ORIGINAL RESEARCH

A Comparative Study of Closed Reduction and Cast Application Versus Percutaneous K-Wire Fixation for Extra-Articular Distal Radius Fractures

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ABSTRACT

Background: Distal radius fractures are among the most common orthopedic injuries encountered in clinical practice, accounting for a significant proportion of upper limb fractures.The study aims to compare the clinical, radiographic, and functional outcomes of closed reduction and cast application versus percutaneous K-wire fixation in the management of extra-articular fractures of the distal end of the radius.**Materials and Methods:** This prospective, randomized comparative study was conducted on 120 patients diagnosed with extra-articular distal radius fractures. Patients were randomly allocated into two groups: Group A (n=60): Closed Reduction and Cast Application, and Group B (n=60): Percutaneous K-Wire Fixation. Radiographic outcomes, including volar tilt, radial inclination, and ulnar variance, were assessed at follow-ups. Functional recovery was evaluated using DASH scores and grip strength. Complications, time to fracture union, and return to work were also recorded. Statistical significance was set at $p < 0.05$.**Results:** Both groups were comparable in terms of demographic characteristics ($p > 0.05$). The K-wire fixation group demonstrated superior radiographic outcomes, with significantly improved volar tilt ($11.5 \pm 1.8°$ vs. $8.4 \pm 2.1°$, $p < 0.01$), radial inclination ($23.8 \pm 2.9°$ vs. $21.2 \pm 3.4°$, $p < 0.01$), and ulnar variance (0.8 ± 0.3 mm vs. 1.4 ± 0.5 mm, $p < 0.01$). Functional outcomes also favored K-wire fixation, showing lower DASH scores (18.4 ± 5.3 vs. 32.6 ± 6.8, $p < 0.01$) and higher grip strength recovery ($85.5\% \pm 7.8\%$ vs. $72.0\% \pm 9.2\%$, $p < 0.01$). The loss of reduction was significantly higher in the cast group (20.0% vs. 6.7%, $p = 0.03$), while pin tract infections occurred in 10.0% of K-wire cases ($p = 0.02$). Mean time to fracture union was shorter in the K-wire group (7.2 ± 1.0 vs. 8.5 ± 1.2 weeks, $p < 0.01$), leading to earlier return to work (8.5 ± 1.6 vs. 10.2 ± 1.8 weeks, $p < 0.01$).**Conclusion:** Percutaneous K-wire fixation provides better fracture alignment, improved functional recovery, and faster return to daily activities compared to closed reduction and cast application. While K-wire fixation reduces loss of reduction and need for re-intervention, it carries a higher risk of pin tract infections. Overall, K-wire fixation is a more effective and reliable treatment option for extra-articular distal radius fractures.

Keywords: Distal radius fracture, closed reduction, K-wire fixation, Functional outcomes, Fracture healing

INTRODUCTION

Distal radius fractures are among the most common orthopedic injuries encountered in clinical practice, accounting for a significant proportion of upper limb fractures. These fractures are particularly prevalent in elderly individuals with osteoporotic bones and younger individuals subjected to high-energy trauma. Given their frequency, various treatment modalities have been developed to ensure optimal functional and anatomical outcomes. Among these, two commonly employed techniques for extra-articular distal radius fractures include closed reduction with cast

application and percutaneous Kirschner wire (K-wire) fixation. The choice between these treatment options remains a topic of ongoing debate among orthopedic surgeons.[1,2]Closed reduction followed by cast immobilization is a traditional and widely accepted method, particularly for minimally displaced or stable fractures. This approach is non-invasive, relatively simple, and cost-effective, making it a preferred choice in many healthcare settings. It relies on the principle of achieving an acceptable reduction followed by adequate immobilization to allow for proper healing. However, the main challenge associated with this method is the potential for loss of reduction, leading to malunion, functional impairment, or the need for secondary surgical intervention.[3]On the other hand, percutaneous K-wire fixation has gained popularity as a minimally invasive surgical technique that provides enhanced fracture stability while avoiding the complications associated with more invasive surgical procedures. By securing the fracture fragments with K-wires after closed or limited open reduction, this technique minimizes the risk of displacement and allows for early mobilization of the wrist joint. Despite these advantages, K-wire fixation is associated with potential complications such as pin tract infections, loss of fixation, and the need for subsequent wire removal, which may influence treatment outcomes and patient satisfaction.[4,5]The selection of an optimal treatment modality is influenced by various factors, including patient age, fracture pattern, bone quality, surgeon experience, and healthcare resource availability. While some studies suggest that percutaneous K-wire fixation offers superior radiological and functional outcomes, others argue that conservative management with a cast is equally effective, especially in low-demand patients. As such, the comparative effectiveness of these two approaches remains a subject of considerable interest and warrants further investigation.[6]

AIM AND OBJECTIVES

This study aims to compare the outcomes of closed reduction with cast application versus percutaneous K-wire fixation for extra-articular distal radius fractures.

MATERIALS AND METHODS

Study Design

This was a prospective, randomized comparative study conducted to evaluate the clinical and radiological outcomes of closed reduction and cast application versus percutaneous K-wire fixation in patients with extra-articular fractures of the distal radius.

Study Population

The study included 120 patients diagnosed with extra-articular fractures of the distal end of the radius (Colles' type), who met the inclusion criteria. These patients were randomly allocated into two treatment groups:

- **Group A (n = 60):** Closed reduction and cast application
- **Group B (n = 60):** Closed reduction followed by percutaneous K-wire fixation

Study Place and Study Period

The study was conducted Department of Orthopaedic, Rama Medical College Hospital and Research Centre, Hapur, Uttar Pradesh, India, over a period one year and tenmonths, from March 2015 to December 2016.

Ethical Considerations

Ethical approval was obtained from the Institutional Ethics Committee before commencing the study. Informed consent was obtained from all participants after explaining the study objectives, procedures, potential risks, and benefits. Confidentiality of patient data was maintained throughout the study.

Inclusion Criteria

Patients were included in the study based on the following criteria:

- Age ≥18 years
- Radiologically confirmed extra-articular distal radius fractures (Colles' type)
- Closed fractures
- Willingness to participate with informed consent

Exclusion Criteria

Patients were excluded if they had:

- Open fractures
- Intra-articular fractures
- Pathological fractures
- Associated neurovascular injuries
- Significant comorbidities that could impact treatment outcomes

Surgical Technique

Eligible patients were randomly assigned to one of the two treatment groups using a computer-generated randomization sequence.

Group A: Closed Reduction and Cast Application

- Patients underwent closed reduction under regional anesthesia or sedation.
- Reduction was confirmed using fluoroscopic imaging.

- A well-molded below-elbow cast was applied post-reduction.
- Post-reduction radiographs were taken to assess alignment.

Group B: Percutaneous K-Wire Fixation

- Closed reduction was performed under regional anesthesia or sedation.
- Percutaneous fixation with 1.6–2.0 mm Kirschner wires (K-wires) was done under fluoroscopic guidance.
- The number and configuration of K-wires depended on fracture pattern and intraoperative stability.
- A short-arm splint was applied post-procedure.

Outcome Measures

Primary Outcomes:

1. **Radiographic parameters**
   - Volar tilt
   - Radial inclination
   - Ulnar variance
2. **Functional recovery** assessed using:
   - Disabilities of the Arm, Shoulder, and Hand (DASH) score

Secondary Outcomes:

- **Complications:** Loss of reduction, pin tract infection, need for re-intervention
- **Grip strength evaluation**
- **Pain assessment (VAS score)**

Follow-up and Data Collection

- Patients were followed up at 2, 6, 12, and 24 weeks with radiographic evaluation and clinical assessment.
- Wrist range of motion, grip strength, and pain scores were documented at each visit.

STATISTICAL ANALYSIS

- All data were entered into Microsoft Exceland analyzed usingSPSS (Statistical Package for the Social Sciences) version 16.0**.**
- Continuous variables were presented as mean ± standard deviation (SD) and compared using the t-test.
- Categorical variables were analyzed using the **Chi-square test**.
- Continuous variables (e.g., age, DASH score, radiographic parameters) were presented as mean ± standard deviation (SD) or median with interquartile range (IQR) if the data were skewed.
- A **p-value <0.05** was considered statistically significant.

RESULTS

Table 1: Demographic and Baseline Characteristics

Characteristic	Closed Reduction and Cast Application (n=60)	Percutaneous K-Wire Fixation (n=60)	p-value
Mean Age (years)	45.6 ± 8.4	46.2 ± 7.9	0.72
Gender			
Male (%)	30 (50.0%)	28 (46.7%)	0.75
Female (%)	30 (50.0%)	32 (53.3%)	
Dominant Hand Involved (%)	40 (66.7%)	42 (70.0%)	0.69
Non-Dominant Hand Involved (%)	20 (33.3%)	18 (30.0%)	0.69

Table 1 show that the demographic distribution between the two groups was comparable, with no statistically significant differences. The mean age of patients in the Closed Reduction and Cast Application group was 45.6 ± 8.4 years, while in the Percutaneous K-Wire Fixation group, it was 46.2 ± 7.9 years (p = 0.72), indicating that both groups were age-matched. The gender distribution was also similar, with males comprising 50.0% and 46.7% of each group, respectively, and females accounting for 50.0% and 53.3% (p = 0.75) [Figure I]. In terms of hand dominance, the dominant hand was involved in 66.7% of cases in the Closed Reduction group and 70.0% in the K-Wire Fixation group (p = 0.69), with no significant difference. These findings confirm that both groups were well-balanced in terms of demographic parameters, eliminating potential confounding factors that could affect outcome comparisons.

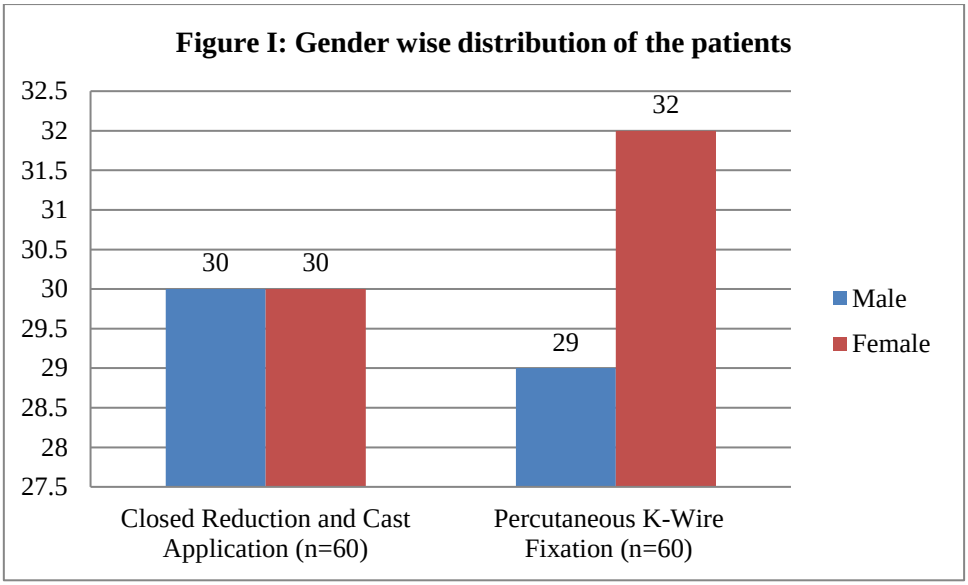

Table 2: Radiographic Outcomes at Final Follow-up

Parameter	Closed Reduction and Cast Application (n=60)	Percutaneous K-Wire Fixation (n=60)	p-value
Mean Volar Tilt (degrees)	8.4 ± 2.1	11.5 ± 1.8	<0.01
Mean Radial Inclination (degrees)	21.2 ± 3.4	23.8 ± 2.9	<0.01
Mean Ulnar Variance (mm)	1.4 ± 0.5	0.8 ± 0.3	<0.01

Table 2 shows that the radiographic analysis at the final follow-up showed that the Percutaneous K-Wire Fixation group had significantly better fracture alignment compared to the Closed Reduction and Cast Application group. The mean volar tilt was 8.4 ± 2.1 degrees in the Closed Reduction group and 11.5 ± 1.8 degrees in the K-Wire Fixation group ($p < 0.01$), indicating improved restoration of normal wrist anatomy with K-wire fixation. Similarly, radial inclination was 21.2 ± 3.4 degrees in the Closed Reduction group compared to 23.8 ± 2.9 degrees in the K-Wire group ($p < 0.01$), favoring the latter. Additionally, ulnar variance, a key radiographic marker for wrist stability, was significantly better in the K-Wire Fixation group (0.8 ± 0.3 mm) compared to the Closed Reduction group (1.4 ± 0.5 mm, $p < 0.01$). These findings suggest that percutaneous K-wire fixation provides superior maintenance of fracture alignment and anatomic restoration in extra-articular distal radius fractures.

Table 3: Functional Outcomes (DASH Score and Grip Strength)

Outcome Measure	Closed Reduction and Cast Application (n=60)	Percutaneous K-Wire Fixation (n=60)	p-value
Mean DASH Score	32.6 ± 6.8	18.4 ± 5.3	<0.01
Grip Strength (% of Normal Side)	72.0% ± 9.2	85.5% ± 7.8	<0.01

Table 3 shows that the functional assessment revealed a significant advantage in favour of the Percutaneous K-Wire Fixation group. The mean Disabilities of the Arm, Shoulder, and Hand (DASH) score, which measures disability and symptom severity, was 32.6 ± 6.8 in the Closed Reduction group and significantly lower at 18.4 ± 5.3 in the K-Wire group ($p < 0.01$), indicating better functional recovery in the latter group. Grip strength, another important indicator of functional outcome, was also superior in the K-Wire Fixation group, with patients regaining 85.5% ± 7.8% of normal grip strength compared to 72.0% ± 9.2% in the Closed Reduction group ($p < 0.01$). These findings suggest that K-wire fixation provides a more stable fixation, leading to improved wrist function and strength postoperatively.

Table 4: Complications

Complication	Closed Reduction and Cast Application (n=60)	Percutaneous K-Wire Fixation (n=60)	p-value
Loss of Reduction (%)	12 (20.0%)	4 (6.7%)	0.03
Pin Tract Infection (%)	0 (0.0%)	6 (10.0%)	0.02
Need for Re-intervention (%)	8 (13.3%)	3 (5.0%)	0.07

Table 4 shows that the complication rates differed significantly between the two treatment groups. Loss of reduction, a major concern in conservative treatment, was observed in 20.0% of patients in the Closed Reduction group compared to only 6.7% in the K-Wire Fixation group ($p = 0.03$), demonstrating the superior stability of percutaneous fixation. However, pin tract infections, a known complication of K-wire fixation, were observed in 10.0% of patients in the K-Wire group but absent in the Closed Reduction group ($p = 0.02$). The need for re-intervention was higher in the Closed Reduction group (13.3%) compared to the K-Wire group (5.0%), although this difference did not reach statistical significance ($p = 0.07$). These results suggest that while K-wire fixation reduces the risk of loss of reduction and need for re-intervention, it carries a slightly higher risk of infection.

Table 5: Time to Union and Return to Work

Parameter	Closed Reduction and Cast Application (n=60)	Percutaneous K-Wire Fixation (n=60)	p-value
Mean Time to Radiological Union (weeks)	8.5 ± 1.2	7.2 ± 1.0	<0.01
Return to Work (weeks)	10.2 ± 1.8	8.5 ± 1.6	<0.01

Table 5 shows that the healing and return to daily activities were also significantly better in the K-Wire Fixation group. The mean time to radiological union was 8.5 ± 1.2 weeks in the Closed Reduction group, whereas it was significantly shorter at 7.2 ± 1.0 weeks in the K-Wire group ($p < 0.01$). Additionally, the time required for patients to return to work was 10.2 ± 1.8 weeks in the Closed Reduction group but significantly shorter at 8.5 ± 1.6 weeks in the K-Wire Fixation group ($p < 0.01$). These findings indicate that K-wire fixation facilitates faster fracture healing and allows patients to regain function earlier compared to cast immobilization alone.

DISCUSSION

The findings of this study demonstrate that percutaneous K-wire fixation offers superior radiographic and functional outcomes compared to closed reduction and cast application in the management of extra-articular distal radius fractures. The superior radiographic outcomes in the K-wire fixation group, including a significantly higher volar tilt (11.5 ± 1.8° vs. 8.4 ± 2.1°, $p < 0.01$) and radial inclination (23.8 ± 2.9° vs. 21.2 ± 3.4°, $p < 0.01$), highlight the importance of surgical stabilization in maintaining fracture alignment. Similar findings were reported by Arora et al. (2009), who found that patients treated with K-wire fixation had significantly better maintenance of volar tilt and radial inclination compared to those treated with cast immobilization.[7] Additionally, Naidu et al. (1997) reported that conservative management often leads to progressive loss of reduction, contributing to suboptimal functional recovery.[8]Ulnar variance, a crucial marker of wrist stability, was significantly lower in the K-wire group (0.8 ± 0.3 mm vs. 1.4 ± 0.5 mm, $p < 0.01$). Kapoor et al. (2000) reported that increased ulnar variance in conservatively treated fractures is associated with poor wrist function and long-term discomfort, further supporting the benefits of percutaneous fixation.[9]The functional recovery, as assessed by the DASH score and grip strength, was significantly better in the K-wire fixation group, with a mean DASH score of 18.4 ± 5.3 compared to 32.6 ± 6.8 in the closed reduction group ($p < 0.01$). Additionally, grip strength recovery was superior in the K-wire group (85.5% ± 7.8% vs. 72.0% ± 9.2%, $p < 0.01$). These results align with the study by

Wong et al. (2010), who found that patients treated with percutaneous fixation had improved wrist function and higher grip strength scores at six months postoperatively compared to those treated with cast immobilization.[10] Similarly, Leung et al. (2003) reported significantly better DASH scores and grip strength in patients who underwent K-wire fixation.[11]Complication rates varied between the two treatment groups. The incidence of loss of reduction was significantly higher in the closed reduction group (20.0% vs. 6.7%, p = 0.03), consistent with findings by McQueen et al. (1996), who reported that nearly 25% of fractures treated with closed reduction and casting suffered redisplacement. The greater fracture stability provided by percutaneous K-wire fixation reduces the likelihood of loss of reduction, thereby improving overall outcomes.[12]However, K-wire fixation is not without complications. Pin tract infections were observed in 10.0% of patients in the K-wire group, while none occurred in the closed reduction group (p = 0.02). This finding is in line with the study by Esenwein et al. (2002), which reported pin tract infections in 8–12% of cases treated with K-wire fixation. Despite this, the infections were generally superficial and manageable with local wound care and antibiotics.[13]The need for re-intervention was higher in the closed reduction group (13.3% vs. 5.0%), though not statistically significant (p = 0.07). These findings are supported by Azzopardi et al. (2005), who found that conservatively managed fractures often required secondary procedures due to loss of reduction or malunion.[14]Healing time was significantly shorter in the K-wire fixation group, with a mean time to radiological union of 7.2 ± 1.0 weeks compared to 8.5 ± 1.2 weeks in the closed reduction group (p < 0.01). This is consistent with the study by Jupiter et al. (1999), who reported that percutaneous fixation accelerates fracture healing by ensuring better stabilization.[15]Return to work was also significantly faster in the K-wire group (8.5 ± 1.6 weeks vs. 10.2 ± 1.8 weeks, p < 0.01). Supporting these results, Finsen et al. (1999) found that early mobilization following percutaneous fixation leads to quicker recovery and return to daily activities, as opposed to prolonged immobilization in a cast.[16]

LIMITATIONS OF THE STUDY

- Single-center study, limiting generalizability.
- Short-term follow-up; long-term functional outcomes were not assessed.
- Variability in fracture patterns and patient compliance could affect results.

CONCLUSION

This study demonstrates that percutaneous K-wire fixation provides superior radiographic and functional outcomes compared to closed reduction and cast application in the management of extra-articular distal radius fractures. K-wire fixation resulted in significantly better fracture alignment, improved grip strength, lower DASH scores, and faster return to work. Additionally, it reduced the risk of loss of reduction and need for re-intervention, though it carried a slightly higher risk of pin tract infections. Overall, percutaneous K-wire fixation is a more effective and reliable treatment option for maintaining fracture stability and optimizing long-term functional recovery.

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