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Evaluating surgical treatment options for distal radius fractures with lunate fossa involvement: A clinical and radiographic study

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Abstract

Background: Distal radius fractures (DRFs) are a common injury in orthopedic treatment, usually addressed with immobilization using a cast or brace. However, this approach can result in unsatisfactory outcomes. As a result, surgical treatment options such as plating, external fixation, and pinning have become increasingly popular, but the effectiveness of these methods requires evaluation. This study aimed to compare the clinical and radiographic outcomes of three specific surgical treatments-plating, external fixation, and pinning-among patients with DRFs.

Methods: In this prospective study, 50 patients meeting the inclusion and exclusion criteria underwent clinical and radiographic evaluations, including assessments of wrist range of motion, grip strength, fine motor skills, pain, and neurovascular examination. Data were collected at three time points: immediately post-surgery, 4-6 weeks post-surgery, and six months post-surgery. Medical records of hospitalized and operated patients were gathered.

Results: The study evaluated the clinical and radiographic outcomes of treating DRFs involving the volar lunate facet with pins, plates, and external fixators using the Fernandez and Dai Punch classification. The study included 50 patients, with a mean age of 45.24 ± 1.78 years and complete follow-up. The results showed no significant correlation between surgical technique and gender. The patients were categorized into two age groups, with the younger group predominantly male. The study investigated medical history and fracture classification. Clinical interventions involved various surgical techniques, and the Fernandez and Dai Punch classifications were used to classify fractures. The study also evaluated the selection of treatment devices for DRFs and assessed the range of wrist motion.

Conclusion: This study found no significant difference in clinical outcomes based on the type of surgical treatment method used for patients with radius fractures. Complications associated with treatment methods were reported but were relatively rare. Clinical and radiographic outcomes showed no significant differences based on gender or age. The study provides valuable information for clinicians and patients to aid in making informed treatment decisions.

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Highlights

What is current knowledge?

There is no consensus on a single best method for treating intra-articular distal radius fractures.

What is new here?

- The study aimed to assess the clinical and radiographic outcomes of three surgical methods-plating, external fixation, and pinning-for treating distal radius fractures in 50 patients.
- There were no significant differences in clinical outcomes among the different surgical techniques (Pins, plates, and external fixators).
- Complications were rare and included issues such as arthritis, infection, and joint stiffness; however, these did not significantly differ between treatment methods.
- Most patients maintained normal wrist motion and grip strength across all surgical methods.

Introduction

Distal radius fractures (DRFs) are one of the most common fractures seen in orthopedic practice, accounting for approximately one-sixth of all fractures (1,2). The management of DRFs has evolved over the years, and numerous treatment options have been proposed. The traditional treatment approach for DRFs involves immobilization with a cast or brace (3-5). However, this approach has been associated with unsatisfactory outcomes, including malunion, loss of reduction, and reduced range of motion (ROM) of the wrist joint. As a result, surgical treatment options, including open reduction and internal fixation (ORIF) with plates and screws or external fixation, have become increasingly popular.

Plating is a commonly used technique for the treatment of DRFs. A study by Lujan et al. (2013) found that plating resulted in better radiographic outcomes and a lower risk of complications compared to other treatment methods (6). However, other studies have suggested that plating may lead to a higher risk of tendon rupture and stiffness (7,8). Other methods have also been implemented for patients suffering from DRFs. Accordingly, external fixators have also been used to treat DRFs. Despite pin site infections (9), it was found that external fixation resulted in good functional outcomes and a low complication rate, particularly in older patients (7,8). Pins are another treatment option for DRFs and their use results in similar functional outcomes to other treatment methods but with a risk of malunion and nonunion. Pins may also cause discomfort and require removal. As a result, they have no major therapeutic benefits over one another (10).

Given the range of treatment options available for DRFs, it is important to evaluate the outcomes of each method to determine the most appropriate approach for individual patients. This study aimed to compare the clinical and radiographic outcomes of three specific surgical treatments-plating, external fixation, and pinning-among patients with DRFs. This will provide valuable information for clinicians and patients in making treatment decisions for this common injury.

Methods

Study population

In this perspective, a total of 143 patients with DRFs involving the volar plate, treated with standard methods, including pinning, external fixation, volar plate fixation, or a combination of these methods, were referred to 5th Azar Hospital, Gorgan, Iran, over three years from September 2019 to September 2022. Of this population, 50 patients were selected based on inclusion and exclusion criteria for clinical and radiographic evaluation by a certified radiologist (Including clinical examination of wrist range of motion, grip strength, fine motor skills, pain, and neurovascular examination, as well as radiographic assessment immediately post-surgery, 4-6 weeks post-surgery, and six months post-surgery). The chosen follow-up appointments after surgery, occurring right after, at 4-6 weeks, and six months post-surgery, align with typical clinical procedures to evaluate early recovery, complications, and long-term functional results. These scheduled check-up times offer a well-rounded method to track the recovery progress and possible delayed issues, guaranteeing a thorough assessment of patients (11).

Inclusion and exclusion criteria and data collection

The inclusion criteria for the study were patients aged 18 and over with a distal intra-articular radius fracture treated with closed reduction and pinning or volar plating and having appropriate follow-up after bony union within two weeks of the injury. The exclusion criteria were cognitive impairment, a history of

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neuromuscular disease, old wrist or DRFs, pathologic fractures, open fractures, neurological injuries, insufficient documentation in the patient file, lack of patient consent to participate in the study, and inability to complete the questionnaire. Accordingly, we have employed the disabilities of the arm, shoulder, and hand (DASH) questionnaire, a common standardized instrument in orthopedic studies. Previous research has confirmed the reliability and validity of the DASH questionnaire, and its scoring system (Range of 0 to 100) corresponds to the extent of disability, where higher scores signify more severe disability (12).

The post-operative evaluation criteria included assessment of dorsal tilt, comminution, step-off, inclination, radial height, and range of motion (Flexion, extension, pronation, and supination) of the wrist joint, as well as examination of complications such as arthritis, loss of reduction, infection, nonunion, tenosynovitis, and joint stiffness.

Medical records of patients hospitalized and operated on for three years were gathered using the DASH score questionnaire, clinical examination, and radiography. Informed consent was obtained from each patient at the time of their referral to the hospital. Therefore, there are no ethical issues related to this study. Furthermore, the study was approved by the Ethics Committee at the Golestan University of Medical Science, Gorgan, Iran, with the code of IR.GOUMS.REC.1401.311.

Sample size calculation

The sample size for this study was calculated using the independent t-test in GPower software, with a type I error rate of 5% ($\alpha = 0.05$) and a power of 80% ($1-\beta = 0.80$) based on an estimated effect size of 1.99 derived from prior studies. This analysis indicated that a sample size of 11 participants per group would be required to detect a statistically significant difference between the groups, resulting in 22 participants. The parameters used in the GPower calculation included a two-tailed test, a critical t-value of 2.086, and 20 degrees of freedom. The high power achieved (0.993) ensures a low probability of Type II error, confirming the adequacy of the sample size for this study. The methodology aligns with best practices in statistical power analysis, as detailed by (13).

Statistical analysis

After inputting the data into SPSS version 22, descriptive statistics such as frequency, percentage, minimum, maximum, mean, median, and standard deviation were calculated. The independent T-test, analysis of variance (ANOVA), and covariance analysis (ANCOVA) were also employed to examine parametric variables between groups. This study's significance level was 0.05 with a 95% confidence interval (CI).

Results

Patient demographics and interventions

The clinical and radiographic outcomes of pins, plates, and external fixators for treating DRFs, involving the volar lunate facet, were evaluated using the Fernandez and Dai Punch classification. Fifty patients (29 [58%] and 21 [42%]) with complete follow-up and a mean age of 45.24 ± 1.78 years were included. No significant correlation was observed between gender and surgical technique. The patients were divided into two age groups: <55 years (72%) and ≥55 years (28%). Younger patients were mostly male (26/36), while older patients were mostly female (11/14). Most fractures were observed in the left wrist (64%). Falls from the same level were the most common cause of fracture (20/50) (Table 1). Pins were used in 24 patients, plates in 16 patients, and external fixators in ten patients. Pins were mostly used in patients <55 years old (70.8%), while plates were mostly used in patients ≥55 years old (81.3%). No significant relationship was found between age, gender, and intervention method (Table 2).

Table 1. Causes of distal radius fractures

Cause	N (%)
Falls from the same level	20 (40%)
Falls from heights	16 (32%)
Car accidents	6 (12%)
Motorcycle accidents	4 (8%)
Car and motorcycle accidents involving pedestrians	2 (4%)
Car and motorcycle accidents	2 (4%)

Table 2. Treatment interventions by age and gender

Age / Gender	Pins (N=24)	Plates (N=16)	External fixators (N=10)	p-value
< 55 years / Male	10 (41.7%)	4 (25.0%)	3 (30.0%)	0.382
< 55 years / Female	7 (29.2%)	0 (0.0%)	0 (0.0%)	0.027
≥ 55 years / Male	3 (12.5%)	7 (43.8%)	2 (20.0%)	0.049
≥ 55 years / Female	4 (16.7%)	5 (31.2%)	5 (50.0%)	0.113

Medical history and fracture classification

The medical history of 50 patients with DRFs, involving the volar lunate facet, was investigated. A total of 36 patients (72%) had no history of disease, while hypertension and diabetes were observed in 8 (16%) and 6 (12%) patients, respectively. Thyroid dysfunction was noted in 2 patients (4%), while chronic heart disease and Alzheimer's disease were each observed in 1 patient (2%). Additionally, 10 out of 50 patients (20%) had a history of previous fractures. The study participants underwent clinical interventions that involved the use of various surgical techniques such as 2 or 3 pins, a volar plate alone or in combination with pins or dorsal plate, and an external fixator with pins. The Fernandez classification was used to classify fractures into transverse, oblique, and comminuted subtypes, with 3 patients (6%) having transverse fractures, 26 patients (52%) having oblique fractures, and 21 patients (42%) having comminuted fractures. Based on the Dai Punch classification, a new system for the classification of DRFs, patients were classified into four groups: depression vertical, volar, dorsal, and double Dai Punch.

The selection of treatment devices for DRFs was investigated in this study, using both the Fernandez and Die Punch classifications. The results showed that as the fracture moved towards a combined type in the Fernandez classification, the selection of treatment devices moved towards a plate and external fixator, while the use of pins was limited. However, there was no significant difference in the choice of treatment device based on the Die Punch subdivision subgroups.

Wrist range of motion in patients with DRFs

The normal range of motion of the wrist was investigated, with a normal range of 120 degrees (85-160 degrees) for flexion and extension, 150 degrees for supination and pronation, and an average of 65 degrees for radial and ulnar deviation (15-25 degrees radial and 30-45 degrees ulnar). The functional range of motion required for daily activities was considered to be 40 degrees for flexion and extension, 50 degrees for supination and pronation, and an average of 15 degrees for radial and ulnar deviation. The functional range was compared to the opposite side and found to be normal in all patients.

Wrist flexion motion was divided into normal and low ranges. Among the 24 patients, 19 (79.1%) had a normal range of flexion motion, while 5 (25%) had a low range of motion. Of the 16 patients who received plates, 11 (68.8%) had a normal range of flexion motion, while 5 (31.3%) had a low range of flexion motion. Of the ten patients who received an external fixator, 6 (60%) had a normal range of flexion motion, while 4 (40%) had a low range of flexion motion. The range of wrist extension, supination, pronation, and radial and ulnar deviation in all patients was within the normal range of motion.

The range of wrist extension was investigated, with a normal range and a limited range. Among the 24 patients who received pins, 23 (95.8%) had a normal range of extension, while one person (4.2%) had a limited range. Among the patients who received a plate, all 16 patients had a normal range of extension. Among the ten patients who received an external fixator, 9 (90%) had a normal range of extension, while one (10%) had a limited range of extension ($p > 0.05$).

Supination and pronation range

The normal range of supination and pronation was examined in patients treated with pins, plates, or an external fixator. The results showed that a majority of patients in all groups had normal supination and pronation levels. Specifically, 22 out of 24 (91.7%) pin recipients, three out of 16 patients (81.3%) who received a plate, and 8 patients (80%) who received an external fixator had normal supination levels. Similarly, 22 out of 24 patients (91.7%) were treated with pins, 13 out of 16 patients (81.3%) were treated with plates, and eight out of ten patients (80%) treated with an external fixator had normal pronation levels. The remaining individuals in all groups had slightly lower levels of pronation ($p > 0.05$). The summarized results are presented in Table 1.

Grip strength

The grip strength of patients was examined after treatment with pins, plates, or an external fixator. The results showed that most patients in all groups had normal grip strength. Specifically, grip strength after pin fixation was normal in 21 out of 24 patients (87.5%). Furthermore, the grip strength was also normal in 11 out of 16 patients (68.8%) treated with a plate and 9 out of 10 patients (90%) treated with an external fixator. The remaining individuals in all groups experienced lower grip strength after surgery. The summarized results are presented in Table 3.

Table 3. Summary of supination and pronation range and grip strength in patients treated with pins, plates, or an external fixator

Groups	Supination	Pronation	Grip strength
Pins (n=24)	91.7%	91.7%	87.5%
Plates (n=16)	81.3%	81.3%	68.8%
External fixator (n=10)	80%	80%	90%

Fractures, radial height, and volar tilt

Bone fractures were observed in 31 patients, with 15 treated with pins, nine with plates, and seven with an external fixator. No significant difference was observed between the groups with and without fractures in the results of the intervention ($p > 0.05$). Radial height was considered normal in all patients, and no significant difference was observed between the groups in this regard ($p > 0.05$). Volar tilt was normal in all patients, with 24 patients who received pins with normal volar tilt, 16 patients who received plates, and one patient who received an external fixator. After four weeks of follow-up, radial height in one patient who had received plate surgery was reported normal. After four months, greater than

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normal volar tilt was observed in one patient who received a pin (p >0.05). The summarized results are presented in Table 4.

Table 4. Summary of fractures, radial height, and volar tilt in patients treated with pins, plates, or an external fixator

Groups	Fractures	Radial height	Volar tilt
Pins (n= 24)	Yes	Normal	Normal
Plates (n= 16)	Yes	Normal	Normal
External fixator (n= 10)	Yes	Normal	Normal

Results of radiographic measurements and follow-up

In this study, the tear angle was observed to be low in 28 out of 50 patients (56%), while normal in 22 patients (44%) (p <0.05). A decrease in tear angle was observed in individuals who received an external fixator (p >0.05). Radial inclination was normal in 49 out of 50 patients (98%), with only 2 patients (2%) exhibiting low radial inclination. No change in radial inclination was observed in patients after receiving a pin, plate, or external fixator. Ulnar variance was negative in 9 patients (18%), positive in 9 patients (18%), and neutral in 32 patients (64%). No significant changes were observed in ulnar variance after six months of surgery.

In the sixth month, 5 out of 14 patients with positive ulnar variance exhibited decreased hand grip strength, while only two out of 25 patients in the negative ulnar variance group and two out of 11 patients in the ulnar variance minus group had decreased hand grip strength. Ulnar variance did not affect supination and pronation. All patients exhibited normal carpal alignment after surgery, except for one patient who showed carpal malalignment on the ulnar side after four weeks.

Relationship between surgical device and clinical improvement

The relationship between the DASH questionnaire scores and the type of surgical device used was evaluated in the sixth month, with mean scores of 24.69, 25.91, and 26.8 for pinning, plating, and external fixation, respectively. No significant relationship was found between the type of surgical device and clinical improvement based on this questionnaire. A comparison of the treatment methods and the final questionnaire score revealed no significant difference in the normal score of the questionnaire between the types of surgical devices. Table 5 summarizes the results of tear angle, radial inclination, and ulnar variance, while Table 6 represents the results of hand grip strength and carpal alignment.

In this study, the tear angle was observed to be low in 28 out of 50 patients (56%), while normal in 22 patients (44%) (p <0.05). A decrease in tear angle was observed in individuals who had received an external fixator (p > 0.05). Radial inclination was normal in 49 out of 50 patients (98%), with only 2 patients (2%) exhibiting low radial inclination. No change in radial inclination was observed in patients after receiving a pin, plate, or external fixator. Ulnar variance was negative in 9 patients (18%), positive in 9 patients (18%), and neutral in 32 patients (64%). No significant changes in ulnar variance were observed after six months of surgery.

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Table 5. Tear angle, radial inclination, and ulnar variance results

Parameter	Normal patients N (%)	Abnormal patients N (%)	P-value
Tear angle	22 (44%)	28 (56%)	< 0.05
Radial inclination	49 (98%)	1 (2%)	-
Ulnar variance	32 (64%)	18 (36%)	-

Table 6. Hand grip strength and carpal alignment results

N (%)	Decreased grip strength N (%)	Carpal malalignment N (%)
Positive Ulnar variance 14 (28%)	5 (10%)	0
Negative Ulnar variance 25 (50%)	2 (4%)	1 (2%)
Neutral Ulnar variance 11 (22%)	2 (4%)	0

Discussion

This study aimed to investigate the clinical and radiographic outcomes of treatment methods for DRFs with the involvement of the volar plate. The study had several objectives, including evaluating the treatment methods used for DRFs with volar plate involvement, examining the complications associated with these treatment methods, and analyzing clinical and radiographic outcomes based on gender and age. The connection among pathological fractures, osteoporosis, and age is crucial and intricate in orthopedic care. Pathological fractures are frequently linked to underlying medical issues such as osteoporosis, particularly in older individuals. Research has indicated that the reduction in bone mineral density as people age plays a significant role in the higher rates of fractures, emphasizing the importance of distinguishing between osteoporotic and non-osteoporotic fractures. Accordingly, Arora et al. found a substantial correlation between advancing age and an increased likelihood of developing osteoporosis and fractures (7), suggesting that specific management plans should be implemented to mitigate these risks.

Patients with concerns about bone health, especially those at risk for or diagnosed with osteoporosis, often take supplementary medications like calcium and vitamin D (14). These supplements play a crucial role in maintaining bone health and decreasing the chances of fractures. Recording the use of supplements is vital as they can impact the healing process and the overall results of orthopedic treatments (15). A study indicated that supplementation is essential in treating fractures, particularly in groups with pre-existing bone density problems (16). The most commonly used treatment methods for DRFs with volar plate involvement were pinning, plating, and external fixation. However, there was no significant difference in clinical outcomes based on the type of treatment method used, as measured by the DASH questionnaire. This finding is consistent with the results of previously published studies, which found no significant differences in functional outcomes between different surgical interventions for DRFs (17,18).

Complications associated with treatment methods included pin migration, screw loosening, and infection; however, these were relatively rare. The overall complication rate reported in this study is similar to that reported in other studies evaluating treatment methods for DRFs with volar plate involvement (19-24). Clinical outcomes based on gender and age showed no significant differences, indicating that treatment methods were similarly effective for men and women across different age groups. These findings are consistent with other studies, evaluating treatment methods for DRFs with volar plate involvement. Radiographic outcomes also showed no significant differences based on gender or age. This finding is consistent with a study by Calbiyik (2018), which found no significant differences in radiographic outcomes between different surgical interventions for DRFs (25).

The findings of this study, combined with the results of other studies, suggest that treatment methods for DRFs with volar plate involvement have similar clinical and radiographic outcomes and are not significantly influenced by factors such as gender or age. However, it is important for healthcare providers to carefully select treatment methods and provide appropriate follow-up care to minimize the risk of complications and ensure optimal outcomes. Further studies with larger sample sizes and longer follow-up periods are needed to confirm these findings and evaluate the long-term outcomes of different treatment methods.

Conclusion

This study aimed to investigate the clinical and radiographic outcomes of treatment methods for DRFs with volar plate involvement. The study found that pinning, plating, and external fixation were the most commonly used treatment methods for these fractures, with no significant differences in clinical outcomes between the methods. Complications associated with treatment methods were relatively rare and included pin migration, screw loosening, and infection. These findings are consistent with previous studies evaluating treatment methods for DRFs with volar plate involvement. Overall, this study provides valuable information for clinicians and patients in making treatment decisions for this common injury.

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Ethical statement

This study followed the Helsinki Declaration of 1964, its later revisions, and similar ethical norms, as well as the criteria of the institutional and national research committee. The Golestan University of Medical Sciences Ethics Committee in Gorgan, Iran, approved the study with ethics number IR.GOUMS.REC.1401.311.

Conflicts of interest

The authors declare no conflicts of interest.

Author contributions

Arezo Kordrostami: Contributed to the study's conception and design, obtained funding, conducted the surgical procedures, collected data, and participated in the clinical evaluations and analysis of results. Additionally, she was involved in drafting and revising the manuscript. Mehdi Aarabi: Assisted in the study's design and methodology, contributed to data collection and interpretation, and performed statistical analysis. He also contributed to the literature review and the drafting and revision of the manuscript. Afshin Sahebjamei: Supervised project administration, study conception, design, implementation, and final approval of the manuscript. All authors read and approved the final manuscript.

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