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Comparison between closed reduction plaster casting and percutaneous Kirschner wire pinning in the management of distal radius fractures in patients aged 65 years and older

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ABSTRACT

Aim: Closed reduction plaster casting (CRPC) and percutaneous pinning (CRPP) remain an important treatment modalities for extra-articular distal radius fractures especially in elderly patients. These two treatment methods have advantages and disadvantages compared to each other. The ideal treatment of extra-articular distal radius fractures is still debatable. We aimed to retrospectively evaluate the clinical and radiological results after CRPC and CRPP for the treatment of distal radius fractures in the patient population over 65 years of age.

Material and Method: Between 1 January 2015 and 1 January 2019, patients older than 65 years of age who presented with extra-articular noncomminuted distal radius fractures were retrospectively evaluated. 95 patients diagnosed with distal radius fracture were separated into 2 groups, who were administered the following: CRPC (n:51), CRPP (n:44). We compared the characteristics of the patients, the mechanisms of injury, fracture types and treatment methods, pre-reduction and post-reduction radiological parameters and clinical functions for the two groups. Volar tilt, radial inclination, ulnar variance, and radial length were compared. Clinical results were also compared.

Results: The mean follow-up period was 19.8 months (range, 12-29 months; SD=11.0) in the CRPC group and 18.6 months (range, 12-26 months; SD=10.9) in the CRPP group. Mean range of motion and grip strength were maintained in both treatment groups at one-year follow-up. There was no statistically significant difference between the groups ($p>0.05$). There was no statistically significant difference between the groups in terms of the scores evaluating the daily activity, pain and mental status of the patients after the treatment ($p>0.05$). There are no statistically significant differences between fixation with CRPC and CRPP in terms of clinical and radiological results ($p>0.05$).

Conclusion: Closed reduction plaster casting and closed reduction percutaneous pinning are equally effective in the treatment of extra-articular distal radius fractures in the elderly.

Keywords: Distal, radius fracture, closed fracture reduction, fracture fixation, Kirschner wires

INTRODUCTION

Fractures of the distal radius are commonly encountered in orthopaedic practice with increasing numbers of low energy fractures in the elderly (1). Due to a more active and expanding elderly population in recent years, the incidence of distal radius fractures has been gradually increasing (2). Distal radius fractures are caused by two very different injury mechanisms. Firstly, porotic fractures in elderly patients and the other is traumatic fractures in young patients. Differences in this injury mechanism and related groups may explain the reason for conflicting statements in publications. Today's information suggests that distal radius fractures in elderly patients represent an insufficiency fracture associated with all risk factors for osteoporosis (3).

Various types of fractures of the distal radius can be treated with different treatment methods. Due to the lack of scientific evidence, specific treatment methods for fracture types cannot be recommended (4). Treatment principles,

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strategies and clinical outcomes for distal radius fractures differ, especially in the elderly patient population. The critical evaluation of the initial radiological imaging is important to recognize the features and stability of the fracture. The fracture pattern, injury mechanism, soft-tissue injury, patient characteristics, and surgeon preference are generally taken into consideration when choosing the most appropriate modality (5). Treatment of distal radius fractures has undergone a very unusual development over the past two decades. In addition to traditional plaster cast treatment, bridge external fixator, dorsal support plate and volar locked plate treatment options are developed. Whichever treatment option we choose, the goal of treatment should be to reduce pain and restore function.

In his original article Abraham Colles noted that "In all its movements in a distant period, it will have the perfect freedom again and will be completely free of pain." (6). Current information confirms that patients over 65 years of age with extra-articular unstable fractures may have satisfactory functional results with the closed treatment method compared to younger patients. Older patients can tolerate more radiographic alignment defects; It was found that the results between the surgical and nonsurgical treatments in patients aged 65 and over were equal (7). Closed reduction with percutaneous pin fixation and/or external fixation have historically been the most common treatment methods for unstable injuries (8, 9).

Closed reduction plaster casting (CRPC) and closed reduction percutaneous pinning (CRPP) remain an important treatment modalities for distal radius fractures especially in elderly patients. These two treatment methods have advantages and disadvantages compared to each other. Most studies define the elderly as patients between the ages of 50 and 75 (7, 10, 11). In this study, patients aged 65 and over were defined as elderly. We aimed to retrospectively evaluate the clinical and radiological results after CRPC and CRPP for the treatment of distal radius fractures in the patient population over 65 years of age.

MATERIAL AND METHOD

Study Design

This retrospective, multicenter study was carried out with the permission of Ondokuz Mayıs University Clinical Research Ethics Committee (Date: 07.02.2019, Decision No: 2019/114). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

The study included a total of 95 patients older than 65 years of age who presented at the Department of Orthopedics and Traumatology at Ondokuz Mayıs and Amasya Universites Faculty of Medicine between 1 January 2015 and 1 January 2019. We used billing records to identify all skeletally mature patients with extra-articular distal radius fractures treated with CRPC and CRPP at two Level I trauma centers. All the details of this clinical study were explained to the patients, and all participated in the study voluntarily, providing written informed consent.

Sample and Sampling

A total of 95 patients older than 65 years of age who diagnosed with distal radius fracture were separated into 2 groups, who were administered the following: CRPC (n:51), CRPP (n:44). We compared the characteristics of the patients, the mechanisms of injury, fracture types and treatment methods, pre-reduction and post-reduction radiological parameters and clinical functions for the two groups. Volar tilt, radial inclination, ulnar variance, and radial length were compared. Clinical results were also compared.

Patients were informed about the potential risks and benefits of both CRPC and CRPP, and the decision was made by the patient. Eight patients had excessive soft tissue swelling on admission, and they were treated with CRPP. Nine patients with increased risk for surgery due to co-existing medical conditions were treated with CRPC. There were 51 patients in the CRPC group and 44 in the CRPP group.

Patients over 65 years of age who presented with unstable, dorsally displaced, no-articular stepping, extra-articular fracture of the distal radial metaphysis (AO-A3) (12) or Frykman types I and II (13) distal radius fractures were included in this study. The fractures were classified according to the AO classification system. There were no distal radioulnar joint dislocations in any of the patients.

Exclusion criteria were multiple fractures, less than 12 months of follow-up, bilateral distal radius fractures, intra-articular fractures, current use of anticoagulant medications or non-steroidal anti-inflammatory drugs (NSAIDs), presence of existing osteoarthritis or sequelae from previous trauma to the upper extremity that may limit the patient's range of motion and function prior to injury, infection, tumor, crystal arthropathies, anemia, intense joint effusion. Inclusion and exclusion criteria were summarized in **Table 1**.

The power analysis of this study was calculated based on the sample size studies of previous studies. A sample size of 90 was required for 95% power in a 95% confidence interval. All patients were selected according to pre-defined and established inclusion and exclusion criteria.

Table 1: Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Age > 60 years	Intra-articular fractures (AO/OTA classification type C),
Dorsally displaced, extra-articular fracture (AO/OTA classification type A3)	Volarly displaced fractures (Smith and AO type-B fractures)
Unstable fractures >20 of dorsal angulation of the articular surface on the lateral radiographic view	Open, bilateral and pathological fractures
Isolated injury	Fractures associated with neurovascular injury
	Bone and joint diseases that could interfere with rehabilitation
	Patients presenting more than a week after injury
	Follow-up shorter than 12 months

Clinical Evaluation

The patients were evaluated in terms of injury mechanism, loss of function, pain and wrist deformity. It is noted which hand is dominantly used. In order to better understand the demands on the upper extremities of the elderly patient, independence in performing activities of daily living was investigated. This is very important and can influence treatment decisions. Systematic examination of the hand and wrist was evaluated from distal to proximal. The vascular status of the hand, capillary filling, radial and ulnar pulses were carefully noted. In the sensory examination, two-point discrimination values, the ability to perceive light touch in the median, ulnar and radial nerve regions were noted. Since acute carpal tunnel syndrome is reported in 5.4% to 8.6% of all distal radius fractures, any presence of paresthesia or numbness in the median distribution was carefully evaluated (14). The presence of open fracture, ecchymosis, edema or angular deformities, laceration or skin tears were also carefully noted. Since the skin and subcutaneous soft tissue are thin in the elderly patient group, skin rupture can be seen very commonly. Particular care was taken not to damage these tissues during closed reduction.

Radiographic Evaluation

Anteroposterior, lateral and oblique radiographs of the hand and wrist were taken before and after the procedure in all cases. Radial inclination, radial height and volar tilt radiological parameters were evaluated. Radiographs of the forearm and elbow were also seen to detect more proximal injuries or elbow instability. After CRPC and CRPP, radiographs were taken documenting the appropriate restoration of radiological parameters. Computed tomography (CT) has been used as a diagnostic aid or to better understand fracture patterns and aid in surgical planning.

Treatment Methods and Follow-up

The latest clinical practice guideline for distal radius fractures of the American Academy of Orthopedic Surgeons (AAOS) states that operative treatment in patients over 65 years of age does not differ significantly in long-term outcomes compared to non-operative treatment (15). The important factors that we paid attention to when planning treatment for patients were fracture pattern, radiographic parameters, age, hand control, and occupation. We primarily applied closed reduction and long arm splinting to extra-articular distal radius fractures over 65 years of age who applied to our institutions. If there is no displacement in the fracture line after one week in the patients we follow up with one-week intervals, we switch to short arm cast (**Figure 1A**). We applied the CRPP procedure to patients who were not reduced or had loss of reduction in the follow-ups (**Figure 1B**).

Figure 1. A) Clinical and radiological images of the patient treated with closed reduction plaster casting. **B)** Pre- and post-treatment radiological images of the patient treated with closed reduction percutaneous pinning.

The splint and plaster cast end on the palmar side of the hand, just proximal to the metacarpal heads, and we allowed early finger range of motion to prevent stiffness and preserve mobility. Conversion of a long arm splint to a short arm cast reduces the overall volume of the splint and allows for increased range of motion and therefore less stiffness. However, it is necessary to be very careful during the transition to the short arm cast. During this procedure, the fracture line may be displaced. This risk is higher in elderly patients (16).

Closed reduction of the fracture was achieved under control radiographies. In the closed reduction group, three-point fixation was obtained in a well-molded, long-arm cast. A long arm cast with the wrist in neutral

flexion/extension and the elbow flexed to 90° in the neutral rotation was carried out initially, converted to a short arm cast in the third week, and then removed in the fifth week.

We applied the CRPP procedure to patients who were not reduced or had loss of reduction in the follow-ups. Under general anesthesia, the fracture was reduced with traction and volar angulation under fluoroscopic control. One pin was implanted from the radial styloid and the other from the tubercle of Lister in a crossing the fracture manner under fluoroscopic guidance. The pins were left protruding percutaneously and the wrist was then immobilized in a well-molded short-arm cast.

All patients had similar follow-up protocols. In the CRPC group, elbow and shoulder exercises were started with the conversion to a short arm cast in the third week. The plasters were removed after five weeks. In the CRPP group, elbow and shoulder exercises were started immediately. The wires were removed after six weeks. Clinical and radiological reviews were performed every week until the plaster was removed.

During this period, the patients were followed up on a weekly basis. Optimal rehabilitation options after treatment of distal radius fractures are controversial. It is stated that there is no difference in the results between the home exercise program and the supervised treatment after the treatment of distal radius fractures, and the preference and compliance of the patient is important (15). A standard exercise program was applied to our patients after plaster follow-up by a certified hand therapist in our clinics. Early finger range of motion has been applied in all patients as it will help prevent stiffness, which is an important complication of immobilization following distal radius fractures.

The intensity of pain was recorded on a visual analog scale from 0 to 10. The range of movement of the wrist was measured using a goniometer and expressed as a percentage of the normal contralateral side (17). Grip strength was assessed by a Jamar dynamometer (Therapeutic Equipment Corporation, Clinton, New Jersey), and the mean of three readings was expressed as a percentage of the normal contralateral side, allowing 10% less for the non-dominant side (18, 19). The ability to perform unilateral and bilateral activities of daily living (ADL) was also scored (17-20).

Standardized anteroposterior and lateral radiographs of the wrist were taken with the forearm in neutral rotation (21). The radiographic results were evaluated in terms of radial inclination, palmar tilt, radial height, and ulnar variance in the last follow-up radiograms. To minimize interobserver error, all results were assessed by one surgeon. Posttraumatic arthritis was evaluated at radiological follow-up with narrowing of the radioscapholunate joints. The dorsal angulation of the distal radius expressed as the number of degrees from the neutral position, the radial inclination and length, and ulnar variance were then measured (22-25).

Statistical Analysis

The data obtained were evaluated using SPSS v.20 software (Statistical Package for Social Sciences). A value of $p<0.05$ was considered statistically significant. In the comparison of two independent groups showing normal distribution, two Independent t-tests were performed, and One-way Analysis of Variance (One Way Anova) was used to compare more than two groups. The Kruskal Wallis H test was performed to investigate differences between more than two independent groups that did not conform to normal distribution. When there was a difference between the groups, to determine from which group or groups this difference originated, the Mann Whitney U test was used to compare the two groups. A new limit level was calculated by dividing the 0.05 value of Type-1 error limit level to the number of comparisons. A new p value was obtained using post-hoc Bonferroni correction.

RESULTS

Age, gender, the AO classification, dominant hand involvement, soft tissue swelling, and smoking habits were noted. Basic characteristics of patients with distal radius fractures are presented in **Table 2**. There was no significant difference between the treatment groups in terms of these variables. The mean follow-up period was 19.8 months (range, 12-29 months; SD=11.0) in the CRPC group and 18.6 months (range, 12-26 months; SD=10.9) in the CRPP group.

Table 2: Baseline characteristics of patients with distal radius fractures

Characteristics	CRPCF(n:51)	CRPPF(n:44)	P value
Mean age	72.98± 4.36	71.36± 4.29	.061
AO/OTA Classification type, A2 vs A3	20/31	18/26	.866
Gender, F/M	30/21	25/19	.843
Dominant hand Involvement (yes/no)	27/23	29/15	.240
Smoker (yes/no)	19/32	18/26	.715

The mean range of motions and grip strength were protected in the first-year follow-up. The results are summarized in **Table 4**. There was no statistically significant difference among the groups.

Table 3: Mean range of movement and grip strength (SD) for both groups at the final follow-up expressed as a percentage of the normal side

	CRPCF	CRPPF	P value
Flexion	82.58±30.50	81.05±26.42	.483
Extension	95.27±17.04	93.43±15.02	.912
Pronation	94.08±23.67	93.6±29.75	.498
Supination	86.95±23.36	87.06±27.61	.849
Radial deviation	87.77±27.10	89.66±26.77	.528
Ulnar deviation	83.89±24.09	88.38±21.13	.896
Grip strength	94.06±26.17	95.49±31.41	.681

Table 4: Mean (SD) scores for functional assessment for both groups at the final follow-up

	CRPCF	CRPPF	P Value
Activities of daily living			
Unilateral	6.12±1.07	6.43±1.02	.144
Bilateral	17.14±1.96	17.43±1.78	.357
Pain score	1.49±1.12	1.34±1.07	.548
SF-36			
Physical score	83.16±8.10	83.30±8.82	.857
Mental score	87.15±9.6	89.17±8.5	.876

The patients performed well in terms of daily activities, pain, and mental status after treatment (**Table 5**). There was no statistically significant difference between the groups.

There was no statistically significant difference among the groups in terms of radiological parameters. Results are summarized in **Table 5**.

Table 5: Mean radiological measurements (SD) for the two treatment groups

Measurement	CRPCF	CRPPF	P value
Palmar angulation			
Normal contralateral wrist	12.29±3.95	12.48±3.96	.860
Preoperative	-1.49±14.20	-2.1±12.33	.725
Postoperative	15.67±2.48	16.65±3.61	.832
1-Year	12.88±4.81	14.70±3.72	.091
Radial length (mm)			
Normal contralateral wrist	11.33±1.99	10.95±2.05	.369
Preoperative	2.45±3.72	3.73±3.05	.941
Postoperative	10.45±1.69	11.17±1.54	.461
1-Year	10.25±1.74	10.54±1.59	.383
Radial inclination			
Normal contralateral wrist	20.66±1.54	21.13±1.44	.141
Preoperative	3.23±3.05	2.45±3.71	.346
Postoperative	20.38±2.01	21.63±1.86	.964
1-Year	18.25±1.74	19.54±1.59	.883
Ulnar variance (mm)			
Normal contralateral wrist	2.09±1.17	2.14±1.19	.441
Preoperative	1.3±1.62	1.22±1.93	.096
Postoperative	1.96±0.87	2.09±1.04	.546
1-Year	1.85±0.95	2.01±0.54	.354

Five patients had pin-tract infections in the CRPP group and all of them were treated with oral antibiotics. Eight patients in the CRPC group had reduction loss in the first week and they were treated with CRPPF. Although these patients were successfully treated, since they did not fit any of the groups, they were excluded from the study. No nonunion or other significant complication was observed among the patients in this study.

DISCUSSION

The ideal treatment of extra-articular distal radius fractures is still debatable. CRPC and CRPP continue to be very important treatment modalities for distal extra-articular radius fractures especially in elderly patients. Both of these therapeutic modalities have benefits and drawbacks in comparison. Most studies define the elderly as patients between the ages of 50 and 75 (7, 10, 11). In this study, patients aged 65 and over were defined as elderly. There is no high-quality scientific data is available about the appropriate treatment technique for elderly patient population, despite the high occurrence of displaced distal radius fractures and the significant potential consequences of inadequate therapy (26). Our goal was to examine the clinical and radiological outcomes of CRPC and CRPP for the treatment of distal radius fractures in patients over 65. Our study showed that in the patient population aged 65 and over, percutaneous pinnig after closed reduction was not superior to plaster casting in the treatment of extra-articular distal radius fractures. Both treatment modalities are characterized by low complication rates and reasonable clinical outcomes.

Treatment often depends on the nature and severity of the fracture, the patient's age and general condition, the surgical indication, and also on the surgeon's technical skill (27). According to the distal radius fracture guidelines supported by the AAOS, fractures based on instability criteria, such as post-reduction radial shortening of> 3 mm, dorsal tilt of> 10 degrees, or intra-articular displacement or step-off of> 2 mm, should be treated surgically (28). Regrettably, these guidelines don't offer precise indications or/and suggestions for the management of elderly patients.

Anatomical reduction with closed manipulation is achieved, but there is no agreement on the most appropriate method to ensure the continuity of reduction in unstable fractures. A meta-analysis reports that conservative treatment with cast-immobilization is adequate in elderly patients (29), but another study concluded that anatomical reduction and fixation with a volar plate is the best option (30). On the other hand, crossfire study found no difference between conservative treatment and cast immobilization in the elderly (31). A recent meta-analysis found no difference between cast

immobilization and several surgical techniques (32). While volar locking plates were found to be superior in terms of DASH scores, this superiority is minimal and does not have clinical importance (33). In summary, the literature is full of conflicts on the ideal treatment of distal radius fractures.

Perfect anatomical reduction of distal radius fractures is thought to be strongly associated with perfect clinical outcomes. Loss of volar tilt is found to be associated with midcarpal instability (34). A 2.5 mm increase in ulnar variance will increase the load on the ulnocarpal joint by 18 to 42% (35). On the other hand, negative ulnar variance is associated with avascular necrosis of the lunate (36). As a result, it is useful to pay attention to anatomical reduction during the treatment process.

Despite the worse radiographic outcomes associated with CRPC, many studies have shown that differences in functional outcomes compared with those treated surgically are not clinically significant (37). Evidence of a relationship between radiological reduction criteria and functional outcomes in elderly people is still equivocal (38). According to a recent study, the most important risk factor for radial collapse following open reduction and internal fixation with a volar plate is post-operative ulnar positive deformity. However, there were no statistically significant differences in range of motion, grip strength, or pain in elderly patients (39). The reduced functional demand in the upper limbs assumed to be connected to aging may be the cause of the lack of correlation between radiographic and functional results. Certain patient-related factors have been demonstrated to be significantly associated with functional results, in contrast to anatomical or radiological data. These variables include the amount of physical activity, anxiety brought on by pain, pain catastrophizing, and the intensity of acute pain (40). Considering these criteria in this study constitutes one of the strengths of the study.

Although several studies on the use of percutaneous K-wires for the stabilization of distal radial fractures have been published (41-44), their use in an elderly population remains uncertain. These studies include different fracture patterns and various treatment modalities, and controlled trials are lacking. Stoffelen and Broos (45) conducted a prospective, randomized trial comparing closed reduction with intrafocal pinning for extra-articular fractures. They found no significant difference in the outcome between the two groups. However, their series included young patients with both stable and unstable fractures and excluded those older than 80 years of age. In a recent meta-analysis, the patient population aged 60 and over showed no clinical or statistical difference between plaster immobilization and K-wire immobilization at 1-year follow-up (37). This conclusion is in line with our research.

In our study, we found that both plaster casting and percutaneous pinning are suitable options for the treatment of distal radius in the elderly with relatively low complication rates. There is no significant difference between CRPC and CRPP in terms of clinical and radiological results. Given the increased life expectancy and low functional demands in the elderly population, maintaining a good quality of life with CRPC and CRPP treatments may be as important as achieving optimal recovery of hand function with other surgical treatments. In addition, the decision to expose patients to even a single surgery in this age group must be made carefully. In this study, it was concluded that CRPC and CRPP treatments may still be a good option for patients older than 65 years of age.

This study has its own limitations. First of all, the retrospective nature of this study may lead to selection bias. It also made randomization impossible, but there were no significant differences between our groups in terms of age, gender, type of fracture, smoking habit, and dominant hand involvement. Our second limitation was the limited population size. A prospective randomized study performed on a wider group may result in a more accurate and valuable conclusion.

CONCLUSION

Percutaneous pinning after closed reduction was not found to be superior to plaster casting in the treatment of extra-articular distal radius fractures in the aged 65 and older patient population. Both treatment modalities are characterized by low complication rates and reasonable clinical results. Further prospective randomized studies will enhance our knowledge of distal radius fractures.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Ondokuz Mayıs University Clinical Research Ethics Committee (Date: 07.02.2019, Decision No: 2019/114).

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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