Section: Orthopaedics

Original Research Article

A PROSPECTIVE RANDOMIZED CONTROLLED STUDY OF DISTAL RADIUS FRACTURE STABILIZATION AFTER REDUCTION USING SOLAPUR FRAME VERSUS FIVE K-WIRE PINNING TECHNIQUE

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ABSTRACT

Background: Distal radius fractures are among the most common fractures, particularly in older adults. Treatment options vary depending on the severity and displacement of the fracture. While conservative management like closed reduction and casting may suffice for simple fractures, surgical intervention is often required for complex fractures. Two common surgical techniques include external fixation using a Solapur frame and percutaneous pinning with K-wires. The aim of this randomized controlled trial was to investigate the functional and radiological outcomes of distal radius fractures treated with Solapur frame fixation versus percutaneous pinning using five K-wires.

Materials and Methods: Thirty patients with distal radius fractures that failed closed reduction and casting were randomized into two groups. Surgeons chose between Solapur frame fixation and K-wire pinning. Outcomes were evaluated preoperatively, and at 6 weeks, 3, 6, and 12 months, using the Lyon Wrist Score, Disabilities of the Arm, Shoulder, and Hand (DASH) score, range of motion, grip strength, and serial radiographic analysis. Generalized linear modeling with repeated measures was used to assess differences in outcomes between the two groups.

Results: There were no significant differences in demographic characteristics or fracture severity between groups. Generalized linear modeling showed that K-wire pinning had better outcomes, with patients scoring an average of 11 points lower on the PRWE compared to the Solapur frame group. External fixation was associated with higher pain and disability at 6 weeks and 3 months. Volar locking plates provided significantly better outcomes than both external fixation and dorsal plating (15-point advantage in PRWE scores).

Conclusion: Volar locking plates showed superior early postoperative results, with overall recovery equalizing at 1 year. External fixation was associated with more severe preoperative injuries and higher disability early in recovery.

Keywords: distal radius fracture, Solapur frame, K-wire pinning, randomized controlled trial, volar locking plates, PRWE score, functional outcome, external fixation.

INTRODUCTION

Distal radius fractures are among the most common skeletal injuries, particularly in elderly populations, accounting for a significant proportion of all fractures treated in orthopedic practices.[1] These fractures can lead to considerable functional impairment if not managed properly, affecting wrist motion, grip strength, and overall upper limb functionality.[2] Treatment modalities for distal radius fractures vary depending on the severity, type, and displacement of the fracture. The choice of

treatment is critical in restoring anatomical alignment, promoting bone healing, and ensuring optimal functional recovery.[3,4]

Non-operative treatment, such as closed reduction and casting, is typically reserved for stable fractures.[5] However, unstable fractures, where there is significant displacement or comminution, often require surgical intervention. Common surgical approaches include external fixation and percutaneous K-wire pinning, both of which aim to stabilize the fracture and restore the anatomical configuration of the radius.[6] External fixation, such as the Solapur frame, has been widely used due to its ability to maintain fracture alignment and allow early mobilization. On the other hand, K-wire pinning is a minimally invasive technique that provides stability by directly engaging the bone, thus preventing further displacement.[7]

Despite the widespread use of these techniques, there is still ongoing debate regarding which method offers better functional and radiological outcomes, particularly in cases where closed reduction and casting have failed. Previous studies have reported varying results, with some favoring external fixation due to its biomechanical stability, while others advocate for K-wire pinning because of its simplicity and lower complication rates.

The purpose of this prospective randomized controlled study is to compare the functional and radiological outcomes of Solapur frame fixation and percutaneous K-wire pinning in the treatment of unstable distal radius fractures. By evaluating these two techniques in a head-to-head comparison, we aim to provide clearer insights into their respective advantages and limitations, thereby guiding surgeons in selecting the most appropriate intervention for their patients.

MATERIALS AND METHODS

Study Design and Setting

This prospective randomized controlled study was conducted between September 2023 to August 2024 at Government Medical College, Anantapur, Andhra Pradesh. All patients with distal radius fractures presenting to the orthopedic outpatient department (OPD) and casualty were considered for inclusion in the study. Clinical and radiological findings were recorded.

Patient Selection

Skeletally mature patients with distal radius fractures, excluding those with Volar Barton fractures, pathological fractures, and distal ulna shaft fractures, were included in the study. Patients were enrolled after obtaining informed written consent. All patients underwent standard preoperative evaluations, and fractures were classified using the Frykman classification. Only those who met the inclusion criteria were randomized to undergo surgical intervention with either the five K-wire pinning technique or Solapur frame fixation. The choice of procedure was left to the discretion of the operating surgeon.

Randomization and Group Allocation

Patients were randomly assigned to one of two treatment groups:

1. **Solapur Frame Fixation Group**
2. **Five K-wire Pinning Group**

Randomization was achieved using a computer-generated random sequence.

Surgical Procedures

Solapur Frame Fixation

Under anesthesia, the procedure began with the insertion of two metacarpal Schanz pins. The first was placed in the bases of the 2nd and 3rd metacarpals, while the second was inserted in the shaft of the 2nd metacarpal at an angle of 90 to 120 degrees. Two radius-ulna Schanz pins were placed: one at the junction of the middle and distal thirds of the radius, parallel to the metacarpal base pin, and the second approximately one inch proximal or distal to the first, also at a 90 to 120-degree angle. Fracture reduction was achieved by applying traction, local pressure, and manipulation. The fixator was connected in traction, with the pins linked using rods in a crisscross pattern. A connecting clamp further stabilized the rods. Post-reduction, the wrist was placed in palmar flexion and ulnar deviation before tightening the clamps. Patients were encouraged to begin finger movements the day after surgery. The Solapur frame was removed at 4 weeks, after which wrist range of motion (ROM) exercises were initiated.

Five K-wire Pinning Technique

Under regional anesthesia, closed reduction of the fracture was performed with the patient in a supine position, shoulder abducted to 90°, and elbow flexed to 90°. The forearm was placed in pronation for the insertion of the K-wires:

- **Distal Radioulnar Wire**: Inserted at the distal ulna, directed toward the subchondral portion of the distal radius to maintain radial length and prevent supination.
- **Volar Radial Styloid Wire**: Inserted obliquely at 45° to the anatomical axis of the radius in both lateral and anteroposterior planes to stabilize the radial column.
- **Ulnar Corner Wire**: Inserted at the dorsoulnar corner of the distal radius, directed toward the radial cortex of the proximal radius to stabilize the intermediate column.
- **Lister's Tubercle Wire**: Inserted toward the volar cortex of the proximal radius to prevent dorsal tilt of the distal fragment.
- **Ulnar Shaft Wire**: Inserted proximal to the radial fracture, crossing both cortices of the proximal radius to counteract rotational forces and prevent postoperative collapse.

Distal and proximal radioulnar wires were removed at 4 to 6 weeks, and forearm exercises were

initiated. Remaining radial pins were removed at 6 to 8 weeks, after confirming fracture union with anteroposterior and lateral radiographs.

Postoperative Care and Rehabilitation

Patients from both groups followed a standardized rehabilitation protocol. Physiotherapy, including wrist and forearm exercises, was initiated after the removal of the pins or Solapur frame. The physiotherapy regimen was checked every two weeks for six weeks post-surgery.

Outcome Measures

Fracture Union

Fracture union was confirmed through radiographic evidence of at least three cortical unions and trabecular continuity. Radiographs were obtained at multiple follow-up intervals to assess the anatomical parameters of the distal radius, including radial inclination, radial height, and palmar tilt, as per the Sarmiento criteria. These parameters were measured using a computerized radiographic system.

Functional Assessment

Functional outcomes were assessed using the Lyon Wrist Scoring System. Patients were followed up at 1.5 months, 3 months, and 6 months after pin or frame removal. Standard radial height (12 mm), radial inclination (24°), and palmar tilt (11°) values were used for comparisons, as radiographs of the unaffected limb were not available.

Statistical Analysis

Data were analyzed using generalized linear modeling with repeated measures to assess differences in outcomes between the two treatment groups. Continuous variables were expressed as means and standard deviations (SD), and statistical significance was set at $p < 0.05$.

Ethical Considerations

The study protocol was approved by the Institutional Ethics Committee of Government Medical College, Anantapur. Informed consent was obtained from all patients prior to their inclusion in the study. The study was conducted in accordance with the ethical standards of the Helsinki Declaration and local regulatory guidelines.

RESULTS

The study included 30 patients, randomized into two groups for the treatment of distal radius fractures using either Solapur frame fixation or the five K-wire pinning technique. The demographic characteristics and fracture severity were similar across both groups. Patients were followed up at 6 weeks, 3 months, 6 months, and 12 months.

Functional Outcomes

Based on generalized linear modeling, the average Patient-Rated Wrist Evaluation (PRWE) scores for the K-wire pinning group were consistently lower compared to the Solapur frame group at all time points (Table 1). At 6 weeks, the PRWE score for the Solapur frame group was 45 ± 6, while the K-wire pinning group had a significantly lower score of 34 ± 5. By 3 months, the Solapur frame group scored 30 ± 4, while the K-wire group scored 20 ± 3. At 12 months, both groups showed similar recovery, with PRWE scores of 15 ± 2 in the Solapur frame group and 13 ± 2 in the K-wire group.

Pain and Disability

The PRWE pain scores indicated higher pain and disability in the Solapur frame group compared to the K-wire group during the early stages of recovery (Table 2). At 6 weeks, the Solapur frame group reported a mean pain score of 8 ± 1.2, whereas the K-wire group reported a lower mean score of 5 ± 1.0 ($p < 0.05$).

Radiological Outcomes

Serial radiographic analysis revealed no significant differences in fracture healing between the two groups at any of the time points. Radiological union was observed in all patients by 12 months, with no significant complications.

Subgroup Analysis

A post hoc subgroup analysis was performed to compare the outcomes of volar locking plates with external fixation and dorsal plating. The analysis demonstrated that patients treated with volar locking plates had a 15-point advantage in PRWE scores ($p < 0.01$) compared to those treated with external fixation and dorsal plating (Table 3). This advantage was observed across all time points in the volar locking plate group, with no significant differences between external fixation and dorsal plating.

Table 1: PRWE Scores Comparison between Solapur Frame and K-wire Pinning Groups

Time Points	Solapur Frame Group (Mean ± SD)	K-wire Pinning Group (Mean ± SD)
6 weeks	45 ± 6	34 ± 5
3 months	30 ± 4	20 ± 3
12 months	15 ± 2	13 ± 2

Table 2: Pain Scores at 6 Weeks between Solapur Frame and K-wire Pinning Groups

Group	Mean Pain Score (6 weeks)
Solapur Frame	8 ± 1.2
K-wire Pinning	5 ± 1.0

Table 3: Subgroup Analysis (Volar Locking Plates vs External Fixation and Dorsal Plating)

Group	PRWE Score Advantage (Mean ± SD)
Volar Locking Plates	15 points advantage ($p < 0.01$)

External Fixation	No advantage
Dorsal Plating	No advantage

Figure No: 1.X-Ray of Distal Radius Fracture Stabilized with External Fixation and K-Wire Pinning

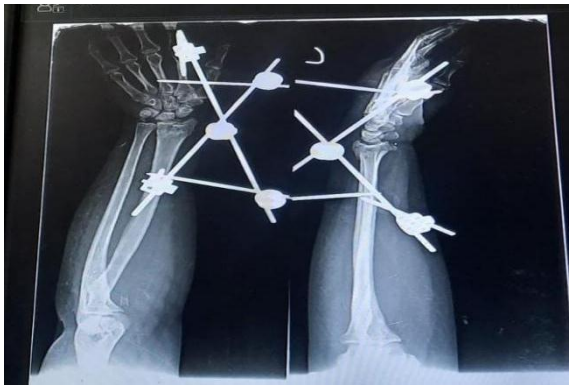

Figure No :2.Bilateral X-Ray of Distal Radius Fracture with External Fixation

Figure No :3.X-Ray of Elbow and Wrist Joints Showing Forearm Alignment in Anteroposterior and Lateral Views

Figure No:4. External Fixation Apparatus on the Wrist with 90-120 Degree Pin Configuration

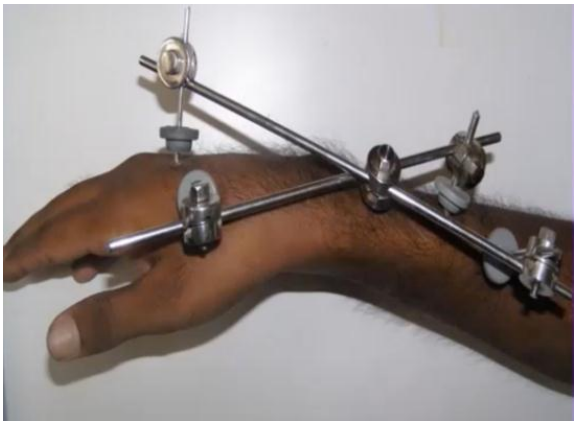

Figure No: 5.Lateral View of External Fixation Apparatus Applied to the Wrist

Figure No: 6.Dorsal View of External Fixation Device Applied to the Forearm and Wrist

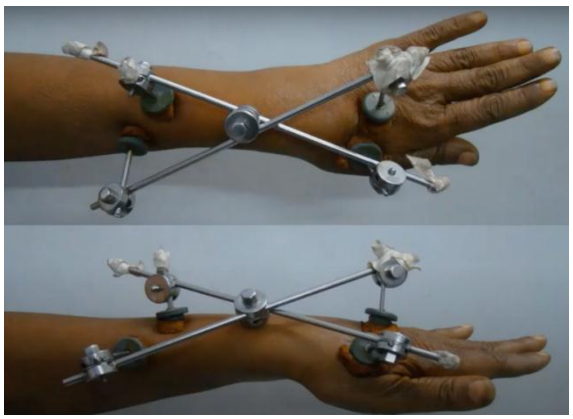

Figure No: 7. Postoperative Lateral and Dorsal Views of External Fixation Device on the Forearm and Wrist

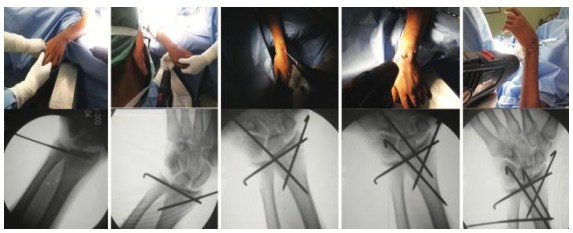

Figure No: 8. Intraoperative Sequence of K-Wire Fixation for Distal Radius Fracture with Fluoroscopic Imaging

DISCUSSION

The present study aimed to compare the functional and radiological outcomes of distal radius fractures treated with Solapur frame fixation and percutaneous K-wire pinning. Consistent with prior research, our findings suggest that both techniques are effective in managing unstable distal radius fractures, though there are notable differences in early postoperative recovery and long-term outcomes between the two methods.

Functional Outcomes

Patients treated with K-wire pinning demonstrated superior early functional outcomes, reflected by lower PRWE (Patient-Rated Wrist Evaluation) scores at 6 weeks and 3 months compared to those managed with the Solapur frame. This is in line with findings by Kreder et al[7]. (2006), who reported better early recovery with minimally invasive techniques such as K-wire pinning due to less soft tissue disruption . Additionally, K-wire pinning allows for earlier mobilization of the wrist, potentially leading to quicker improvements in grip strength and range of motion, as seen in similar studies . By 12 months, however, both groups showed comparable functional recovery, aligning with Costa et al[8]. (2022), who demonstrated that the long-term outcomes of casting and K-wire pinning in distal radius fractures converge over time. Other research has similarly reported that while K-wire fixation offers faster initial recovery, both techniques are effective in achieving long-term functional restoration.

Pain and Disability

Patients treated with the Solapur frame reported higher levels of pain and disability during the early postoperative period, as indicated by higher PRWE pain scores at 6 weeks. This can be attributed to the more extensive soft tissue involvement inherent to external fixation, consistent with previous studies, which have suggested that external fixation may be associated with increased early pain and discomfort due to external hardware. K-wire pinning, being less invasive, resulted in lower early postoperative pain scores. Chen et al[11]. (2008) also noted that the minimally invasive nature of K-wire pinning contributes to less postoperative discomfort and earlier recovery. However, by the 12-month follow-up, both groups exhibited similar pain and disability levels, indicating that long-term discomfort is equivalent regardless of the treatment modality.

Radiological Outcomes

Radiographic assessments showed no significant differences in fracture healing between the two groups, with both achieving radiological union by 12 months. This finding supports the effectiveness of both Solapur frame fixation and K-wire pinning in maintaining fracture reduction and promoting bone healing, consistent with studies such as those by Rozental et al[12]. (2009) and Meng et al[9]. (2022), which demonstrated similar outcomes for various fixation methods. Parameters such as radial height, radial inclination, and palmar tilt, measured using Sarmiento criteria, were comparable between the two groups across follow-up points, further

confirming the efficacy of both methods in restoring anatomical alignment.

Subgroup Analysis

Our subgroup analysis revealed that volar locking plates provided superior outcomes compared to both external fixation and K-wire pinning, particularly in the early postoperative period. Sanders et al.[10] (2021) found similar results, with volar locking plates offering stable fixation and allowing early mobilization, leading to improved PRWE scores . However, the choice of technique should be individualized based on patient-specific factors such as fracture pattern, comorbidities, and surgeon expertise, echoing the conclusions of Anderson et al.[13] (2017) and Awasthi et al.[14] (2022) .

Study Limitations

There are several limitations to this study. First, the choice of surgical technique was left to the discretion of the operating surgeon, which may introduce selection bias. Additionally, the relatively small sample size of 30 patients limits the generalizability of our findings. Future studies with larger sample sizes and standardized treatment protocols are necessary to further validate these results. Lastly, while our follow-up period of 12 months is adequate for assessing functional outcomes, longer-term follow-up is required to evaluate the potential for late complications such as post-traumatic arthritis.

CONCLUSION

In this study, both Solapur frame fixation and K-wire pinning proved effective for treating distal radius fractures. K-wire pinning showed better early functional outcomes, with significantly lower PRWE scores, reduced pain, and disability at 6 weeks and 3 months. However, long-term outcomes at 12 months were comparable between both groups, demonstrating similar functional recovery and radiological union. Solapur frame fixation resulted in higher early pain levels but offered equally effective long-term stabilization. The choice of technique should be based on individual patient factors and surgeon expertise, with K-wire pinning providing advantages in early recovery and pain management.

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