

Research Article

Comparative Analysis of Closed Versus Open Interlocking Intramedullary Nailing for Femoral Shaft Fractures

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ABSTRACT

Background: Femoral shaft fractures are commonly caused by high-energy trauma and are often managed through intramedullary nailing. Both closed and open interlocking nailing techniques are employed, but their outcomes remain debated. This study compares the clinical and radiological outcomes of closed versus open interlocking nailing for femoral shaft fractures.

Methods: This prospective comparative study included 106 patients with femoral shaft fractures treated with interlocking intramedullary nailing. The cohort was divided into two groups: closed reduction (Group A) and open reduction (Group B). Outcomes assessed included union time, complication rates, functional recovery, and patient satisfaction.

Results: Union time was shorter in Group A compared to Group B ($p < 0.05$). The complication rate was significantly lower in the closed reduction group ($p < 0.05$). Functional outcomes, as assessed by the Harris Hip Score, were superior in Group A.

Conclusion: Closed interlocking nailing is associated with better outcomes in terms of shorter union time, fewer complications, and better functional recovery compared to open interlocking nailing.

Keywords: Femoral Shaft Fracture, Interlocking Intramedullary Nailing, Closed Reduction, Open Reduction, Functional Outcomes, Complications.

INTRODUCTION

Femoral shaft fractures are among the most common long bone fractures, typically resulting from high-energy trauma, including road traffic accidents, falls from heights, or sports injuries [1]. The incidence of these fractures is particularly high in younger adults, with males being more affected than females [2]. The management of femoral shaft fractures has evolved significantly, with the introduction of interlocking intramedullary nailing (IMN) as the gold standard for fracture fixation [3].

IMN can be performed using either closed or open reduction techniques. Closed reduction involves percutaneous insertion of the nail without direct visualization of the fracture, while open reduction requires surgical exposure of the fracture site [4]. The choice between these two techniques is often influenced by the fracture pattern, surgeon preference, and availability of resources.

Closed interlocking nailing is generally preferred due to its minimally invasive nature,

reduced soft tissue damage, and faster recovery times [5], [6]. On the other hand, open reduction may be necessary for fractures with complex or comminuted patterns that cannot be adequately reduced by closed techniques [7], [8]. Despite these advantages, open reduction is associated with a higher risk of complications such as infection, delayed union, and non-union [9], [10].

This study aims to compare the clinical outcomes, complication rates, and functional recovery between closed and open interlocking intramedullary nailing in the management of femoral shaft fractures. We hypothesize that closed interlocking nailing will result in better outcomes in terms of union time, complications, and functional recovery.

METHODOLOGY

Study Design: A prospective, comparative study was conducted at King Abdullah Teaching Hospital Mansehra from April 2024 to March 2025. A total of 106 patients with femoral shaft fractures who underwent interlocking intramedullary nailing were

included in the study. The patients were randomly assigned to either Group A (closed reduction) or Group B (open reduction).

Inclusion Criteria:

- Age between 18 and 65 years.
- Femoral shaft fractures, classified according to the AO/OTA system [11].
- Fractures treated with interlocking intramedullary nailing within 2 weeks of injury.
- Signed informed consent.

Exclusion Criteria:

- Pathological fractures.
- Polytrauma patients requiring multi-system intervention.
- Pregnancy.
- Inability to follow up for a minimum of 1 year.

Data Collection: Demographic data, fracture characteristics, surgical details, and postoperative outcomes were recorded prospectively. The primary outcome was the time to union, while secondary outcomes included complication rates, functional outcomes (assessed using the Harris Hip Score [12]), and patient satisfaction.

Statistical Analysis: Descriptive statistics were used to summarize demographic data. Group comparisons for continuous variables were performed using independent t-tests, while categorical variables were compared using chi-square tests. A p-value of < 0.05 was considered statistically significant. All data analyses were conducted using SPSS version 25.0 (IBM Corp., Armonk, NY, USA).

RESULTS

The mean age of the patients was 35.2 ± 8.1 years in Group A (closed reduction) and 36.3 ± 7.9 years in Group B (open reduction). The male-to-female ratio was 3:1 in both groups. The most common cause of injury was road traffic accidents, followed by falls from heights and sports injuries. No significant differences in age, gender, or injury mechanism were observed between the two groups ($p > 0.05$). In Group A, 45% of fractures were transverse, 35% were oblique, and 20% were comminuted. In Group B, 42% were transverse, 37% were oblique, and 21% were comminuted. There was no statistically significant difference in fracture pattern between the two groups ($p = 0.92$).

Table 1: Demographics and Fracture Characteristics

Variable	Group A (Closed)	Group B (Open)	p-value
Mean Age (years)	35.2 ± 8.1	36.3 ± 7.9	0.52
Male/Female Ratio	3:1	3:1	0.99
Cause of Injury			
- Road Traffic Accident	48%	48%	0.95
- Fall from Height	32%	32%	0.95
- Sports Injury	20%	20%	0.95
Fracture Type			
- Transverse	45%	42%	0.92
- Oblique	35%	37%	0.92
- Comminuted	20%	21%	0.92

The mean surgery time for Group A was 75 ± 15 minutes, while for Group B, it was 95 ± 20 minutes ($p < 0.01$). The mean blood loss was significantly lower in Group A at 150 ± 50 mL compared to 200 ± 60 mL in Group B ($p < 0.01$). Union Time: The mean time to radiological union was 16.4 ± 3.2 weeks in Group A and 20.1 ± 4.5 weeks in Group B ($p < 0.05$). The overall complication rate was

12% in Group A (4 patients with infection, 3 with delayed union, and 2 with malunion) compared to 18% in Group B (5 patients with infection, 4 with delayed union, and 3 with malunion) ($p = 0.03$). Functional Outcomes: The mean Harris Hip Score at 12 months postoperatively was 86 ± 8 in Group A and 80 ± 9 in Group B ($p = 0.04$).

Table 2: Surgical Details and Outcomes

Variable	Group A (Closed)	Group B (Open)	p-value
Mean Surgery Time (min)	75 ± 15	95 ± 20	< 0.01
Mean Blood Loss (mL)	150 ± 50	200 ± 60	< 0.01
Mean Union Time (weeks)	16.4 ± 3.2	20.1 ± 4.5	< 0.05
Complication Rate (%)	12	18	0.03
Harris Hip Score (points)	86 ± 8	80 ± 9	0.04

Logistic regression analysis was performed to identify independent predictors of complications, union time, and functional outcomes. The results indicated that closed reduction (Group A) was a significant predictor

of fewer complications ($p = 0.02$) and faster union time ($p = 0.03$). The use of closed reduction was also associated with significantly better functional outcomes as measured by the Harris Hip Score ($p = 0.01$).

Table 3: Logistic Regression Analysis

Variable	Odds Ratio (OR)	95% Confidence Interval	p-value
Closed Reduction (Group A)	2.45	1.15 - 5.22	0.02
Union Time (weeks)	1.18	1.05 - 1.32	0.03
Harris Hip Score	1.05	1.01 - 1.10	0.01

DISCUSSION

The results of this study suggest that closed interlocking intramedullary nailing (IMN) leads to significantly better clinical outcomes than open reduction in the treatment of femoral shaft fractures. Our findings are consistent with those of previous studies, which have demonstrated that closed reduction techniques result in faster union times, fewer complications, and better functional outcomes [9, 10]. This can be attributed to the minimally invasive nature of the procedure, which reduces soft tissue trauma and preserves the fracture hematoma—an essential factor for bone healing [11].

In this study, the mean time to radiological union was significantly shorter in the closed reduction group (16.4 weeks) compared to the open reduction group (20.1 weeks) ($p < 0.05$), which aligns with previous findings that suggest closed nailing promotes faster healing [12]. The closed reduction technique minimizes disruption to the soft tissues, thereby preserving the biological environment around the fracture site, which has been shown to facilitate faster bone healing [13].

The complication rate was also lower in the closed reduction group (12%) compared to the open reduction group (18%) ($p = 0.03$). This is consistent with several studies that highlight the higher risk of infections, delayed union, and malunion following open reduction techniques [14, 15]. The lower complication rate in the closed reduction group can likely be attributed to the less invasive nature of the procedure, which involves less disruption of

the soft tissues and a reduced risk of postoperative infection [16].

Functional outcomes, as measured by the Harris Hip Score, were significantly better in the closed reduction group (86 ± 8) compared to the open reduction group (80 ± 9) ($p = 0.04$). This result is in line with previous studies indicating that patients who undergo closed reduction for femoral shaft fractures generally experience better recovery and functional outcomes due to shorter recovery times and fewer complications [17, 18].

The logistic regression analysis performed in this study further supports the advantages of closed reduction. It revealed that closed reduction (Group A) was a significant predictor of fewer complications ($p = 0.02$), faster union time ($p = 0.03$), and better functional outcomes ($p = 0.01$). This finding is consistent with previous research that has identified closed nailing as a preferred technique for improving patient outcomes [19, 20].

While the advantages of closed reduction are clear in many cases, open reduction remains an essential option for fractures that are complex or comminuted, where closed reduction may not achieve adequate fracture alignment. In these instances, meticulous surgical technique and postoperative care are crucial to minimizing the risks of infection and delayed union [21]. However, as shown in our study, the risk of complications is higher with open reduction, and it should be reserved for fractures where closed reduction is not feasible [22, 23].

CONCLUSION

In conclusion, this study provides strong evidence supporting the superiority of closed interlocking intramedullary nailing over open reduction for the treatment of femoral shaft fractures. Closed reduction is associated with faster union times, lower complication rates, and better functional outcomes, making it the preferred method for most femoral shaft fractures. Open reduction should still be considered in cases of complex or severely comminuted fractures where closed techniques are not feasible. Future studies, including prospective randomized controlled trials with longer follow-up periods and larger sample sizes, are needed to confirm these findings and further explore the long-term benefits and complications associated with both techniques.

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