<td>Extension angle</td>
<td>71.84±8.20 (75 (55; 80)</td>
<td>64.58±12.87 (67.5 (40; 80)</td>
<td>z= 1.591, 0.120</td>
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<tr>
<td>Flexion angle</td>
<td>61.32±6.63 (60 (45; 70)</td>
<td>56.67±12.67 (60 (35; 70)</td>
<td>z= 0.711, 0.509</td>
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<tr>
<td>Supination angle</td>
<td>80.53±6.64 (80 (60; 90)</td>
<td>85.42±5.42 (87.5 (75; 90)</td>
<td>z= 2.087, 0.043</td>
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<tr>
<td>Pronation angle</td>
<td>82.89±6.52 (85 (70; 90)</td>
<td>67.08±16.58 (72.5 (30; 85)</td>
<td>z= 3.256, 0.001</td>
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<tr>
<td>Ulnar deviation angle</td>
<td>22.89±5.55 (25 (10; 30)</td>
<td>22.5±5.84 (20 (10; 30)</td>
<td>z= 0.212, 0.857</td>
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<tr>
<td>Radial deviation angle</td>
<td>15.2±6.45 (15 (5; 20)</td>
<td>15±6.03 (17.5 (5; 20)</td>
<td>z= 0.129, 0.921</td>
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<tr>
<td>Radial length (mm)</td>
<td>9.95±1.96 (10 (6; 14)</td>
<td>10.67±2.71 (11 (4; 15)</td>
<td>t= 0.859, 0.397</td>
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<tr>
<td>Radial slope (°)</td>
<td>19.53±2.78 (19 (14; 26)</td>
<td>18.92±3.6 (19.5 (11; 26)</td>
<td>t= 0.531, 0.600</td>
</tr>
<tr>
<td>Volar slope (°)</td>
<td>8.32±3.59 (9 (0; 14)</td>
<td>6.92±4.81 (7.5 (-2; 14)</td>
<td>z= 0.816, 0.435</td>
</tr>
</tbody>
</table>

Mean±SD: Mean±Standard deviation / (min; max): (minimum; maximum)  
*t: independent samples t-test. z: Mann-Whitney U test.

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in group 2 (z= 2.087; p=0.043). The mean pronation angle was significantly lower in group 2 (z= 3.256; p=0.001) (Table 2).

**Discussion**

Distal radius fractures make up 15-25% of all fractures. The peak age related to the distal radial fracture incidence is the 30s secondary to high-energy injuries in male individuals. In female individuals, it develops after low-energy traumas and is often seen after menopause due to osteopenia [21]. Treatment of distal radius fractures has increased in favor of surgical approach in the last two decades. The use of volar locking plates has many advantages in the surgical treatment of unstable distal radius fractures. Volar plates have expanded the indications for the surgical treatment of these fractures and greatly improved their clinical and radiological results [24,25]. The advantages of volar locking plate fixation for distal radius fractures can be early functional recovery, possibility of an optimal restoration of the wrist anatomy, direct visualization of the fracture, and preservation of the achieved reduction. In addition, volar locking plates can allow stabilization of segmental and unstable distal radius fractures. At the same time, volar locking plates can allow patients to move in earlier periods, preventing muscle weakness and joint stiffness.

There are two factors that cause DRUJ instability following distal radius fracture. The first is TFCC damage with the injury on the ulnar styloid side, and the second is the decrease in the tension in the TFCC due to the translation of the distal radius fracture fragments. Injuries to the ulnar styloid side structures accompanying distal radius fractures have been analyzed in some studies in which patients were treated with locking plates, and in most cases, reduction of the distal radius fracture has been reported to improve acute DRUJ instability [21,26]. Since it is difficult to determine the presence of TFCC damage preoperatively, intraoperative evaluation should always be done after fracture detection. Requires extra articular pinning in DRUJ reduced position for 6 weeks with elbow immobilization for stability. Supination is the most stable position in which DRUJ is reduced [26]. In our study, we performed extraarticular pinning in supination for patients with DRUJ instability on examination after intraoperative distal radius fixation and fixation with open reduction volar locking plates for AO type C distal radius fractures with surgical indications. In our study, in which male patients constituted the majority, the mean age was between 30-40 for both groups in accordance with the literature. There are many studies comparing the surgical options of the distal radius fracture other than the volar locking plate with the volar locking plate. These studies evaluated the functional outcomes of patients with various functional scores such as DASH, Quick-DASH, Mayo wrist score and determined the values in favor of patients treated with volar locking plates each time [27-31]. In their study in 2017, Johandi et al. [32] published the results of TFCC primary repair application after volar plate fixation to the distal radius fracture in 12 patients with DRUJ instability accompanying distal radius fractures. According to this, radioulnar stress test was negative in 10 of 12 patients at the end of the first year. Similarly, in our study, the mean MMWS of patients treated with volar plates was 88.68 in group 1 and 85.42 in group 2. Good-excellent results were encountered in 26 (84%) of 31 patients in both groups. In addition, none of the 12 patients with distal radius fractures and DRUJ instability had chronic DRUJ instability in the follow-up.

DRUJ instability after a distal radius fracture is considered to be an important factor affecting the functional outcome. Because DRUJ is an important structure for movement and force transmission between forearm and wrist. Therefore, if DRUJ instability continues, arthritis may occur with wrist pain, low grip strength, and joint mobility restriction. In two studies conducted, it was found that in patients with DRUJ instability detected during the clinical examination, it was associated with low functional scores 1 year and 6
years later. Therefore, it is thought that the permanent DRUJ instability is an important cause of the problems [33]. When treating distal radius fractures, not only bone reduction and fixation, but also the effect of associated soft tissue lesions on postoperative results should be taken into account [34-36]. Restoration of stability, full and painless rotational arch are the treatment goals of post-traumatic unstable distal radioulnar joint. However, despite several studies trying to address these issues, discussions continue on appropriate diagnostic criteria and treatment. Unfortunately, it is difficult to assess DRUJ instability using only plain radiography, and its ability to provide an objective assessment of DRUJ function in clinical examinations is limited [37]. However, although it contains problems related to being objective today, radioulnar stress test stands out due to its fast and easy application in diagnosis. In our study, we identified the DRUJ instability of our patients with the radioulnar stress test after fixing the distal radius fracture intraoperatively with a volar locking plate. In their study, Kim et al. [38] found that all patients with a positive radioulnar stress test had acute triangular fibrocartilage complex (TFCC) rupture in radiocarpal arthroscopy. In practical terms, we think that this diagnostic test is sufficient.

In a study conducted by Lee et al. [39] with patients who had positive intraoperative radioulnar stress test after distal radius fracture fixation, they stated that they did not find a statistically significant difference in their radiological parameters on the follow-up radiographs between the groups. In our study, there was no statistically significant difference between the wrist movements in terms of extension, flexion, radial and ulnar deviation angles. However, in the group with distal radius fracture and DRUJ instability, the supination angle was significantly higher and the pronation angle was significantly lower compared to the group with isolated distal radius. In group 2, we may have encountered this result since fixation was performed in full supination for 4-6 weeks postoperatively.

Our study had some limitations. Firstly, the number of patients in the groups was relatively low. It needs to be supported by studies with larger series. Secondly, our follow-up period was approximately 2 years on average for both groups. During this period, it is difficult for us to comment on the long-term results of patients. Thirdly, there are studies stating that the blood supply and the healing capacity of TFCC decrease along with age [40,41]. Especially in group 2, the mean age of patients is 32.5, which may be related to good functional outcomes.

As a result, our conclusion from our study is that satisfactory results are obtained for patients with DRUJ instability accompanying the distal radius fracture using transfixation immobilization with ulnoradial percutaneous K-wire for 4-6 weeks in full supination. Although the transfixation treatment with our ulnoradial K-wire for DRUJ instability is an interventional procedure, it can be considered as a strict modification of conservative treatment for patients undergoing surgery for distal radius fracture, since it aims to immobilize the wrist for a certain period of time in full supination. In addition, it should be kept in mind that the patient’s compliance with the treatment steps and the appropriate physical therapy are among the non-surgical factors that positively affect the success of the treatment.

Conflict of interest statement
The authors have no conflicts of interest to declare.

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