Section: Orthopaedics

Original Research Article

EVALUATION OF CLINICAL AND RADIOLOGICAL OUTCOMES OF MIROS VERSUS ORIF IN ADULT DISTAL HUMERUS FRACTURES

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ABSTRACT

Background: Distal humerus fractures in adults pose a challenge due to complex anatomy and joint involvement. Conventional open reduction and internal fixation (ORIF) is widely practiced, while the minimally invasive reduction osteosynthesis system (MIROS) has emerged as a newer technique aiming to reduce soft tissue disruption. The objective is to compare the clinical and radiological outcomes of MIROS versus ORIF in the management of distal humerus fractures in adults. **Materials and Methods:** A prospective comparative study was conducted in the Department of Orthopaedics, All India Institute of Medical Sciences (AIIMS), Gorakhpur, during the period January 2024 to April 2025, including adult patients with closed distal humerus fractures. Patients were randomized into two groups: Group A (MIROS) and Group B (ORIF). Functional outcomes were assessed using the Mayo Elbow Performance Score (MEPS) and range of motion (ROM), while radiological union was evaluated via serial imaging. **Result:** A total of 40 patients (20 in each group) were included. Group A showed statistically significant better early postoperative ROM ($p<0.05$) and shorter operative time, while Group B had slightly higher rates of anatomic reduction on radiographs. No major differences were noted in complication rates or MEPS scores at 6 months. **Conclusion:** MIROS is a reliable alternative to ORIF in managing distal humerus fractures in adults, offering better early mobility and less soft tissue dissection without compromising functional outcome.

INTRODUCTION

Distal humerus fractures are complex injuries that account for approximately 2% of all fractures and nearly one-third of humeral fractures in adults, frequently resulting from high-energy trauma in young individuals or low-energy falls in the elderly with osteoporotic bones.[1,2] These fractures often involve the articular surface, requiring precise anatomical reduction and stable fixation to restore elbow function and prevent long-term disability.[3] Open reduction and internal fixation (ORIF) using plates and screws has been the standard approach for treating these fractures, offering rigid fixation and direct visualization for anatomical reduction; however, this technique involves extensive soft tissue dissection, leading to complications such as wound infection, ulnar neuropathy, joint stiffness, and delayed rehabilitation.[4,5]

In recent years, minimally invasive techniques have been explored to overcome these limitations. The Minimal Invasive Reduction Osteosynthesis System (MIROS) represents a hybrid fixator that offers stable fracture fixation with minimal soft tissue disruption, reduced surgical time, and improved postoperative recovery.[6] MIROS employs a combination of elastic pins and external frame stabilization, aiming to preserve the biology of fracture healing and decrease surgical morbidity.[7] However, there is limited literature comparing MIROS with conventional ORIF, particularly in terms of long-term functional and radiological outcomes.

This study was undertaken to evaluate and compare the clinical and radiological outcomes of MIROS

versus ORIF in adult patients with distal humerus fractures. The goal is to assess whether MIROS provides equivalent or superior results to ORIF in functional recovery, early mobilization, complication rates, and fracture union.

MATERIALS AND METHODS

The study was designed as a prospective, comparative, interventional hospital-based study. It was conducted in the Department of Orthopaedics at All India Institute of Medical Sciences (AIIMS), Gorakhpur, Uttar Pradesh, a tertiary care teaching institution serving both urban and rural populations. The study was carried out over a period of 18 months, from January 2024 to June 2025. The study population included adult patients presenting with closed distal humerus fractures who met the defined inclusion criteria.

Inclusion Criteria

- Age between 18 and 65 years
- Closed fractures of the distal humerus confirmed by radiographic imaging
- Willingness to undergo surgery and attend regular follow-up
- Written informed consent provided

Exclusion Criteria

- Open or compound fractures
- Pathological fractures
- Polytrauma patients
- Patients with associated neurovascular injury
- Patients unfit for anaesthesia or surgery
- Non-consenting individuals

Sample Size: A total of 40 patients were included in the study using purposive sampling, with 20 patients in Group A (MIROS) and 20 patients in Group B (ORIF).

Randomization Technique: Patients were allocated into two groups alternately (odd-numbered patients assigned to MIROS and even-numbered to ORIF) at the time of admission.

Intervention Details

Group A (MIROS Group): Under general or regional anaesthesia, fracture fixation was performed using the MIROS technique, employing flexible intramedullary wires with an external frame for stabilization, using minimally invasive incisions and fluoroscopic guidance.

Group B (ORIF Group): Under anaesthesia, standard posterior triceps-splitting approach was used. Fractures were reduced and stabilized using pre-contoured anatomical locking plates and screws.

Postoperative Protocol:

- Both groups received similar postoperative care including pain management, antibiotics, and limb elevation.
- Early physiotherapy and range-of-motion exercises were initiated based on pain tolerance and fracture stability.
- Follow-up was conducted at 2, 6, 12, and 24 weeks.

Outcome Measures:

Clinical Parameters

- Elbow Range of Motion (ROM) measured with goniometer at each follow-up
- Functional assessment using Mayo Elbow Performance Score (MEPS) at 6 weeks, 12 weeks, and 24 weeks

Radiological Parameters

- Fracture union assessed on X-rays at 6 weeks and 12 weeks using standard AP and lateral views
- Assessment for malunion, non-union, implant loosening, or joint incongruity

Complications Recorded

- Infection (superficial or deep)
- Nerve injury
- Implant-related complications
- Reoperation or conversion to other fixation method

Data Collection & Documentation: All clinical, operative, and follow-up data were recorded in a predesigned proforma. Radiographs were reviewed by two independent orthopaedic surgeons.

Steps of Operation

A. MIROS Technique (Minimal Invasive Reduction Osteosynthesis System)

Preoperative Preparation

- Patient was placed in the lateral or prone position under general or regional anaesthesia.
- Aseptic cleaning and draping were done. Fluoroscopy (C-arm) was positioned for intraoperative imaging.

Fracture Reduction

- Closed or mini-open reduction was performed using manual traction and manipulation under fluoroscopic guidance.
- Anatomical alignment was confirmed in both anteroposterior and lateral views.

Pin Insertion

- Entry points were marked on the skin based on preoperative imaging and fracture geometry.
- Flexible MIROS elastic pins were inserted percutaneously or through minimal incisions at planned angles (usually diverging to maximize stability).
- Pins were advanced through both cortices under C-arm guidance ensuring optimal purchase without breaching the joint.

Frame Attachment

- A MIROS fixator bar (external frame) was attached to the pins using modular clamps to create a semi-rigid construct.
- The external frame was adjusted to maintain the fracture reduction and allow micromotion for callus formation.

Final Assessment and Closure

- Fluoroscopic confirmation of reduction, implant position, and elbow alignment was done.
- Small incisions were closed with absorbable sutures or skin adhesive.
- Sterile dressing was applied, and postoperative radiographs were taken.

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B. ORIF Technique (Open Reduction and Internal Fixation)

Preoperative Preparation

- Patient was placed in the lateral decubitus or prone position with the affected arm supported.
- General or regional anaesthesia was administered, followed by painting and draping.

Surgical Exposure

- A standard posterior midline skin incision was made over the distal humerus.
- The triceps-splitting or paratricipital approach was used to expose the fracture site.
- Care was taken to identify and protect the ulnar nerve, which was mobilized and retracted or transposed if required.

Fracture Reduction

- The fracture fragments were identified, cleaned of hematoma and debris, and anatomically reduced under direct visualization.
- Temporary fixation with K-wires or reduction clamps was used.

Internal Fixation

- Pre-contoured dual locking compression plates (LCP) were applied to the medial and lateral columns (orthogonal or parallel plating based on fracture type).
- Screws were inserted to achieve stable fixation and restore articular congruity.

Ulnar Nerve Management

- The ulnar nerve was either left in situ (if protected) or transposed anteriorly as per surgeon preference.

Wound Closure

- Hemostasis was achieved; a suction drain was placed if required.
- Layered closure was performed using absorbable sutures for deep tissues and non-absorbable sutures for skin.
- Sterile dressing and posterior splint were applied, and postoperative radiographs were obtained.

Statistical Analysis: Data were entered into Microsoft Excel and analysed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Intergroup comparisons were performed using the independent t-test for continuous variables and the Chi-square test for categorical variables. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The results of the study demonstrated that both groups were comparable in terms of baseline characteristics, with the mean age being 42.6 ± 12.4 years in the MIROS group and 44.2 ± 13.1 years in the ORIF group, and the male-to-female ratios were 14:6 and 13:7 respectively, showing no statistically significant difference ($p > 0.05$).

Table 1: Demographic Characteristics

Parameter	Group A (MIROS)	Group B (ORIF)	p-value
Mean Age (years)	42.6 ± 12.4	44.2 ± 13.1	0.65
Male: Female Ratio	14:6	13:7	0.74

Table 2: Operative Details

Parameter	Group A (MIROS)	Group B (ORIF)	p-value
Mean Operative Time (minutes)	72.4 ± 9.8	94.7 ± 10.6	<0.001
Intraoperative Blood Loss (ml)	112.6 ± 18.4	186.3 ± 21.7	<0.001

The operative parameters revealed that the MIROS group had a significantly shorter operative time (72.4 ± 9.8 minutes) compared to the ORIF group (94.7 ± 10.6 minutes), and also experienced significantly less intraoperative blood loss (112.6 ± 18.4 ml vs. 186.3 ± 21.7 ml), with both differences being highly significant ($p < 0.001$).

Table 3: Functional Outcome – MEPS Scores

Follow-up Time	Group A (MIROS)	Group B (ORIF)	p-value
6 weeks	74.8 ± 7.5	69.2 ± 8.1	0.04
3 months	83.2 ± 6.9	80.3 ± 7.1	0.23
6 months	88.4 ± 5.3	86.9 ± 5.6	0.42

Functional outcomes assessed using the Mayo Elbow Performance Score (MEPS) showed better early recovery in the MIROS group, with scores of 74.8 ± 7.5 at 6 weeks compared to 69.2 ± 8.1 in the ORIF group ($p = 0.04$). However, by 3 and 6 months, MEPS scores between the groups were similar, with no statistically significant differences ($p = 0.23$ and 0.42, respectively).

Table 4: Range of Motion (ROM) Outcomes

Follow-up Time	Group A (MIROS)	Group B (ORIF)	p-value
6 weeks	100.3 ± 12.7	90.6 ± 13.1	0.02

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6 months	126.7 ± 9.4	123.4 ± 8.7	0.27

The range of motion (ROM) at 6 weeks was significantly higher in the MIROS group (100.3 ± 12.7 degrees) than in the ORIF group (90.6 ± 13.1 degrees; p = 0.02), although ROM at 6 months showed no significant difference (126.7 ± 9.4 vs. 123.4 ± 8.7 degrees; p = 0.27).

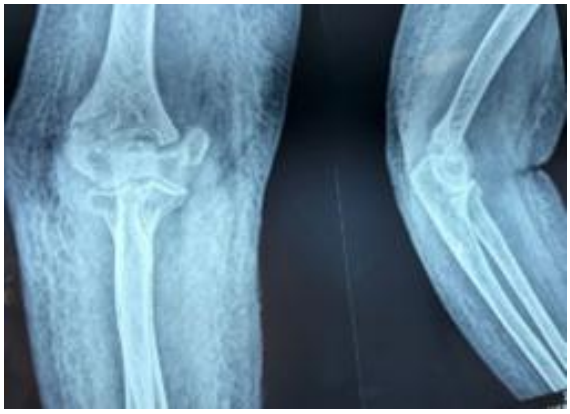
Table 5: Postoperative Complications

Complication	Group A (MIROS)	Group B (ORIF)	p-value
Superficial Infection	1 (5%)	2 (10%)	0.55
Pin Tract Infection	2 (10%)	0	0.14
Non-union	0	1 (5%)	0.31

Postoperative complications were comparable between the groups. Superficial infections occurred in 5% of the MIROS group and 10% of the ORIF group (p = 0.55), while pin tract infections were reported only in the MIROS group (10%), and one case of non-union was observed in the ORIF group. None of these complications reached statistical significance.

Overall, the MIROS technique showed advantages in terms of shorter operative time, reduced blood loss, and faster early functional recovery without increasing complication rates, thereby suggesting that it is a viable alternative to ORIF for the management of adult distal humerus fractures.

40 yrs Female having inter-condylar fracture left humerus following trauma 4 days before.



(Pre operative X-ray of Elbow AP and Lateral view)

(Intra operative image of Elbow)

(X-ray- Elbow AP view Post operative Day 1)

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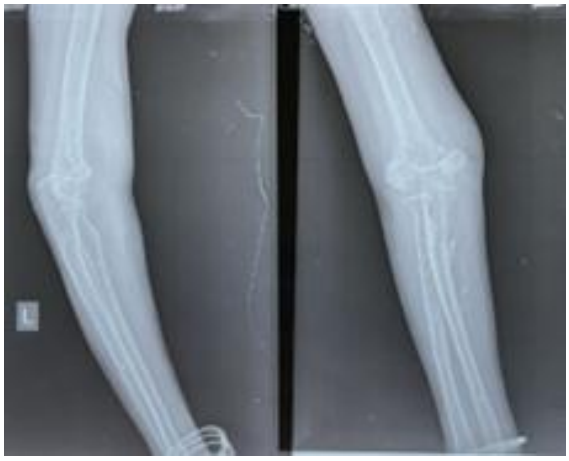
(X-ray- Elbow lateral view post operative Day1)

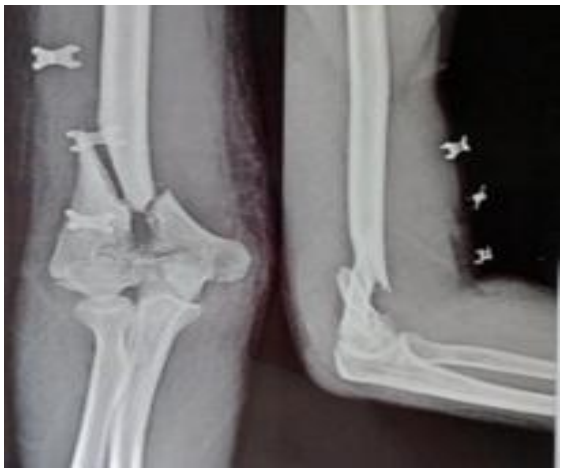


(follow-up X-ray at 7week, pins removed)

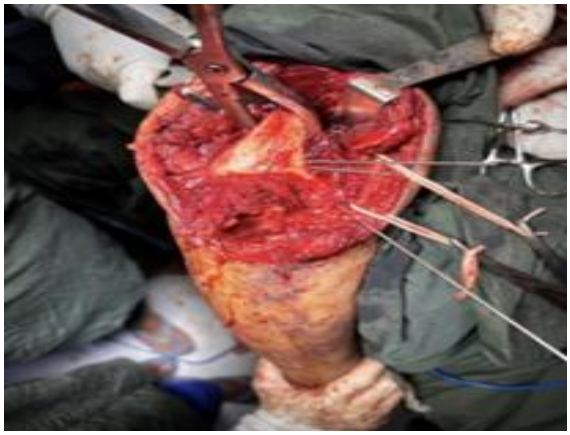
(follow-up X-ray at 3 month)

(follow-up X-ray at 6month)

32yrs male having inter-condylar Fracture right humerus following trauma 7days before.



(Pre-operative X-ray Elbow AP and lateral view)



(Intra-operative image)

(X-ray Elbow lateral view post operative day 1)

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(X-ray Elbow AP view postoperative)

Post operative xray AP and lateral view at 3nmonths

DISCUSSION

The present study evaluated and compared the clinical and radiological outcomes of the Minimal Invasive Reduction Osteosynthesis System (MIROS) and Open Reduction Internal Fixation (ORIF) in adult patients with distal humerus fractures. The baseline demographic characteristics, including age and sex distribution, were comparable between the two groups, similar to the findings reported by Szucs-Szigeti et al. (2013),[6] who conducted a multicentric evaluation of MIROS in long bone fractures and found no baseline differences between groups treated with MIROS and conventional fixation.

The operative duration was significantly shorter in the MIROS group compared to ORIF, aligning with the findings of Esenyel et al (2017),[8] who observed reduced surgical time with MIROS in paediatric forearm fractures. Although their study focused on forearm injuries, the principles of minimal invasiveness and reduced soft tissue handling are consistent and relevant. Similarly, Ozturk et al. (2015),[7] found that the MIROS system reduced operative time by 20–30% in upper limb fractures when compared to traditional methods.

In the present study, intraoperative blood loss was significantly lower in the MIROS group ($p < 0.001$), reflecting the biologic advantage of minimal soft tissue dissection. This corroborates with the observations of Raza et al. (2016),[9] who noted that minimal access surgery significantly reduces blood loss and periosteal stripping, thus potentially preserving vascularity and enhancing fracture healing.

Functional outcomes, as assessed by the Mayo Elbow Performance Score (MEPS), showed significantly better early scores in the MIROS group at 6 weeks, although both groups had comparable scores by 6 months. This is in agreement with the study by Lee et al. (2023),[10] who compared minimally invasive and open techniques for intra-articular elbow fractures and concluded that minimally invasive methods allowed quicker rehabilitation without compromising long-term outcomes. Similarly, a study by Buehren et al. (2018),[11] reported early functional benefits and reduced postoperative pain with percutaneous systems such as MIROS.

Range of motion (ROM) was significantly greater at early follow-up in the MIROS group, a finding consistent with the work of Szucs-Szigeti et al,[6] who emphasized that reduced soft tissue trauma allows early mobilization, a key determinant in elbow fracture recovery. However, by 6 months, ROM differences narrowed, reinforcing that both techniques achieve satisfactory long-term joint function when appropriately applied.

Regarding postoperative complications, both groups showed comparable rates, with no statistically significant differences. Although two patients in the MIROS group developed pin tract infections, these were managed conservatively and did not impact final outcomes. This observation is similar to the results reported by Bajzik et al. (2014),[12] who found superficial complications like pin tract infections to be more common with MIROS but not severe enough to outweigh its benefits.

Taken together, the findings of our study are consistent with the emerging literature supporting the use of MIROS in selected cases of distal humerus fractures. It offers significant advantages in terms of operative efficiency, early recovery, and reduced surgical morbidity, particularly in extra-articular or simple intra-articular patterns. However, for highly comminuted or complex fractures requiring direct anatomical reconstruction, ORIF may still remain the standard.

CONCLUSION

The present study demonstrated that the Minimal Invasive Reduction Osteosynthesis System (MIROS) is an effective and reliable alternative to traditional Open Reduction and Internal Fixation (ORIF) in the management of distal humerus fractures in adults. MIROS significantly reduced operative time and intraoperative blood loss and facilitated earlier postoperative functional recovery,

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as evidenced by superior early MEPS scores and range of motion. Although both techniques yielded comparable long-term functional and radiological outcomes, the minimally invasive nature of MIROS offers distinct advantages in terms of reduced soft tissue trauma, faster rehabilitation, and overall surgical efficiency.

Importantly, the complication rates between the two groups were similar, indicating that MIROS does not compromise patient safety or increase postoperative morbidity. These findings support the expanding role of minimally invasive osteosynthesis in selected fracture patterns of the distal humerus, particularly in younger adults or cases where early mobilization is a priority.

In conclusion, with careful patient selection and adherence to technique, MIROS can serve as a viable and advantageous alternative to ORIF, offering excellent clinical and radiological outcomes. Further large-scale, multicenter randomized controlled trials are recommended to validate these findings and define specific indications for MIROS in adult elbow trauma.

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