

Efficacy of the MIROS Technique in Displaced Proximal Humerus Fractures: A Prospective Evaluation

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ABSTRACT

Background: Displaced proximal humeral fractures in the elderly present significant management challenges due to underlying osteopenia and high complication rates associated with open surgery. The Minimally Invasive Reduction and Osteosynthesis System (MIROS) offers a biological, percutaneous alternative designed to provide angular stability while preserving soft tissue envelope and vascularity.

Methods: This prospective cohort study evaluated 30 patients (18 females, 12 males; mean age 61.2 ± 7.4 years) with displaced proximal humeral fractures treated using the tensioned percutaneous transosseous system (MIROS technique). Patients were followed systematically at 6 weeks, 12 weeks, and 6 months. Functional outcomes were assessed using the QuickDASH scoring system, while secondary outcomes included radiological union, range of motion (ROM) recovery, and complication rates.

Results: Mean QuickDASH scores improved significantly across follow-up intervals, decreasing from 62.4 ± 8.1 at 6 weeks to 38.2 ± 6.5 at 12 weeks, and reaching 18.5 ± 4.2 at 6 months ($p < 0.001$ for trend). Radiological union was documented in 15% of patients at 6 weeks, 85% at 12 weeks, and 100% by 6 months. At final follow-up, 85% of patients achieved full active range of motion. Complications were minor and manageable: superficial pin tract infections occurred in 2 patients (6.7%) at 6 weeks and resolved completely by 12 weeks with oral antibiotics. Chronic mild joint stiffness persisted in 3 patients (10%). There were zero cases of implant failure or avascular necrosis (AVN).

Conclusions: The MIROS technique is a highly effective, biologically friendly surgical option for displaced proximal humerus fractures, delivering predictable bone union, excellent functional recovery, and a low complication profile without the risks of avascular necrosis or hardware failure.

Keywords: Proximal Humerus Fracture, MIROS Technique, Percutaneous Pinning, QuickDASH, Osteoporosis, Minimally Invasive Surgery.

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1. INTRODUCTION

Proximal humeral fractures account for approximately 5% of all adult fractures and represent the third most common osteoporotic fracture, following wrist and hip fractures. The incidence rises exponentially with age, particularly among females over 60 years old, where the female-to-male ratio reaches 3:1. While non-displaced or minimally displaced fractures are successfully managed with conservative sling immobilization and early physical therapy, displaced and unstable multi-part fractures require surgical stabilization to restore anatomy and upper limb function.

The optimal surgical management of displaced proximal humerus fractures remains controversial. Open reduction and internal fixation (ORIF) with locking compression plates (e.g., PHILOS) provides rigid anatomical fixation but is frequently associated with extensive periosteal stripping, high intraoperative blood loss, screw cut-out in

osteoporotic bone, and an increased risk of humeral head avascular necrosis (AVN). Conversely, conventional closed reduction and percutaneous pinning minimizes soft tissue trauma but often lacks sufficient mechanical stability to maintain reduction in comminuted or poor-quality bone.

The Minimally Invasive Reduction and Osteosynthesis System (MIROS) addresses these limitations by combining the biological advantages of percutaneous wiring with enhanced angular stability. By utilizing multiple flexible Kirschner wires linked externally via a rigid metallic clamp, the system functions as a tensioned transosseous construct. This study aims to evaluate the functional recovery, radiological union rates, and complication profile of patients undergoing MIROS fixation for displaced proximal humeral fractures.

2. MATERIALS AND METHODS

Study Design and Setting A prospective institutional cohort study was conducted in the Department of

Orthopaedics at Adichunchanagiri Institute of Medical Sciences over an 18-month period. Institutional Ethics Committee clearance was obtained prior to study initiation, and written informed consent was secured from all participating subjects.

Patient Selection The study enrolled a consecutive series of 30 adult patients presenting with acute displaced proximal humerus fractures.

- **Inclusion Criteria:** Patients aged above 18 years with displaced 2-part, 3-part, or selected 4-part proximal humerus fractures (classified according to the Neer and AO/OTA systems) presenting within 2 weeks of injury.
- **Exclusion Criteria:** Skeletal immaturity, pathological fractures, compound fractures, polytrauma with an Injury Severity Score (ISS) > 16, concomitant neurovascular injuries at presentation, and fractures extending into the humeral shaft.

Surgical Technique and Postoperative Protocol All procedures were performed under regional anesthesia (interscalene brachial plexus block) or general anesthesia using fluoroscopic guidance. Closed reduction was achieved using longitudinal traction, manipulation, and percutaneous reduction tools when necessary. Multiple threaded and smooth Kirschner wires (typically 2.0 mm to 2.5 mm) were introduced percutaneously from the lateral and anterior cortices of the humeral shaft, directed across the fracture site into the subchondral bone of the humeral head. The protruding pins were connected externally using the specialized MIROS clamping system to tension the wires and create an angular-stable construct.

Postoperatively, the limb was supported in a universal shoulder sling. Passive pendular exercises and gentle passive assisted range of motion (ROM) were initiated as tolerated during the first 3 weeks. Active-assisted and active ROM exercises were commenced between 4 and 6 weeks based on clinical and radiographic progress. Pin removal was performed in the outpatient clinic or minor operating theater once radiological union was confirmed, typically between 6 and 8 weeks.

Outcome Measures Patients were evaluated systematically at 6 weeks, 12 weeks (3 months), and 6 months post-surgery.

- **Primary Functional Outcome:** The QuickDASH (Disabilities of the Arm, Shoulder and Hand) scoring system was utilized to assess upper extremity disability and functional recovery at each visit.
- **Secondary Outcomes:** Standard anteroposterior and axillary lateral radiographs were assessed for cortical bridging and trabecular continuity to define radiological union. Clinical recovery of shoulder range of motion (ROM) and all intraoperative or postoperative

complications (pin tract infection, loss of reduction, implant failure, stiffness, and AVN) were documented.

Statistical Analysis Data were compiled using Microsoft Excel and analyzed using SPSS version 20.0. Continuous variables (age, QuickDASH scores) were expressed as mean $\pm$ standard deviation (SD). Categorical variables (gender, union rates, complications) were reported as frequencies and percentages. Repeated measures ANOVA and paired t-tests were used to evaluate changes in QuickDASH scores over time. A p-value < 0.05 was considered statistically significant.

3. RESULTS

Demographic Profile A total of 30 patients completed the mandatory 6-month follow-up. The cohort comprised 18 females (60%) and 12 males (40%), reflecting the female predominance typical of osteoporotic fractures. The mean age of the study population was 61.2 ± 7.4 years (range: 45–76 years). Low-energy ground-level falls were the primary mechanism of injury in 73.3% of cases (22 patients), whereas high-energy road traffic accidents accounted for 26.7% (8 patients).

Functional Recovery (QuickDASH Scores) Functional outcomes demonstrated continuous, statistically significant improvement across all follow-up intervals ($p < 0.001$ for trend).

- At **6 weeks**, during the initial healing and pin-retention phase, the mean QuickDASH score was 62.4 ± 8.1 , reflecting expected early functional limitation.
- By **12 weeks**, following pin removal and progressive rehabilitation, the mean score improved substantially to 38.2 ± 6.5 .
- At the **6-month** final evaluation, patients achieved excellent functional recovery, with a mean QuickDASH score of 18.5 ± 4.2 .

Radiological Union and Range of Motion (ROM) Radiological progression of fracture healing correlated closely with functional restoration:

- At **6 weeks**, 15% of patients (4/30) demonstrated complete radiological union, while the remainder showed early callus formation. Clinical ROM at this stage was restricted primarily to mild passive movements due to pin prominence and soft tissue healing.
- At **12 weeks**, radiological union increased to 85% (25/30). Clinically, patients achieved moderate active-assisted to early active shoulder elevation and rotation.
- By **6 months**, 100% of patients (30/30) achieved solid radiological union. A full, functional active range of motion was successfully restored in 85% of the cohort (25/30).

Complications The procedure demonstrated an excellent safety profile with no major intraoperative neurovascular complications:

- **Pin Tract Infection:** Superficial pin tract infections were identified in 2 patients (6.7%) at the 6-week follow-up. Both cases were classified as Grade 1 infections and resolved completely by the 12-week evaluation following a short course of oral antibiotics and daily pin site dressing; premature pin extraction was not required.
- **Joint Stiffness:** Mild postoperative shoulder stiffness was noted in 5 patients (16.7%) at 6 weeks. With structured physical therapy, this resolved in most cases, though 3 patients (10%) exhibited chronic, mild restriction in terminal overhead elevation and internal rotation at 6 months, none of whom required surgical release or manipulation under anesthesia.
- **Hardware Failure and AVN:** There were zero instances (0%) of secondary pin migration, loss of reduction, implant failure, or radiographically evident avascular necrosis of the humeral head throughout the 6-month study period.

4. DISCUSSION

The primary finding of this study is that the tensioned percutaneous transosseous system (MIROS technique) provides reliable fracture stability, resulting in 100% union by 6 months and excellent functional recovery as evidenced by a final mean QuickDASH score of 18.5 ± 4.2 . These results reinforce the growing consensus that biological, minimally invasive fixation can match or exceed the functional outcomes of open plating in elderly populations while minimizing severe surgical complications.

Our functional and radiological outcomes align closely with recent literature evaluating the MIROS system. Metwally et al. demonstrated that modified MIROS fixation in elderly patients with Neer 2- and 3-part fractures yielded superior Constant scores, better preservation of humeral head height, and significantly fewer complications (14.3% vs. 52.3%) compared to conservative management. Similarly, Carbone et al., in a comparative study of elderly patients with severe comorbidities, reported that MIROS achieved significantly higher functional scores and faster recovery times than traditional percutaneous pinning, attributing the success to the external clamping mechanism which prevents pin migration and provides multi-planar stability.

A major advantage of the MIROS technique observed in our cohort was the complete absence of avascular necrosis (0% AVN) and implant failure. Open reduction and internal fixation with locking plates, while mechanically robust, requires extensive soft tissue dissection that can disrupt the fragile residual

blood supply to the humeral head. Furthermore, rigid locking plates in osteoporotic bone frequently suffer from screw penetration or varus collapse. Because MIROS is performed percutaneously without periosteal stripping, fracture hematoma and vascularity are preserved. The flexible K-wires allow micro-motion at the fracture site, promoting robust secondary bone healing rather than rigid primary healing, which is particularly beneficial in osteopenia. Complications in our series were minor and easily managed. The 6.7% incidence of superficial pin tract infection is comparable to rates reported by Kelkar et al. and Carulli et al. for percutaneous pinning procedures. Standardized pin site hygiene and oral antibiotics successfully eradicated these infections without compromising graft stability. Furthermore, while 10% of patients experienced chronic mild stiffness, their final functional scores remained highly satisfactory for daily activities, avoiding the need for secondary arthrolysis.

Study Limitations This study has certain recognized limitations. The sample size of 30 patients, while statistically powered to demonstrate significant linear trends in QuickDASH scores ($p < 0.001$), is relatively small. Additionally, the study represents a single-center prospective cohort without a direct randomized control group (such as patients treated exclusively with PHILOS plating or non-operative management). Finally, while a 6-month follow-up captures complete bony union and primary functional recovery, a longer-term evaluation of 12 to 24 months would be beneficial to screen for late-onset avascular necrosis or post-traumatic osteoarthritis.

5. CONCLUSION

The MIROS tensioned percutaneous pinning system is an effective, reliable, and biologically sound surgical strategy for displaced proximal humeral fractures, particularly in mature and osteoporotic patients. By combining the low morbidity of percutaneous wiring with the angular stability of an external tensioning frame, the technique ensures 100% fracture union, rapid pain relief, and restoration of functional range of motion while eliminating the risks of hardware cut-out and avascular necrosis.

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