RESEARCH PAPER

Comparative Study of Functional and Radiological Outcomes of MIROS and Multiple Percutaneous K-Wire Fixation in the Management of Proximal Humerus Fractures: A Prospective Analysis

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ABSTRACT

Background: Proximal humerus fractures are common injuries, particularly in the elderly, and their optimal management remains controversial. Minimally invasive techniques such as percutaneous K-wire fixation and the Minimally Invasive Reduction and Osteosynthesis System (MIROS) have gained popularity due to their potential to preserve vascularity and reduce complications.

Objective: To compare the radiological and functional outcomes of MIROS technique with conventional multiple K-wire fixation in the management of proximal humerus fractures.

Methods: A prospective comparative study was conducted from May 2024 to May 2025 at a tertiary care centre. Eighteen patients aged ≥18 years with displaced proximal humerus fractures were included and equally divided into two groups: K-wire fixation (n=9) and MIROS (n=9). Patients were evaluated clinically and radiologically using serial X-rays, with computed tomography performed in selected cases. Fractures were classified using the Neer classification. Functional outcomes were assessed at 6 months using the Constant–Murley Score. Statistical analysis was performed using SPSS version 20.

Results: Baseline demographic and operative parameters were comparable between the groups. The mean time to union was shorter in the MIROS group (8.5 ± 1.2 weeks) compared to the K-wire group (11.2 ± 6.1 weeks), though not statistically significant (p=0.24). Functional outcomes, including pain, range of motion, power, and activities of daily living, were consistently better in the MIROS group, with a higher mean Constant score (82.3 vs 75.6), but without statistical significance (p=0.40). Complications were more frequent in the K-wire group, including delayed union and pinrelated issues, whereas MIROS demonstrated fewer complications overall.

Conclusion: Both K-wire fixation and MIROS provide satisfactory clinical and radiological outcomes in proximal humerus fractures. Although not statistically significant, MIROS shows a trend toward improved functional outcomes, earlier union, and fewer complications, suggesting it may be a preferable option in selected cases.

Keywords: Proximal humerus fracture; MIROS technique; K-wire fixation; Percutaneous pinning; Neer classification; Minimally invasive osteosynthesis; Constant–Murley score.

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INTRODUCTION

Fractures of the proximal humerus are among the most frequently encountered injuries in the elderly population, ranking third after wrist and hip fractures. They account for approximately 5% of all appendicular skeletal injuries. In contrast, in children and adolescents, these fractures are most often caused by high-energy mechanisms such as road traffic accidents, falls from significant heights, or participation in vigorous sports activities. Rarely, they may also result from intense muscle contractions, as seen during

seizures or electrical shocks.

The classification of proximal humeral fractures is commonly based on the system proposed by Neer. According to this system, fractures are categorised into one-part, two-part, three-part, and four-part types, along with fracture-dislocations and articular surface injuries. A fragment is considered displaced when it is separated by more than 1 cm or angulated beyond 45 degrees from its anatomical position.

Management strategies for these fractures depend on multiple factors, including patient age, bone quality, functional demands, fracture pattern, and the surgeon's expertise. Evidence suggests that displaced fractures of the proximal humerus tend to have unfavorable functional outcomes if not managed appropriately.

Traditionally, hemiarthroplasty has been preferred for complex three- and four-part fractures due to the high risk of avascular necrosis of the humeral head. However, over the past two decades, a better understanding of the vascular anatomy has led to a shift toward preservation techniques, with reduction and fixation—either internal or external—being increasingly employed even in more complex fracture patterns.

Closed reduction and percutaneous pinning (CRPP), first described by Bohler in 1962, has gained wider acceptance in recent years. Minimally invasive approaches such as percutaneous pinning have become popular alternatives to open reduction and extensive internal fixation, as they minimize soft tissue disruption and reduce the risk of complications like avascular necrosis. These techniques are particularly effective in patients with good bone stock, especially for unstable twopart surgical neck fractures and selected three- and four-part injuries.

The Minimally Invasive Reduction and Osteosynthesis System (MIROS) is another technique designed for the management of proximal humeral fractures. It utilizes elastic K-wires that are stabilized externally using a clamp, allowing correction of angular deformity and stabilization of fracture fragments. The procedure is relatively simple and does not require extensive instrumentation. A modified version of MIROS employs intramedullary elastic nails for improved reduction and fixation, with Ilizarov cubes replacing the conventional clamp.

The present study aims to evaluate and compare the radiological and functional outcomes of the MIROS technique with those of conventional multiple K-wire fixation in the treatment of proximal humeral fractures.

MATERIALS & METHODS

A Prospective Comparative Study was conducted in the period from May 2024 to May 2025.

- **Study Area**: Adichunchanagiri Institute of Medical Sciences.
- **Study Population**: All Male\Female patients aged 18 or more displaced proximal humerus fracture admitted in the hospital which comes under inclusion criteria
- **Objective**: To compare the radiological and functional outcome of MIROS technique and traditional multiple K-wires fixation for the treatment of proximal humeral fractures.
- **INCLUSION CRITERIA:** Patients with post traumatic proximal humeral fractures, and age more than 18 years old.
- **EXCLUSION CRITERIA:** Patients with open fractures of proximal humerus, pathological fractures, patients not willing to give consent, patients with previous injuries that have already compromised function and movement of shoulder and patients having neurovascular deficit.
- Half of patients were treated by K-wires and the other by MIROS technique.

This is what all of the participants in this research had to go through:

1. A thorough review of the patient's medical history and an orthopaedic examination.
2. Radiologically by anteroposterior view and axillary view of proximal humerus, shoulder Xray and computed tomography (CT) in selected cases, then were classified according to Neer's classification,
3. All patients had full preoperative lab investigation before surgery including: Complete blood picture,Random blood sugar, Viral screen, Coagulation studies (PT/PTT) as well as Kidney and liver function tests.

SURGICAL TECHNIQUE

1. K-wire Fixation Group

Anesthesia:

All patients underwent the procedure under general anesthesia. A broad-spectrum antibiotic was administered prophylactically prior to induction to reduce the risk of infection.

Patient Positioning:

The patient was placed in a supine position. The affected shoulder was positioned slightly beyond the edge of the operating table to allow optimal visualisation using fluoroscopy. Before sterile draping, anteroposterior (AP) and axillary views were obtained with an image intensifier to confirm clear visualisation of the fracture and proper anatomical orientation.

Preparation and Draping:

The operative field was prepared in a sterile manner, covering the anterior and posterior aspects of the chest. The area extended from the midline up to the base of the neck to ensure adequate exposure.

Reduction and Pinning Technique:

Fracture reduction was initially achieved through gentle manual traction combined with controlled manipulation of the arm. In cases where reduction was difficult, a 3.5 mm K-wire was used as a joystick to assist in aligning the fragments. Additionally, a blunt elevator could be employed to mobilise and reposition the humeral head fragments when necessary.Reduction was considered satisfactory once acceptable alignment was confirmed on both anteromedial

and axillary fluoroscopic views.

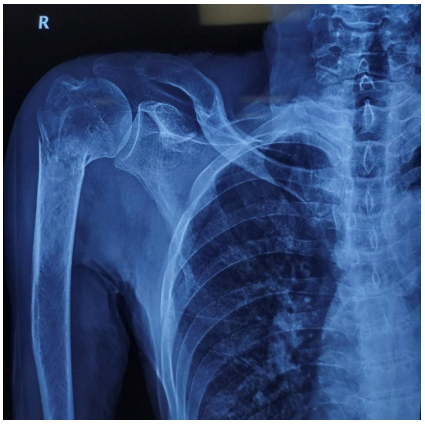

Fig.1:Pre-op radiograph of a 65 year old male.

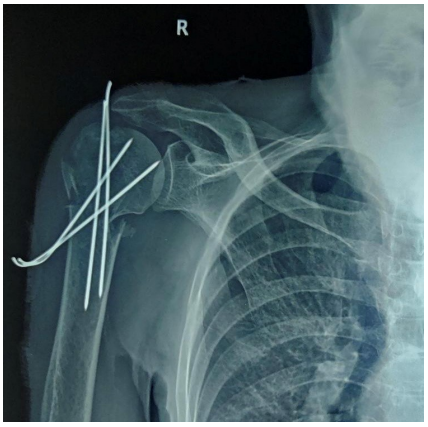

Fig.2: Immediate post op X-ray radiograph of fracture fixation with multiple K-wires

2. MIROS Group

Anesthesia:

All patients underwent surgery under general anesthesia. Prophylactic administration of a broadspectrum antibiotic was carried out prior to induction to minimise the risk of postoperative infection.

Patient Positioning:

The patient was placed in a supine position, with the affected shoulder positioned slightly beyond the edge of the operating table to allow unobstructed fluoroscopic assessment. Before sterile draping, anteroposterior (AP) and axillary views were obtained using an image intensifier to confirm clear visualisation of the fracture and proper identification of bony landmarks.

Preparation and Draping:

The entire upper torso was sterilised and draped, extending from both shoulders to the base of the neck and across the anterior chest along the midline, ensuring adequate exposure of the operative field.

Reduction and Fixation Technique:

Initial fracture reduction was achieved through traction and gentle manipulation of the limb, with confirmation obtained using AP and axillary fluoroscopic imaging. When closed reduction was difficult, a Steinmann pin was utilised to assist in aligning the fracture fragments.

In cases of significant displacement where satisfactory reduction could not be achieved by manipulation alone, one or two elastic k wires of equal diameter were introduced. These were advanced across the fracture site into the proximal metaphyseal region of the humerus to aid stabilisation.

Subsequently, fixation was reinforced using K-wires. The first wire was inserted through the greater tuberosity and advanced medially to engage the medial cortex. A second K-wire was introduced into the humeral head and directed to penetrate the distal humeral cortex. Additional K-wires were inserted from the proximal metaphysis, distal to the fracture site, and advanced cranially into the subchondral bone of the humeral head to enhance stability.

Elastic K-wires are externally secured in a metal clamp, allowing for decrease of angular displacement and fixing of fracture fragments.After confirming adequate fixation and ensuring that no hardware had breached the articular surface, passive range-of-motion testing was performed under fluoroscopic guidance to assess stability and construct integrity.

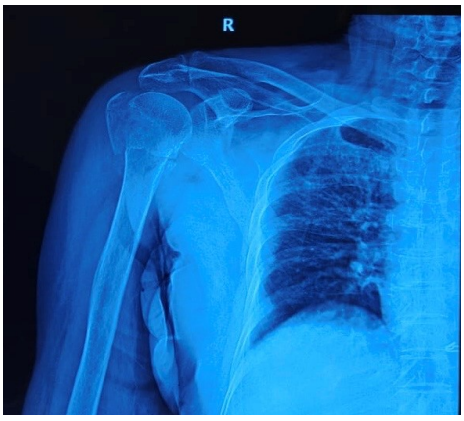

Fig.3:Pre-op radiograph of a 62 year old female

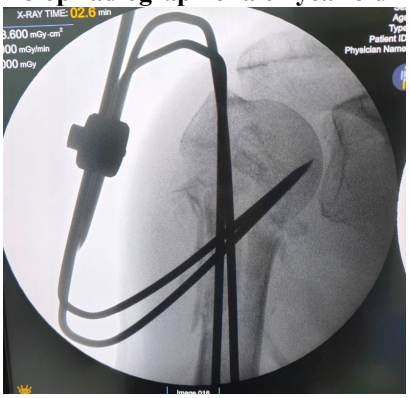

Fig.4:Intra-op C arm picture of fracture fixation with MIROS

Postoperative Protocol and Follow-up

Patients were monitored over a follow-up period of six months. Radiographic assessments were performed at two-week intervals until fracture union was achieved and the fixation pins were removed. Additional evaluations were carried out at 3 months and 6 months postoperatively.

Functional outcomes were assessed at the end of the follow-up period using the Constant–Murley Score (CS), a 100-point scoring system designed to evaluate shoulder function.

Statistical Analysis

Data analysis was conducted using the Statistical Package for the Social Sciences (SPSS), version 20. Quantitative variables were expressed as mean, standard deviation, and range, while qualitative variables were summarised as frequencies and percentages.

For comparison of quantitative independent variables, the Student's t-test was applied. The Pearson chi-square test was used to analyse categorical data. A p-value of ≤ 0.05 was considered statistically significant.

RESULTS

Table 1: Demographic Profile

The demographic characteristics of both groups were comparable, with similar mean age distribution and equal gender representation. The prevalence of comorbidities and smoking habits showed no statistically significant difference between groups. This indicates a well-matched baseline population, allowing reliable comparison of outcomes.

VARIABLE		THE K WIRE GROUP		THE MIROS GROUP		P VALUE
		No.	%	No	%	
Age		56.1 +/- 10.9		54.2 +/- 10.3		0.79
Gender	Male	4	44.4	3	33.3	1
	Female	5	55.6	6	66.7	
Chronic illness	Yes	4	44.4	3	33.3	0.34
	No	5	55.6	6	66.7	
Smoking	Yes	2	22.2	3	33.3	0.26
	No	7	77.8	6	66.7	

Table 2: Operative Data

Operative parameters such as time to surgery and duration of surgery were similar in both groups, with no statistically significant difference. Although the MIROS group had a slightly longer operative time, this was not clinically meaningful. Overall, both techniques demonstrated comparable intraoperative profiles.

Variable	K-wire Group	MIROS Group	p-value
Time to surgery (days)	3.4 ± 1.7	3.1 ± 1.4	0.88
Duration of surgery (min)	57.2 ± 9.8	63.5 ± 11.9	0.26

Neer Classification

The distribution of fracture types (2-part, 3-part, and 4-part) was similar between the K-wire and MIROS groups. No statistically significant difference was observed, indicating comparable fracture severity in both groups. This ensures that outcome differences are not influenced by fracture pattern variation.

Type	K-wire	MIROS	p-value
2-part	3 (33.3%)	3 (33.3%)	0.84
3-part	4 (44.4%)	3 (33.3%)	
4-part	2 (22.2%)	3 (33.3%)	

Table 3: Radiological Union

The mean time to fracture union was shorter in the MIROS group compared to the K-wire group, suggesting faster healing. However, the difference was not statistically significant. This trend may reflect better stability provided by the MIROS construct.

Parameter	K-wire	MIROS	p-value
Union time (weeks)	11.2 ± 6.1	8.5 ± 1.2	0.24

Table 4: Functional Outcome (Constant Score)

The MIROS group demonstrated higher mean Constant scores across all components, including pain, range of motion, power, and activities of daily living. Despite better functional trends, the differences were not statistically significant. Both techniques ultimately provided satisfactory functional outcomes.

Parameter	K-wire	MIROS	p-value
Pain	8.6 ± 4.7	11.4 ± 3.1	0.21
ROM	31.2 ± 7.0	33.1 ± 7.8	0.65
Power	20.7 ± 2.4	21.5 ± 3.2	0.64
ADL	15.0 ± 2.6	16.9 ± 3.5	0.21
Total Score	75.6 ± 16.9	82.3 ± 17.1	0.40

Range of Motion

Range of motion was marginally better in the MIROS group for flexion, abduction, and rotational movements. However, these differences were not statistically significant. This suggests a trend toward improved mobility with MIROS, possibly due to enhanced fixation stability.

Movement	K-wire	MIROS	p-value
Flexion	126.1 ± 27.5	133.4 ± 30.2	0.69
Abduction	129.2 ± 28.7	136.8 ± 31.4	0.70
Internal Rotation	8.2 ± 1.3	8.7 ± 1.8	0.47
External Rotation	7.9 ± 1.2	8.4 ± 1.5	0.57

Table 5: Complications

Complication rates were higher in the K-wire group compared to the MIROS group, although the difference was not statistically significant. Notably, delayed union and nonunion occurred only in the K-wire group. MIROS showed fewer complications overall but had one case of subluxation.

Variable	K-wire Group (N=9)	MIROS Group (N=9)	Pvalue
COMPLICATION			
Present	5 (55.6%)	4 (44.4%)	0.62
Absent	4 (44.4%)	5 (55.6%)	
TYPE OF COMPLICATION			
Pin tract infection	2	1	
Stiffness	2	2	
Delayed union	1	0	
Pin migration + GT displacement	1	0	
Nonunion	0	0	
Inferior subluxation of glenohumeral joint	0	1	

Table 6: Functional Grading

A higher proportion of patients in the MIROS group achieved excellent outcomes, while fewer patients had poor results compared to the K-wire group. However, the overall distribution of outcomes was not statistically significant. This indicates both techniques yield comparable clinical success, with a slight advantage for MIROS.

Outcome	K-wire	MIROS
Excellent	2 (22.2%)	3 (33.3%)
Good	3 (33.3%)	3 (33.3%)
Fair	2 (22.2%)	2 (22.2%)
Poor	2 (22.2%)	1 (11.1%)

DISCUSSION :

This study compared the clinical and radiological outcomes of K-wire fixation and MIROS technique in proximal humerus fractures. Both groups were demographically comparable, ensuring a balanced baseline for outcome assessment.

Operative variables, including timing of surgery and duration, were similar between the groups. Although the MIROS technique required slightly longer operative time, this difference was not statistically significant and may reflect the additional steps involved in achieving stable fixation.

Radiological union occurred earlier in the MIROS group; however, the difference did not reach statistical significance. This trend may be related to the enhanced stability provided by the construct, which supports better fracture healing conditions.

Functional outcomes assessed using the Constant score were higher in the MIROS group across all domains, including pain relief, range of motion, muscle strength, and daily activities. Despite this consistent trend, the differences were not statistically significant, indicating that both techniques provide comparable overall functional recovery. Range of motion was marginally improved in the MIROS

group, particularly in flexion and abduction. This may be attributed to improved fixation stability allowing earlier mobilisation and reduced joint stiffness.

The incidence of complications was higher in the K-wire group, with cases of delayed union and nonunion observed only in this group. In contrast, the MIROS group demonstrated fewer complications overall, although one patient developed inferior glenohumeral subluxation, emphasising the need for careful postoperative monitoring.

Functional outcome grading showed a greater proportion of excellent results and fewer poor outcomes in the MIROS group. However, statistical analysis confirmed no significant difference between the two techniques.

In conclusion, both K-wire fixation and MIROS are effective treatment options for proximal humerus fractures. While MIROS demonstrates a trend toward improved functional outcomes and fewer complications, the choice of technique should be individualised based on fracture pattern and surgical expertise.

CONCLUSION :

Based on the findings of this study and using the observed results as reference, both K-wire fixation and MIROS technique provide satisfactory clinical and radiological outcomes in the management of proximal humerus fractures.

Although statistical analysis did not demonstrate a significant difference between the two groups across functional scores, range of motion, fracture union, and complication rates, the MIROS technique consistently showed a trend toward better functional outcomes, earlier fracture union, and a relatively lower complication profile.

K-wire fixation remains a reliable, simpler, and cost-effective option, particularly in patients with lower surgical demands or higher operative risks. However, MIROS offers the advantage of improved construct stability, which may facilitate earlier mobilisation and potentially better functional recovery.

Therefore, while both techniques are comparable in effectiveness, MIROS may be preferred in selected cases where enhanced stability and early rehabilitation are desired. The final choice of treatment should be individualised, taking into account fracture configuration, bone quality, and surgeon expertise.

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