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Original Article

Orthopaedics Section

Clinical and Radiographic Outcomes in Distal Radius Fractures Using K-wires versus Fragment-specific Plates: A Prospective Interventional Study

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ABSTRACT

Introduction: Orthopaedic practice frequently deals with Distal Radius Fractures (DRFs); however, the treatment strategies for optimal functional outcomes remain uncertain. K-wiring (Kirschner Wire) is a minimally invasive technique preferred for simple fractures, whereas Fragment-Specific Plating (FSP) offers targeted fixation for complex fracture patterns.

Aim: To compare the functional and radiological outcomes of DRFs managed with K-wiring versus FSP.

Materials and Methods: The present prospective interventional study was performed in the Department of Orthopaedics of a tertiary care hospital at Pune, Maharashtra, India, over 24 months from January 2023 to December 2024. A total of 40 patients were randomly categorised: K-wire group (n=20) and Plate group (n=20). Functional outcome was assessed with the Mayo modified wrist score, while radiological outcomes included radial inclination, radial height, and volar tilt. The patients were followed-up at 3, 6, and 12 months.

Results: At three and six months, significantly greater proportion of patients in the Plate group had higher range of motion (p=0.003 and 0.029, respectively), and total scores (p=0.017 and 0.039, respectively). Similarly, at 6 and 12 months, patients in the Plate group had higher grip strength scores (p=0.025 and 0.010, respectively). Moreover, at three and 12 months, patients in the plate group had higher satisfaction (p=0.003) and higher pain scores (p=0.028), respectively. Both the groups had comparable radial inclination at all the intervals (p>0.05) and volar tilt at three months (p=0.116). At three months, the mean radial height was significantly greater in the plate group (p=0.012). Furthermore, at six and 12 months, the plate group demonstrated significantly higher radial height (p=0.003 and <0.001, respectively) and volar tilt (both p<0.001) compared to the K-wire group. However, the K-wire group was associated with significantly reduced operative time and shorter duration of hospital stay (both p<0.001).

Conclusion: Both K-wiring and FSP are effective surgical methods for managing DRFs. However, FSP provides significantly better functional and radiological outcomes, and should be preferred, particularly in patients with complex DRFs.

Keywords: Grip strength, Plating, Range of motion

INTRODUCTION

The DRFs are frequently encountered in orthopaedic outpatient clinics, constituting roughly 17.5% of all fractures observed in adults. These fractures exhibit a bimodal age distribution, often resulting from high-impact injuries in younger individuals and low-impact mechanisms, such as ground-level falls, in geriatric patients, particularly in postmenopausal women with predisposing osteoporotic conditions [1]. Over the years, numerous treatment modalities have been developed for managing DRFs, ranging from conservative approaches such as closed reduction and casting to surgical interventions, including use of external fixators, percutaneous pinning using K-wires, and Open Reduction and Internal Fixation (ORIF) using plates. The primary goals of treatment are anatomical reduction, stable fixation, early mobilisation, and optimal restoration of wrist function. However, the choice of surgical technique remains controversial, particularly in cases involving unstable or intra-articular fractures [2]. K-wire fixation, or percutaneous pinning, is a time-honored, minimally invasive procedure frequently utilised for managing extra-articular fractures or minimally displaced intra-articular fractures. It offers several advantages, including shorter operative time, minimal soft tissue disruption, lower cost, and ease of hardware removal. It is particularly suitable for elderly patients or those with co-morbidities who may not tolerate prolonged anaesthesia or extensive surgery [3,4].

In contrast, FSP is a more recent advancement designed to address the limitations of conventional volar locking plates. FSP involves the targeted fixation of individual fracture fragments using small plates, allowing for precise anatomical realignment and enhanced mechanical stability [5]. This technique is particularly beneficial for complex intra-articular fractures and has been associated with improved functional outcomes and earlier return to activity [6].

Despite the growing use of both techniques, there remains a lack of consensus regarding their comparative efficacy. While FSP is often favoured for complex fractures, K-wiring continues to be widely used due to its simplicity and effectiveness [7]. This study, therefore, seeks to evaluate and compare the functional and radiological outcomes of DRFs managed with K-wiring versus FSP, offering important insights into the most effective surgical technique for treating these prevalent and frequently encountered injuries.

MATERIALS AND METHODS

The present prospective interventional study was performed in the Department of Orthopaedics of a tertiary care hospital at Pune, Maharashtra, India from January 2023 to December 2024. The study protocol was approved by the Institutional Ethics Committee (IESC/287/2023) and written informed consent was obtained from the patients prior to initiation of the study.

Inclusion and Exclusion criteria: The study included adult patients of either sex, aged 18 years or older, and presenting with

fresh, closed, displaced DRFs, either intra-articular or unstable, that necessitated surgical intervention. While patients with open fractures, pathological fractures, bilateral wrist injuries, or associated neurovascular damage were excluded.

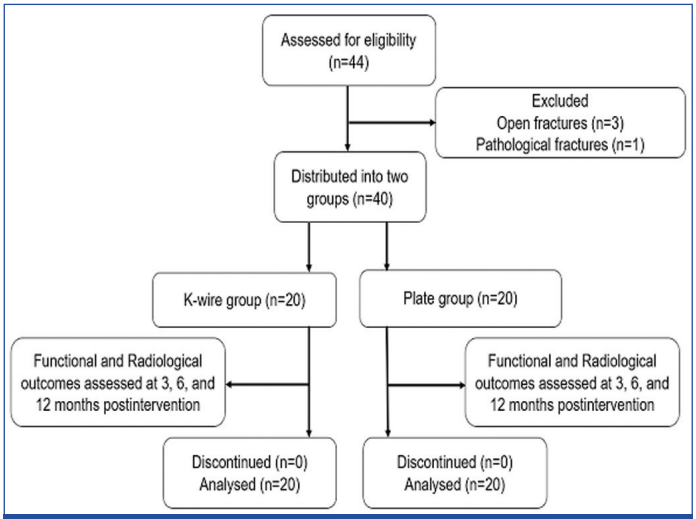
Sample size calculation: A study by Oraby AMH et al., was used to calculate the sample size, and modified Mayo Wrist Score (MMWS) at six months was used. The sample size is determined on the basis of the following formula [8]:

$$n = \left(\frac{Z_{1-\beta} + Z_{1-\frac{\alpha}{2}} * \sqrt{2 * \sigma^2}}{d}\right)^2 = \left(\frac{1.96 + 0.84 * \sqrt{2 * 8.82^2}}{-9}\right)^2 = 15.09$$

Where, σ1=Standard deviation of K-wire=9.78, σ2=Standard deviation of plating=7.75, σ=Pooled standard deviation=8.82, d=Difference in means of two group= -9, α=0.05, β=0.80, Z0.20=0.84 for 80% power, and Z0.025=1.96 for 95% confidence interval.

Thus, sample size required for each group was approximately 15 patients per group. Considering a drop-out rate of 20%, final sample size was calculated to be 18 patients for each group. However, a total of 20 patients per group were enrolled.

Based on the random number table and simple randomisation method, the patients were randomly divided into two equal groups: the K-wire group received closed reduction with percutaneous K-wire fixation (n=20) and the plate group was treated with ORIF using fragment-specific plates (n=20). The blinding was not performed; thus, the patient, surgeon, and the assessor were aware of the procedure. [Table/Fig-1] illustrates the study flowchart.

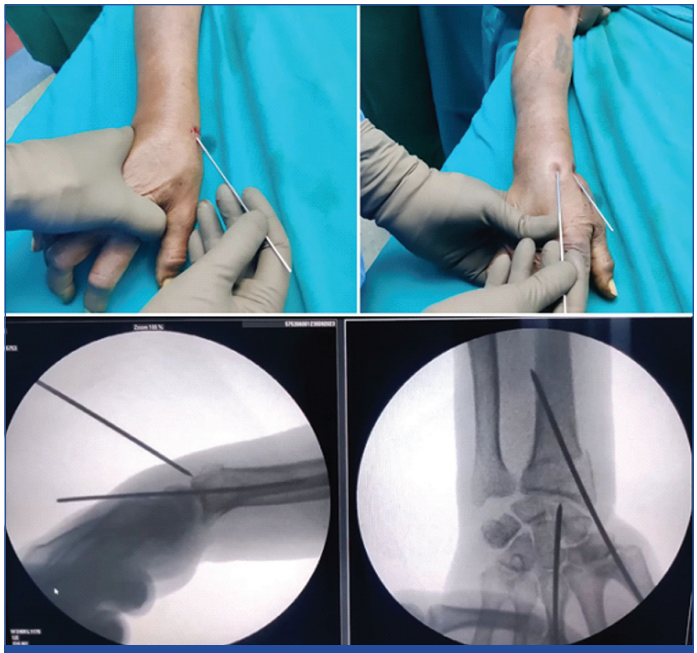


[Table/Fig-1]: Study flowchart.

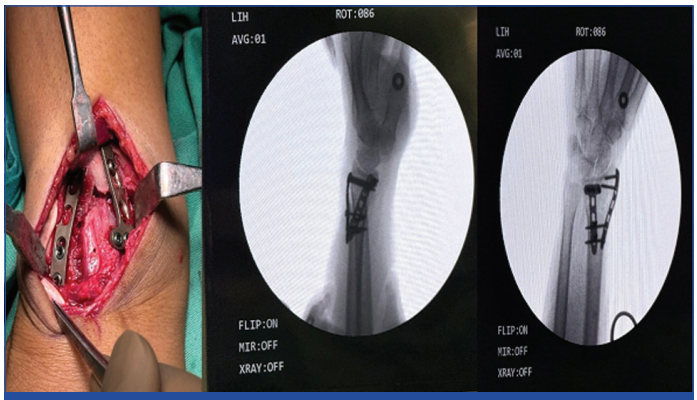
Study Procedure

All procedures were conducted under either regional or general anaesthesia, based on the patient's clinical status and anesthetic fitness. In the K-wire group, fracture reduction was achieved through closed manipulation under fluoroscopic guidance, followed by the insertion of 1.6 mm or 2.0 mm K-wires percutaneously across the fracture site [Table/Fig-2]. The wrist was stabilised with a below-elbow plaster slab. K-wires were typically taken out after 5-6 weeks, after which a brief period of casting was applied for added support prior to starting active physiotherapy. In the Plate group, a standard volar approach was utilised to expose the fracture site. Individual fracture fragments were stabilised using low-profile plates specifically contoured to fit the radial and ulnar columns (Unimedical Biomedical Technologies, Turin - Italy) [Table/Fig-3]. The fixation aimed to restore the anatomical alignment of the articular surface and radial metaphysis. Postoperatively, the limb was immobilised with a splint for a short duration, and early wrist mobilisation exercises were encouraged. Patients in both groups were subjected to an identical rehabilitation protocol.

Postoperative follow-up assessments were carried out at 3, 6, and 12 months. Functional assessment was performed using the



[Table/Fig-2]: Intraoperative image and C-arm images of K-wire fixation.



[Table/Fig-3]: Intraoperative image and C-arm images of fragment specific plate fixation.

MMWS, which considers pain, satisfaction, range of motion, and grip strength [9]. The MMWS is a 100-point scale used to assess wrist function based on pain, satisfaction, range of motion, and grip strength, each contributing 25 points. Scores are interpreted as excellent (90-100), good (80-89), fair (65-79), or poor (<65), offering a reliable evaluation tool for postoperative and trauma-related wrist outcomes [9]. Radiological outcomes were evaluated through conventional anteroposterior and lateral radiographs of the wrist, assessing parameters such as radial height, radial inclination angle, and volar angulation.

STATISTICAL ANALYSIS

IBM Statistical Package for Social Sciences (SPSS) Statistics for Windows, Version 23.0 (Armonk, NY, USA) was used for statistical analysis. Categorical data were presented as counts and corresponding percentages, whereas continuous data were reported as mean values with standard deviations. The Chi-square test and independent sample t-test were used to assess association between categorical and continuous variables, respectively. A two-tailed probability value of <0.05 was considered as statistically significant.

RESULTS

[Table/Fig-3] illustrates the study flowchart. Both K-wire and plate groups did not differ significantly regarding demographic characteristics, age (p=0.626) and sex (p=0.744). Moreover, the groups had comparable co-morbidities (p=0.256), mode of injury (p=0.465), and laterality of fracture (p=0.749). However, the mean operative time (p<0.001) and hospital stay (p<0.001)

were significantly greater in the plate group than the K-wire group [Table/Fig-4].

Characteristics	K-wire group (n=20)	Plate group (n=20)	p-value
Age, Mean±SD, years	42.20±13.58	44.15±11.42	0.626
Sex, n (%)			
Male	13 (65%)	12 (60%)	0.744
Female	7 (35%)	8 (40%)	
Co-morbidity, n (%)			
Yes	3 (15%)	6 (30%)	0.256
No	17 (85%)	14 (70%)	
Mode of injury, n (%)			
Domestic FOOSH	7 (35%)	8 (40%)	0.465
RTA	7 (35%)	8 (40%)	
FOOSH from height	3 (15%)	2 (10%)	
Assault	2 (10%)	1 (5%)	
Other	1 (5%)	1 (5%)	
Laterality, n (%)			
Right	12 (60%)	11 (55%)	0.749
Left	8 (40%)	9 (45%)	
Operative time, Mean±SD, mins	46.00±6.91	78.95±17.63	<0.001
Hospital stays, Mean±SD, days	3.10±0.72	4.15±0.99	<0.001

[Table/Fig-4]: Baseline demographic and clinical characteristics.
FOOSH: Fall on outstretched hand; RTA: Road traffic accident

At three months, patients in the plate group had higher pain (p=0.080) and grip strength scores (p=0.056) than those in the K-wire group; however, it did not reach statistical significance. While significantly greater proportion of patients in the plate group had higher satisfaction (p=0.003), range of motion (p=0.003), and total scores (p=0.017) [Table/Fig-5].

Outcomes		K-wire group (n=20)	Plate group (n=20)	p-value
Pain	25	0 (0%)	0 (0%)	0.080
	20	2 (10%)	10 (50%)	
	15	7 (35%)	5 (25%)	
	10	8 (40%)	4 (20%)	
	5	2 (10%)	1 (5%)	
	0	1 (5%)	0 (0%)	
Satisfaction	25	0 (0%)	1 (5%)	0.003
	20	0 (0%)	8 (30%)	
	10	11 (55%)	7 (35%)	
	0	9 (45%)	4 (20%)	
Range of motion	25	0 (0%)	0 (0%)	0.003
	15	0 (0%)	9 (45%)	
	10	4 (20%)	4 (30%)	
	5	7 (35%)	5 (25%)	
	0	9 (45%)	2 (10%)	
Grip strength	25	0 (0%)	0 (0%)	0.056
	15	0 (0%)	5 (25%)	
	10	6 (30%)	10 (50%)	
	5	6 (30%)	3 (15%)	
	0	8 (40%)	2 (10%)	
Total score	90-100	0 (0%)	0 (0%)	0.017
	80-89	0 (0%)	0 (0%)	
	65-79	0 (0%)	5 (25%)	
	<65	20 (100%)	15 (75%)	

[Table/Fig-5]: Between group comparison of Mayo modified wrist score at 3 months.

At six months, both the K-wire and the plate groups had comparable pain (p=0.465) and satisfaction scores (p=0.749), while significantly greater proportion of patients in the plate group had higher grip strength (p=0.025), range of motion (p=0.029), and total scores (p=0.039) [Table/Fig-6].

Outcomes		K-wire group (n=20)	Plate group (n=20)	p-value
Pain	25	3 (15%)	6 (30%)	0.465
	20	11 (55%)	10 (50%)	
	15	4 (20%)	4 (20%)	
	10	2 (10%)	0 (0%)	
	5	0 (0%)	0 (0%)	
	0	0 (0%)	0 (0%)	
Satisfaction	25	0 (0%)	2 (10%)	0.749
	20	11 (55%)	10 (50%)	
	10	9 (45%)	8 (40%)	
	0	0 (0%)	0 (0%)	
Range of motion	25	0 (0%)	5 (25%)	0.029
	15	8 (40%)	6 (30%)	
	10	12 (60%)	8 (40%)	
	5	0 (0%)	1 (5%)	
	0	0 (0%)	0 (0%)	
Grip strength	25	0 (0%)	5 (25%)	0.025
	15	5 (25%)	7 (35%)	
	10	11 (55%)	7 (35%)	
	5	4 (20%)	1 (5%)	
	0	0 (0%)	0 (0%)	
Total score	90-100	0 (0%)	4 (20%)	0.039
	80-89	0 (0%)	1 (5%)	
	65-79	4 (20%)	5 (25%)	
	<65	16 (80%)	10 (50%)	

[Table/Fig-6]: Between group comparison of Mayo modified wrist score at 6 months.

At 12 months, significantly greater proportion of patients in the plate group had higher pain (p=0.028) and grip strength scores (p=0.010). However, the Plate and the K-wire groups did not differ in terms of satisfaction (p=0.311), range of motion (p=0.055), and total scores (p=0.120) [Table/Fig-7].

Throughout the study period, both the K-wire and the Plate groups had comparable radial inclination (p>0.05). At three months, the mean radial height was significantly greater in the Plate group (p=0.012), while both the groups did not differ in volar tilt (p=0.116). During the subsequent follow-ups at six and 12 months, the patients

Outcomes		K-wire group (n=20)	Plate group (n=20)	p-value
Pain	25	12 (60%)	18 (90%)	0.0285
	20	7 (35%)	2 (10%)	
	15	1 (5%)	0 (0%)	
	10	0 (0%)	0 (0%)	
	5	0 (0%)	0 (0%)	
	0	0 (0%)	0 (0%)	
Satisfaction	25	5 (25%)	8 (40%)	0.311
	20	13 (65%)	12 (60%)	
	10	2 (10%)	0 (0%)	
	0	0 (0%)	0 (0%)	
Range of motion	25	5 (25%)	12 (75%)	0.055
	15	15 (75%)	8 (25%)	
	10	0 (0%)	0 (0%)	
	5	0 (0%)	0 (0%)	
	0	0 (0%)	0 (0%)	

Grip strength	25	4 (20%)	12 (60%)	0.010
	15	13 (65%)	8 (40%)	
	10	3 (15%)	0 (0%)	
	5	0 (0%)	0 (0%)	
	0	0 (0%)	0 (0%)	
Total score	90-100	5 (25%)	10 (50%)	0.120
	80-89	3 (15%)	5 (25%)	
	65-79	10 (50%)	5 (25%)	
	<65	2 (10%)	0 (0%)	

[Table/Fig-7]: Between group comparison of Mayo modified wrist score at 12 months.

in the Plate group had significantly greater radial height (p=0.003 and <0.001, respectively) and volar tilt (both p<0.001) [Table/Fig-8], thus resulting in better radiological outcome compared to the K-wire group.

Outcomes		K-wire group (n=20)	Plate group (n=20)	p-value
Radial inclination (°)	3 months	20.40±3.19	19.10±1.59	0.114
	6 months	18.45±3.99	18.20±1.88	0.802
	12 months	16.10±3.19	17.35±1.18	0.113
Radial height (mm)	3 months	10.50±2.42	12.40±2.14	0.012
	6 months	11.25±1.74	13.65±2.78	0.003
	12 months	9.85±1.35	14.50±3.05	<0.001
Volar tilt (°)	3 months	9.45±1.39	8.65±1.73	0.116
	6 months	7.35±1.76	10.30±1.69	<0.001
	12 months	6.25±1.21	10.80±1.20	<0.001

[Table/Fig-8]: Between group comparisons of radiological outcomes at 3, 6 and 12 months.

Postoperatively, 2 (10%) patients in the K-wire group had minor pin tract infections that resolved with oral antibiotics, while 3 (15%) patients in the plating group had mild stiffness that was managed with physiotherapy.

[Table/Fig-9] illustrates pre-operative and postoperative radiograph of ulnar neck fracture with DRF fixed with fragment specific plates. [Table/Fig-10] illustrates postoperative radiographs showing the clinical application of the four methods of K-wire fixation.

[Table/Fig-9]: Pre-operative and postoperative radiograph of ulnar neck fracture with Distal Radius Fracture (DRF) fixed with fragment specific plates.

[Table/Fig-10]: Postoperative radiographs showing the clinical application of the four methods: (a) two-wire Kapandji's configuration; (b) three-wire Kapandji's configuration; (c) two-wire interfragmentary configuration; (d) three-wire interfragmentary configuration.

DISCUSSION

In summary, while both techniques are effective for DRFs management, FSP not only provides significantly better functional recovery but also achieves statistically superior radiological outcomes, making it the preferred choice for anatomically complex or intra-articular fractures. Conversely, K-wiring remains a valid option for selected cases, especially when minimally invasive methods are clinically indicated.

In this comparative study of K-wire vs. Plate fixation, both groups were demographically similar, thus suggesting homogenous nature of the groups. At various follow-up points, the Plate group showed superior outcomes: higher range of motion and total scores at three and six months, greater grip strength at six and 12 months, and higher satisfaction and pain scores at three and 12 months, respectively. Radial inclination was similar between groups throughout, and volar tilt was comparable at three months. The plate group exhibited superior radiological parameters, demonstrating greater radial height at three months and significantly increased radial height and volar tilt at both six and 12 months in comparison to the K-wire group, albeit at the expense of significantly prolonged operative time and hospital stay.

In the present study, the overall functional outcome was significantly better in the Plate group. A study by Oraby AMH et al., reported that the Plate group had a significantly higher MMWS at both three and six months [8]. Similarly, Bahari-Kashani M et al., and Samal BP et al., demonstrated that use of plating system led to significantly higher MMWS than K-wire [10,11]. Moreover, in a pooled quantitative analysis, Franceschi F et al., reported that locking plate resulted in significantly better functional outcome compared to K-wire [12]. Thus, the plating group consistently proves superior functional outcomes compared to the K-wire group. The more reliable fracture reduction and maintenance of alignment is attributed to the rigid support provided by the plate and screws. This supports earlier conclusions that plate fixation is advantageous for DRFs [7].

In the present study, the overall radiological outcome was significantly better in the Plate group. A study by Wutphiriya-angkul S reported that the Plate group exhibited marginally superior radiographic parameters at the 6-month postoperative follow-up compared to the K-wire group; however, the differences were not statistically significant [13]. Similarly, Radaideh A et al., observed that volar tilt, radial height, and radial inclination differed between the Plate and the K-wire groups; however, this difference did not reach statistical significance [14]. These findings were further confirmed by a pooled quantitative analysis in which Franceschi F et al., reported that locking plate and K-wire had comparable radiological outcomes [12]. These results suggest improved anatomical alignment, which could support better long-term joint function and lower the risk of

complications. Complications were minimal and manageable in both groups [15]. Minor pin tract infections occurred in the K-wire group, while mild stiffness was noted in a few plating cases, resolving with physiotherapy. No major hardware-related or neurovascular complications were reported.

K-wire fixation, due to its minimally invasive nature, offered benefits such as shorter operative duration and a decreased length of hospital stay. This makes it particularly suitable for elderly patients or those with significant co-morbidities who may not tolerate prolonged surgical procedures. The simplicity of the technique and minimal soft-tissue disruption contribute to its continued relevance in clinical practice [16]. However, the trade-off appears in the form of slower functional recovery, particularly with respect to grip strength and range of motion.

While both techniques are valid, the choice between K-wiring and plating should be individualised. K-wiring remains a valuable option for simple fractures or patients needing a shorter, less invasive procedure. Plating, on the other hand, offers superior functional recovery and should be preferred for complex or intra-articular fractures. Surgeon expertise, patient activity level, and fracture morphology should guide the treatment decision to ensure optimal outcomes.

Limitation(s)

This study had certain limitations. Only 40 patients (20 in each group) were included in the study, which might have limited how broadly the results can be applied. Stronger statistical power would result from a larger sample size. Although the study followed patients for up to 12 months, long-term outcomes, such as late complications, arthritis and functional deterioration, were not assessed. While efforts were made to compare similar fracture types, some variation in fracture complexity might have affected the outcomes. Only MMWS was used; additional validated scoring systems, such as DASH or PRWE, could have provided a more comprehensive assessment. Finally, blinding was not performed, thus leading to observer bias.

CONCLUSION(S)

This study presents an in-depth comparison of K-wiring and FSP for the surgical management of DRFs. Both techniques were effective in achieving fracture union and restoring wrist function. However, the FSP group demonstrated significantly better functional outcomes, particularly in terms of grip strength, range of motion and pain relief at six and 12 months postoperatively. These superior results can be attributed to the anatomical restoration and stable fixation provided by the fragment-specific approach, which facilitates early mobilisation and improved rehabilitation. Radiological outcomes also favoured the FSP group, with statistically significant improvements in radial height and volar tilt at the 12-month follow-up. However, radial inclination was comparable between the groups at all follow-up intervals. These findings indicate better anatomical alignment, which may contribute to long-term joint function and reduced complications. In contrast, the K-wiring group was associated with quicker surgical procedures, shorter hospitalisation periods, and lower overall treatment costs. It remains a suitable option for elderly patients or those with co-morbidities who require a less invasive procedure. Further studies with larger sample size and follow-up beyond 12 months are required to confirm superiority of FSP over K-wiring in patients with DRFs.

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