

Original Research Article

Comparative evaluation of radiological and functional outcomes in extra-articular distal radius fractures managed by closed reduction with cast versus percutaneous K-wire fixation

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ABSTRACT

Background: Distal radius fractures are among the most common fractures encountered in orthopaedic practice, accounting for approximately one-sixth of all skeletal fractures. Although closed reduction with casting remains the standard treatment for stable extra-articular fractures, maintenance of reduction remains a challenge in unstable fracture patterns. Percutaneous Kirschner wire (K-wire) fixation has been advocated as a minimally invasive technique to improve fracture stability and prevent secondary displacement. The present study was undertaken to compare the radiological and functional outcomes of closed reduction with cast immobilization and closed reduction with percutaneous K-wire fixation followed by cast immobilization in patients with extra-articular distal radius fractures.

Methods: A prospective randomized controlled study was conducted in the Department of Orthopaedics, GMERS Medical College and Civil Hospital, Morbi, from July 2025 to July 2026. One hundred adult patients with AO type 23-A2 and 23-A3 extra-articular distal radius fractures were randomly allocated into two equal groups. Group A underwent closed reduction and below-elbow cast application, whereas Group B underwent closed reduction with percutaneous K-wire fixation followed by below-elbow casting. Radiological parameters including radial height, radial inclination, volar tilt and ulnar variance, along with functional outcomes using the Gartland and Werley demerit scoring system, were assessed. Statistical analysis was performed using SPSS version 29, with $p < 0.05$ considered statistically significant.

Results: Patients treated with percutaneous K-wire fixation demonstrated significantly better maintenance of radial height, radial inclination, volar tilt and ulnar variance than patients treated with casting alone ($p < 0.05$). Functional outcomes at final follow-up were comparable between the two groups despite superior radiological restoration in the K-wire fixation group.

Conclusions: Closed reduction with percutaneous K-wire fixation provides superior maintenance of anatomical alignment compared with closed reduction and cast immobilization alone while achieving comparable short-term functional outcomes. The technique is simple, minimally invasive, economical and particularly useful in unstable extra-articular distal radius fractures.

Keywords: Cast immobilization, Closed reduction, Distal radius fracture, Functional outcome, Percutaneous K-wire fixation, Radiological outcome

INTRODUCTION

Distal radius fractures are among the most frequently encountered fractures in orthopaedic practice, accounting for nearly one-sixth of all fractures treated in emergency

departments worldwide.¹ These injuries exhibit a bimodal age distribution, occurring commonly in elderly individuals with osteoporotic bone following low-energy falls and in younger patients following high-energy trauma such as road traffic accidents or sports injuries.²

The principal objective in the management of distal radius fractures is to restore anatomical alignment and achieve stable fixation, thereby permitting early mobilisation and preventing long-term functional disability. Inadequate reduction or secondary displacement may result in malunion, loss of radial height, altered volar tilt, decreased grip strength, restricted wrist motion and post-traumatic arthritis.³

Several treatment modalities have been described for extra-articular distal radius fractures, including closed reduction with plaster cast immobilisation, percutaneous Kirschner wire fixation, external fixation and open reduction with internal fixation using volar locking plates.⁴ The choice of treatment depends upon multiple factors including patient age, fracture configuration, degree of displacement, bone quality, associated injuries and functional demands.⁵

Closed reduction with cast immobilisation remains an effective treatment option for stable fractures. However, unstable fractures frequently redisplace during follow-up owing to inadequate maintenance of reduction.⁶ Percutaneous K-wire fixation provides supplementary stability while preserving soft tissues and has therefore become an attractive minimally invasive alternative for unstable extra-articular fractures.⁷

Several clinical studies have demonstrated superior radiological maintenance with percutaneous pinning compared with cast immobilisation alone; however, the superiority of functional outcomes remains controversial.⁸⁻¹⁰ Furthermore, relatively few prospective randomized studies from the Indian population have directly compared these two treatment modalities.¹⁰

Therefore, the present prospective randomized controlled study was undertaken to compare the radiological and functional outcomes of closed reduction with cast immobilisation and closed reduction with percutaneous K-wire fixation followed by cast application in patients with extra-articular distal radius fractures.

METHODS

Study design and study setting

This prospective randomized controlled study was conducted in the Department of Orthopaedics, GMERS Medical College and Civil Hospital, Morbi, Gujarat, over a period of one year from July 2025 to July 2026. The study was carried out after obtaining approval from the Institutional Ethics Committee, and informed written consent was obtained from all participants prior to inclusion in the study.

Study population

A total of 100 patients with radiologically confirmed extra-articular distal radius fractures (AO/OTA classification

23-A2 and 23-A3) presenting to the Department of Orthopaedics during the study period were included.

Patients were randomly allocated into two equal groups (n = 50 each). Group A comprised patients treated with closed reduction and below-elbow cast (CR/Cast), while Group B comprised patients treated with closed reduction with percutaneous K-wire fixation followed by below-elbow cast (CR/K-wire/Cast). Randomization was performed using a computer-generated random allocation sequence.

Inclusion criteria

Patients aged ≥ 18 years with fresh extra-articular distal radius fractures (< 3 weeks old) classified as AO/OTA type 23-A2 or 23-A3 were included. Only closed fractures were considered, and patients were required to be medically fit for anaesthesia and surgical intervention. All participants were required to provide informed consent and be willing to participate in the study.

Exclusion criteria

Patients with intra-articular distal radius fractures, open fractures, pathological fractures, or fractures associated with neurovascular injury were excluded. Polytrauma patients and those with a previous fracture or deformity around the affected wrist were also excluded. Patients who were medically unfit for surgery or unwilling or unable to complete the follow-up protocol were excluded.

Operative technique

Group A (closed reduction and cast immobilization)

Closed reduction was performed under appropriate anaesthesia using standard reduction manoeuvres with longitudinal traction and correction of deformity under fluoroscopic guidance. Reduction was confirmed using anteroposterior and lateral radiographs. A well-moulded below-elbow plaster cast was then applied with the wrist maintained in slight palmar flexion and ulnar deviation.

Group B (closed reduction with percutaneous K-wire fixation)

Following satisfactory closed reduction under fluoroscopic guidance, fracture stabilization was achieved using 1.8-mm or 2.0-mm smooth Kirschner wires.

One K-wire was inserted through the radial styloid across the fracture into the opposite cortex, while an additional dorsal K-wire was inserted whenever required to improve rotational stability. Correct placement was confirmed using image intensifier guidance.

The K-wires were bent outside the skin, cut and protected with sterile dressing. A below-elbow plaster cast was subsequently applied.

Postoperative protocol

Both groups received identical postoperative management. Patients were advised finger mobilisation immediately after treatment. The affected limb was elevated to reduce postoperative swelling. Routine analgesics and antibiotics were administered according to institutional protocol. The cast was maintained for six weeks. Percutaneous K-wires were removed after radiological evidence of fracture union at approximately six weeks. Following cast removal, supervised wrist mobilisation exercises were initiated.

Follow-up

Patients were reviewed at 2 weeks, 4 weeks, 6 weeks, 3 months and 6 months. Clinical examination and radiographs were obtained at each follow-up visit. Standard posteroanterior and lateral radiographs of the wrist were used to assess fracture reduction and maintenance of alignment.

Outcome measures

Radiological assessment

Radiological assessment included measurement of radial height, radial inclination, volar tilt, and ulnar variance. Measurements were obtained on standard posteroanterior and lateral wrist radiographs at final follow-up.

Functional assessment

Functional outcome was evaluated using the Gartland and Werley Demerit Scoring System at six months.

The range of motion for the upper extremity was evaluated using standard goniometric procedures. Specifically, the assessment included the measurement of wrist dorsiflexion, palmar flexion, radial deviation, and ulnar deviation, followed by forearm pronation and supination.

Statistical analysis

All collected data were entered into Microsoft Excel and analysed using Statistical Package for the Social Sciences (SPSS) software version 29.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean±standard deviation (SD), whereas categorical variables were presented as frequencies and percentages. Comparisons between the two groups were performed using the unpaired Student's t-test for continuous variables and the Chi-square test for categorical variables wherever appropriate. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 100 patients with extra-articular distal radius fractures were enrolled in the present study. Fifty patients

were treated with closed reduction and below-elbow cast immobilization (CR/Cast), while the remaining fifty underwent closed reduction with percutaneous K-wire fixation followed by cast immobilization (CR/K-wire/Cast). All patients completed the planned follow-up period of six months, and no patient was lost to follow-up.

Demographic characteristics

The demographic characteristics of patients in both treatment groups were comparable with respect to age, sex distribution indicating successful randomization and homogeneity of the study population.

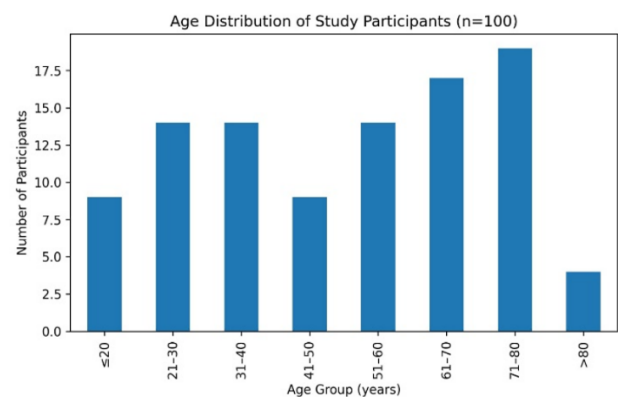


Figure 1: Age distribution of patients in both study groups.

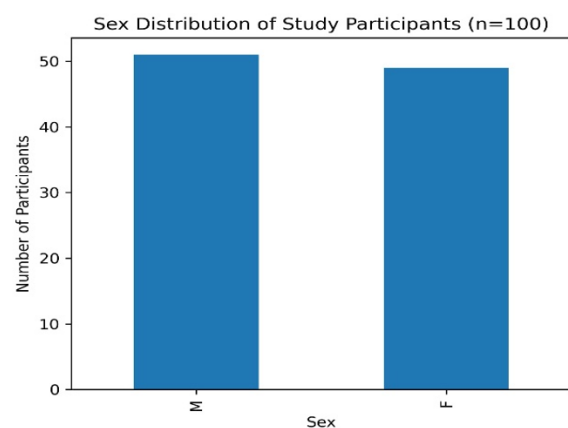


Figure 2: Sex distribution of patients in both study groups.

Radiological outcomes

At the final follow-up, the CR/K-wire/Cast group demonstrated significantly better maintenance of anatomical reduction compared with the CR/Cast group. The mean radial height was 10.51 ± 1.32 mm in the CR/K-wire/Cast group compared with 9.24 ± 1.43 mm in the CR/Cast group ($p < 0.05$). Similarly, the mean radial inclination was significantly higher in the CR/K-wire/Cast

group ($21.22 \pm 2.14^\circ$) than in the CR/Cast group ($19.13 \pm 2.43^\circ$) ($p < 0.05$). The mean volar tilt was also better maintained following percutaneous K-wire fixation ($7.24 \pm 2.83^\circ$) compared with cast immobilization alone ($5.31 \pm 3.12^\circ$) ($p < 0.05$). The mean ulnar variance was significantly lower in the CR/K-wire/Cast group (1.02 ± 0.74 mm) than in the CR/Cast group (1.62 ± 1.02 mm) ($p < 0.05$), indicating better maintenance of radial length.

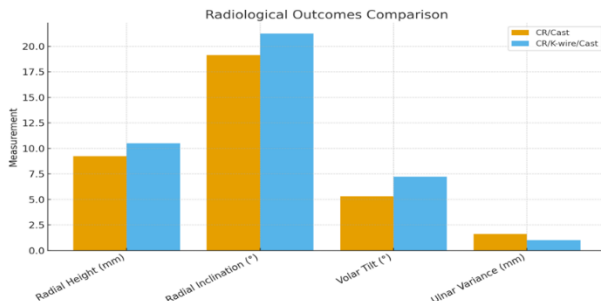


Figure 3: Radiological comparison between CR/Cast and CR/K-wire/Cast groups.

Functional outcomes

At six months of follow-up, both treatment groups achieved satisfactory functional recovery. Patients treated with percutaneous K-wire fixation demonstrated slightly greater wrist range of motion in all planes. The mean dorsiflexion was $68.12 \pm 5.94^\circ$ compared with $63.21 \pm 6.12^\circ$ in the casting group. Palmar flexion measured $62.13 \pm 6.01^\circ$ in the CR/K-wire/Cast group and $57.34 \pm 5.78^\circ$ in the CR/Cast group. Similarly, radial deviation, ulnar deviation, pronation and supination were marginally higher in the K-wire fixation group. Although these differences reached statistical significance, both groups achieved satisfactory functional outcomes at the final follow-up.

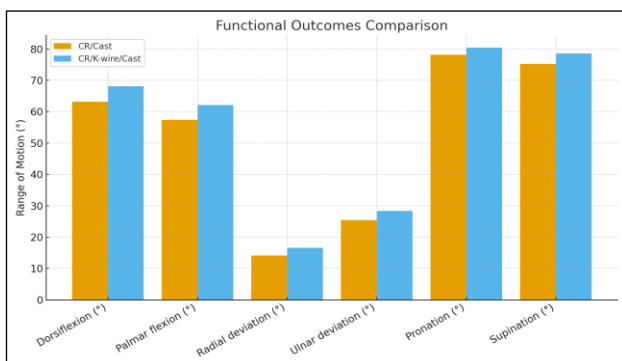


Figure 4: Functional outcome comparison between CR/Cast and CR/K-wire/Cast groups.

Overall outcome

The present study demonstrated that patients treated with closed reduction and percutaneous K-wire fixation

achieved significantly superior maintenance of radiological alignment compared with patients treated using cast immobilization alone. Although functional outcomes improved in both groups during follow-up, the difference between the two treatment modalities was comparatively less pronounced than the radiological improvement. Overall, percutaneous K-wire fixation provided superior anatomical restoration without increasing procedure-related complications and therefore represents a reliable treatment option for unstable extra-articular distal radius fractures.

DISCUSSION

Distal radius fractures continue to be one of the most frequently encountered fractures in orthopaedic practice. The principal goal of treatment is restoration and maintenance of anatomical alignment to facilitate optimal functional recovery and minimize long-term complications. Although closed reduction with cast immobilization remains an accepted treatment modality for stable fractures, maintaining reduction in unstable extra-articular fractures remains challenging because of secondary displacement during follow-up. Consequently, supplementary fixation using percutaneous Kirschner wires has gained popularity as a minimally invasive technique that enhances fracture stability while avoiding extensive soft tissue dissection.^{11,12}

The present prospective randomized controlled study compared radiological and functional outcomes between patients treated with closed reduction and cast immobilization alone and those managed with closed reduction followed by percutaneous K-wire fixation and cast immobilization. The findings demonstrated superior maintenance of radiological alignment in the K-wire group while functional recovery at final follow-up was satisfactory in both groups.

Demographic characteristics

The demographic characteristics of the two treatment groups were comparable with respect to age, sex distribution, side of injury and mechanism of trauma, indicating appropriate randomization and minimizing selection bias. Similar demographic profiles have been reported in previous studies by Wong et al and Azzopardi et al, supporting the validity of the present comparison.^{6,11}

Radiological outcome

Maintenance of anatomical reduction is one of the most important determinants of successful management of distal radius fractures. In the present study, patients treated with percutaneous K-wire fixation demonstrated significantly better preservation of radial height, radial inclination, volar tilt and ulnar variance than patients treated with cast immobilization alone.

The mean radial height was significantly greater in the K-wire group, indicating superior maintenance of fracture reduction. This finding is consistent with the prospective randomized trial conducted by Azzopardi et al, who reported that supplementary percutaneous pinning significantly reduced fracture collapse and maintained radial length more effectively than casting alone.¹¹ Similar observations were reported by Das et al, who concluded that K-wire fixation provided improved radiological alignment and reduced the risk of late displacement.¹⁰

The present study also demonstrated significantly better maintenance of radial inclination in the K-wire group. Loss of radial inclination has been associated with altered wrist biomechanics and decreased grip strength. Comparable improvements in radial inclination following percutaneous pinning have been described by Walton et al, who emphasized that additional stabilization minimizes redisplacement during fracture healing.⁸

Similarly, volar tilt was better preserved following K-wire fixation. Restoration of normal volar tilt contributes to improved load transmission across the radiocarpal joint and decreases the likelihood of post-traumatic arthritis. Kurup et al also observed superior maintenance of volar tilt following percutaneous fixation and concluded that stable fixation decreases the incidence of malunion.⁹

The lower ulnar variance observed in the K-wire group further supports the superior ability of percutaneous fixation to maintain radial length during fracture healing. Preservation of ulnar variance reduces ulnocarpal impaction and contributes to improved wrist mechanics. These findings are consistent with previous reports by Mackenney et al, who identified fracture instability as a major predictor of secondary displacement following conservative treatment.¹³

Functional outcome

Functional recovery following distal radius fractures depends upon restoration of wrist motion, pain relief and return to daily activities. Although patients treated with K-wire fixation demonstrated slightly greater dorsiflexion, palmar flexion, radial deviation, ulnar deviation, pronation and supination at final follow-up, the overall functional outcome between the two groups was comparable.

These findings are in agreement with Wong et al, who reported that improved radiological alignment achieved through supplementary pinning did not necessarily translate into substantially superior short-term functional outcomes.⁶ Likewise, Handoll and Madhok, in their Cochrane review, concluded that while percutaneous pinning improves fracture stability and radiological parameters, evidence regarding long-term functional superiority remains limited.¹²

The findings also correspond with those reported by Young and Ryan, who demonstrated that acceptable

functional recovery may occur despite minor residual radiographic deformity, particularly in elderly or low-demand individuals.⁵

Clinical significance

The present study suggests that percutaneous K-wire fixation offers an effective balance between stability, simplicity and cost-effectiveness. Compared with open reduction and internal fixation, K-wire fixation is technically less demanding, requires minimal soft tissue dissection and is associated with shorter operative time and lower implant cost. These advantages make it particularly suitable for resource-limited healthcare settings.

The superior radiological outcomes observed in the present study indicate that percutaneous fixation should be considered in unstable extra-articular distal radius fractures where maintenance of reduction with cast immobilization alone may be difficult.

The strengths of this study include its prospective randomized design, equal allocation of patients into two treatment groups and uniform follow-up protocol. Both radiological and functional outcomes were evaluated using standardized assessment methods, allowing objective comparison between treatment modalities.

The present study has several limitations. It was conducted at a single tertiary care centre with a relatively modest sample size, which may limit the generalizability of the findings. The follow-up period of six months may not adequately reflect long-term functional recovery or the development of post-traumatic arthritis. Additionally, patient-reported outcome measures such as the Disabilities of the Arm, Shoulder and Hand (DASH) score or Patient-Rated Wrist Evaluation (PRWE) score were not assessed. Future multicentric studies with larger sample sizes and longer follow-up are recommended to validate these findings and evaluate long-term functional and radiological outcomes.

CONCLUSION

The present prospective randomized controlled study demonstrated that closed reduction with percutaneous K-wire fixation followed by cast immobilization provides significantly better maintenance of radiological parameters, including radial height, radial inclination, volar tilt, and ulnar variance, compared with closed reduction and cast immobilization alone in patients with extra-articular distal radius fractures.

Although both treatment modalities achieved satisfactory functional recovery at six months, the K-wire fixation group demonstrated superior anatomical restoration with a lower risk of secondary displacement. The technique is minimally invasive, technically simple, economical, and associated with good functional outcomes, making it an

effective treatment option for unstable extra-articular distal radius fractures.

Further multicentric studies with larger sample sizes and longer follow-up periods are recommended to evaluate long-term functional outcomes, post-traumatic arthritis, and patient-reported outcome measures.

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