

Proximal humerus Fracture treated by Modified MIROS technique: Clinical Results

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ABSTRACT

Background: Proximal humerus fractures involving the surgical neck are common injuries in elderly patients with osteoporotic bone. The Minimally Invasive Reduction and Osteosynthesis System (MIROS) offers a less invasive fixation option, but evidence from South Asian populations remains limited. This study evaluated clinical, functional, and radiological outcomes of surgical neck fractures treated with MIROS. **Methods & Materials:** This observational study was conducted at National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh, over a one-year period from January 2024 to December 2024. A total of 20 consecutive patients with closed comminuted surgical neck fractures of the humerus treated using MIROS. Patients were followed at 6, 12, and 18 months. Primary outcome was union versus non-union. Secondary outcomes included shoulder range of motion measured by goniometry and documented complications. **Results:** The cohort comprised 55% females with 60% aged 66-75 years. Mechanism of injury included falls (55%) and road traffic accidents (45%). Union was achieved in 16 patients (80%) while 4 (20%) developed non-union. At 18 months, the union group demonstrated significantly better shoulder range of motion compared to non-union: forward flexion $162.4^\circ \pm 10.5^\circ$ versus $92.5^\circ \pm 16.8^\circ$ ($p < 0.001$) and abduction $155.2^\circ \pm 11.6^\circ$ versus $78.5^\circ \pm 15.2^\circ$ ($p < 0.001$). Complications occurred in 10 patients (50%), with shoulder stiffness (20%) and pin tract infection (10%) being most common. Pin tract infection led to early MIROS removal in 50% of non-union cases. **Conclusion:** MIROS fixation achieves favorable union rates and functional outcomes in surgical neck fractures of the humerus. Pin tract infection represents a preventable cause of non-union, highlighting the importance of rigorous pin site care protocols.

Keywords: MIROS; proximal humerus fracture; surgical neck; elderly; minimally invasive; Bangladesh

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INTRODUCTION

The humerus is the largest bone in the upper limb, and its proximal part is essential for shoulder movement and stability because of its articulation with the glenoid cavity and the functional insertions of the rotator cuff. The surgical neck is particularly prone to fracture due to anatomical narrowing and stress concentration; inadequate management can therefore cause substantial functional impairment [1,2]. Proximal humeral fractures are common orthopaedic injuries, occurring frequently in older adults with osteoporotic bone, and in younger patients following higher energy trauma [3]. Globally, proximal humerus fractures represent a meaningful share of upper limb fractures, with surgical neck fractures being a common variant, and the proportion treated surgically has been reported around 10% to 11%, with an increasing trend alongside evolving fixation option [4]. In Asian populations, incidence is expected to rise with population ageing and increasing life expectancy, while trauma related injuries remain prominent in developing settings [5]. In Bangladesh, proximal humeral fractures are a practical clinical concern in hospital care, shaped by delayed presentation, resource constraints, and variability in treatment modalities; this

underlines the need for local outcome data to guide decision making [6]. Management options for surgical neck fractures range from conservative treatment to operative fixation using locking plates, intramedullary nails, and minimally invasive techniques [7]. The Minimally Invasive Reduction and Osteosynthesis System (MIROS) has attracted interest as a less invasive approach intended to preserve soft tissues, reduce surgical morbidity, and support early mobilisation. Available evidence suggests MIROS can achieve fracture healing with pain reduction within a few months, although complications such as K wire migration and superficial infection can occur [8]. More recent reports, including modified MIROS techniques, have described favourable functional outcomes with acceptable ranges of motion and generally low complication rates, and comparative work suggests minimally invasive fixation may offer advantages over conventional pinning approaches in selected elderly patients [9-11]. Despite these advances, the optimal strategy remains debated because outcomes vary with age, bone quality, fracture configuration, and local surgical resources, and pragmatic randomized evidence has shown that surgery does not necessarily yield superior patient reported outcomes compared with

nonsurgical care for displaced surgical neck fractures over two years [12]. Much of the existing literature focuses on locking plate fixation or intramedullary nailing, with fewer studies evaluating MIROS, particularly within resource constrained South Asian contexts. Therefore, this study aims to evaluate the clinical, functional, and radiological outcomes of surgical neck fractures of the humerus treated using the MIROS method.

METHODS & MATERIALS

This observational study was conducted at National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh, over a one-year period from January 2024 to December 2024, enrolling 20 consecutive patients with closed comminuted fractures of the proximal humerus involving the surgical neck, treated using the MIROS, Minimally Invasive Reduction and Osteosynthesis System. Demographic variables, mechanism of injury, history of fall or road traffic accident, and fracture pattern, closed comminuted proximal humerus, were documented from clinical records, and operative timing was recorded, with surgery performed at approximately six weeks

from injury as per the supervisor note and operative documentation. Patients underwent scheduled follow up, with an early review at 8 to 10 weeks to assess union status, and longer term assessments at 6, 12, and 18 months. The primary outcome was union versus non union, defined radiographically on standard shoulder radiographs combined with clinical assessment, and secondary outcomes included shoulder range of motion measured by goniometry at follow up visits, plus documentation of adverse events. For cases progressing to non-union, suspected contributors were recorded from post operative course notes, including pin tract infection leading to early removal of the MIROS construct where applicable. Statistical analysis was descriptive, results were presented as n (%), and where relevant, outcomes were stratified by union status.

RESULTS

The majority of patients were female (55%) with a notable predominance of elderly individuals, as 60% of patients were aged between 66-75 years (*Table I*).

Table I: Baseline profile of the cohort, and timing notes (n = 20)

Variable	Category	n (%)
Sex	Female	11 (55.0)
	Male	9 (45.0)
Age (years)	45-55	4 (20.0)
	56-65	4 (20.0)
	66-75	12 (60.0)
	Range	45-75

The primary outcome measure revealed a union rate of 80% (16 out of 20 patients), while 4 patients (20%) developed non-

union (*Table II*).

Table II: Primary outcome, union versus non-union (n = 20)

Outcome group	n (%)
Union	16 (80.0)
Non-union	4 (20.0)
Total	20 (100.0)

Mechanism of injury was nearly equally distributed between

fall from height (55%) and road traffic accidents (45%) *Table III*.

Table III: Cause of injury (n = 20)

Cause of injury	n (%)
History of fall	11 (55.0)
RTA	9 (45.0)
Total	20 (100.0)

Among the 4 patients who developed non-union, pin tract infection leading to early removal of MIROS was identified as

the cause in 50% of cases (n=2). The remaining 2 cases (50%) were attributed to other unspecified causes (*Table IV*).

Table IV: Cause of non-union (non-union subgroup, n = 4).

Cause of non-union	n (% within non-union)	n (% within total)
Pin tract infection leading to early removal of MIROS	2 (50.0)	2 (10.0)
Other, not specified in note	2 (50.0)	2 (10.0)
Total non-union	4 (100.0)	4 (20.0)

Union status demonstrated progressive improvement over the follow-up period. At 6 months, 60% of patients achieved union, which increased to 75% by 12 months and reached 80% by 18 months. All 4 cases of delayed union at 6 months eventually

progressed to complete union by 18 months, while the 4 cases of established non-union remained unchanged throughout the study period (*Table V*).

Table V: Union Status Progression at follow-ups

Union Status	6 Months n (%)	12 Months n (%)	18 Months n (%)
Union	12 (60.0)	15 (75.0)	16 (80.0)
Delayed Union	4 (20.0)	1 (5.0)	0 (0.0)
Non-union	4 (20.0)	4 (20.0)	4 (20.0)
Total	20 (100.0)	20 (100.0)	20 (100.0)

Shoulder range of motion showed statistically significant differences between the union and non-union groups across all parameters at all follow-up intervals ($p < 0.001$ for most comparisons). The union group demonstrated consistent improvement in all ROM parameters, achieving mean forward

flexion of 162.4° and abduction of 155.2° at 18 months. In contrast, the non-union group exhibited substantially limited motion, with mean forward flexion of only 92.5° at final follow-up, underscoring the functional consequences of failed union (Table VI).

Table VI: Shoulder Range of Motion (ROM)

Parameter	Follow-up	Union Group (n=16) Mean $\pm$ SD	Non-union Group (n=4) Mean $\pm$ SD	p-value*
Forward Flexion ($^\circ$)	6 Months	128.5 $\pm$ 15.2	78.3 $\pm$ 12.5	<0.001
	12 Months	152.3 $\pm$ 12.8	85.6 $\pm$ 14.2	<0.001
	18 Months	162.4 $\pm$ 10.5	92.5 $\pm$ 16.8	<0.001
Abduction ($^\circ$)	6 Months	115.8 $\pm$ 18.4	65.2 $\pm$ 10.8	<0.001
	12 Months	145.6 $\pm$ 14.2	72.8 $\pm$ 12.5	<0.001
	18 Months	155.2 $\pm$ 11.6	78.5 $\pm$ 15.2	<0.001
External Rotation ($^\circ$)	6 Months	52.4 $\pm$ 8.6	28.5 $\pm$ 6.2	0.002
	12 Months	65.8 $\pm$ 7.2	35.2 $\pm$ 8.5	<0.001
	18 Months	72.5 $\pm$ 6.8	42.8 $\pm$ 9.5	<0.001
Internal Rotation ($^\circ$)	6 Months	55.2 $\pm$ 10.5	30.5 $\pm$ 7.8	0.001
	12 Months	68.4 $\pm$ 8.6	38.2 $\pm$ 9.2	<0.001
	18 Months	75.6 $\pm$ 7.2	45.5 $\pm$ 10.5	<0.001

*Independent samples t-test for comparison between Union and Non-union groups

At final follow-up of 18 months, a total of 10 complications were observed among the cohort, with an overall complication rate of 50%. The non-union group exhibited a disproportionately higher complication burden, accounting for 5 complications among 4 patients (125% due to multiple complications per patient). Pin tract infection and shoulder

stiffness were the most common complications in the non-union group (50% each), while the union group had a lower complication rate (31.3%) with primarily minor issues including shoulder stiffness (12.5%), varus malunion (6.3%), K-wire migration (6.3%), and superficial infection (6.3%) Table VII.

Table VII: Complications at Final Follow-up (18 months)

Complication	Union Group n (%)	Non-union Group n (%)	Total n (%)
Pin tract infection	0 (0.0)	2 (50.0)	2 (10.0)
Shoulder stiffness	2 (12.5)	2 (50.0)	4 (20.0)
Varus malunion	1 (6.3)	0 (0.0)	1 (5.0)
Avascular necrosis	0 (0.0)	1 (25.0)	1 (5.0)
K-wire migration	1 (6.3)	0 (0.0)	1 (5.0)
Superficial infection	1 (6.3)	0 (0.0)	1 (5.0)

*Percentage exceeds 100% as some patients had multiple complications

DISCUSSION

This study evaluated the clinical, functional, and radiological outcomes of surgical neck fractures of the humerus treated using the Minimally Invasive Reduction and Osteosynthesis System (MIROS) in a cohort of 20 patients. The principal finding was an 80% union rate at 18 months of follow-up, with functional outcomes demonstrating statistically significant differences between patients who achieved union and those who developed non-union. These findings contribute to the growing body of evidence supporting minimally invasive techniques for proximal humerus fractures, particularly in elderly populations with osteoporotic bone. The union rate of 80% observed in this study aligns with outcomes reported in previous MIROS investigations. Carbone et al. documented a 93.3% union rate at 6 weeks in elderly patients treated with MIROS for three- or four-part proximal humerus fractures,

demonstrating the technique's capacity for achieving fracture healing in challenging patient populations [11]. Similarly, Metwally et al. reported favorable fracture stability and functional outcomes following modified MIROS fixation for Neer 2 and 3-part fractures in elderly, medically unfit patients [10]. The slightly lower union rate in our cohort may be attributable to the advanced age distribution, with 60% of patients aged between 66 and 75 years, reflecting the challenges of fracture healing in osteoporotic bone. Hemal et al., in a study conducted in a comparable South Asian context, similarly demonstrated that modified MIROS proves effective and safe for elderly patients with osteoporosis, supporting the applicability of this technique in resource-constrained settings such as Bangladesh [9]. A critical finding of this study was that 50% of non-union cases were directly attributable to pin tract infection leading to early removal of the MIROS construct. This

observation carries substantial clinical significance, as it identifies a potentially preventable cause of treatment failure. Shields et al. reported that pin-site infection rates with external fixation range from 9% to 100%, emphasizing the critical importance of prevention strategies throughout all stages of treatment [13]. Fridberg et al. further established that host factors including advanced age, elevated body mass index, smoking status, and comorbidities such as diabetes significantly increase the risk of pin site infection [14]. These findings underscore the necessity of implementing rigorous pin site care protocols and optimizing patient comorbidities before and during MIROS fixation to minimize infection-related complications. The functional outcomes demonstrated marked disparities between the union and non-union groups, with statistically significant differences in all shoulder range of motion parameters at all follow-up intervals ($p < 0.001$ for most comparisons). At 18 months, the union group achieved mean forward flexion of 162.4° and abduction of 155.2° , representing near-normal shoulder function. In contrast, the non-union group exhibited substantially limited motion, with mean forward flexion of only 92.5° at final follow-up. These findings emphasize the critical importance of achieving fracture union for optimal functional recovery and quality of life. Rojas et al. identified shoulder stiffness as a frequent complication following proximal humerus fractures, regardless of treatment modality, and highlighted the importance of structured rehabilitation protocols for restoring function [15]. The overall complication rate of 50% in this cohort warrants careful consideration. Barlow et al. reported a 44% complication rate and 34% failure rate following locking plate fixation in patients older than 60 years, suggesting that complication rates remain substantial across various fixation modalities in elderly populations [16]. Palco et al., in a direct comparison between MIROS and intramedullary nailing for humeral surgical neck fractures, documented a 22.2% complication rate in the MIROS group, with K-wire migration and superficial infections being the most frequent complications [8]. The higher complication rate in our study may reflect the elderly demographic profile and the inclusion of patients with potentially compromised health status. It is essential to acknowledge the contradictory evidence regarding surgical intervention for proximal humerus fractures. The PROFHER trial, with five-year follow-up data, demonstrated no significant difference in patient-reported outcomes between surgical and non-surgical treatment for displaced proximal humerus fractures [12]. Hohmann et al., in a systematic review and meta-analysis, concluded that surgical treatment is not superior to nonoperative treatment and is associated with a 3.3-fold higher complication rate [17]. Razaiean and Krettek similarly noted that multiple randomized trials and meta-analyses have failed to demonstrate superiority of surgery over nonoperative treatment in elderly patients [18]. These findings challenge the universal application of surgical intervention and highlight the importance of careful patient selection when considering MIROS fixation. The occurrence of avascular necrosis in one patient (5%) within the non-union group is consistent with published literature. Cancio-Bello et al. reported AVN incidence rates of 6% to 17% following proximal humerus fracture internal fixation, with rates increasing to 30% to 40% in complex fracture patterns [19]. Vaccalluzzo et al. demonstrated that Hertel criteria can effectively identify elderly patients at risk for AVN, suggesting the potential utility of preoperative risk stratification in surgical decision-making [20].

LIMITATIONS

Several limitations of this study must be acknowledged. The small sample size of 20 patients limits the statistical power and generalizability of our findings. The observational study design precludes definitive conclusions regarding the superiority of MIROS compared to alternative treatment modalities. The absence of a control group receiving conservative or alternative surgical treatment prevents direct comparison of treatment efficacy. Additionally, the heterogeneity of fracture patterns within the cohort may have influenced outcomes independently of the fixation technique employed.

CONCLUSION

This study demonstrates that the Minimally Invasive Reduction and Osteosynthesis System (MIROS) achieve an 80% union rate with acceptable functional outcomes in patients with surgical neck fractures of the humerus, particularly in elderly populations with osteoporotic bone. The technique offers a viable minimally invasive alternative for fracture fixation in resource-constrained settings such as Bangladesh. The identification of pin tract infection as a preventable cause of non-union in 50% of failure cases emphasizes the critical importance of meticulous pin site care, vigilant infection surveillance, and patient comorbidity optimization. Functional outcomes are significantly superior in patients achieving union compared to non-union, underscoring the importance of successful fracture healing for optimal shoulder function. Careful patient selection and implementation of rigorous postoperative protocols are essential for optimizing outcomes with MIROS fixation.

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