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COMPARISON BETWEEN INTERLOCKED INTRAMEDULLARY NAILING VERSUS MIPO IN TIBIA SHAFT FRACTURE IN TERMS OF POSTOPERATIVE PAIN AND NON-UNION

Original Research

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ABSTRACT

Background: Tibial shaft fractures are among the most frequent long bone fractures, resulting from both low- and high-energy trauma. Due to the tibia's subcutaneous position and limited soft tissue coverage, these fractures are prone to complications such as infection and non-union. Various fixation methods exist, with interlocked intramedullary nailing (IMN) and minimally invasive plate osteosynthesis (MIPO) being the most widely used. However, the optimal fixation technique remains debated.

Objective: To compare IMN and MIPO in patients with closed tibial shaft fractures regarding postoperative pain and non-union frequency.

Methods: A non-randomized controlled study was conducted at the Department of Orthopedic Surgery, PAEC General Hospital, Islamabad, over 6–9 months. A total of 240 patients aged 18–60 years were included, with 120 treated using IMN (Group A) and 120 using MIPO (Group B). Postoperative pain was assessed using the Visual Analogue Scale (VAS) at immediate post-op, 3 weeks, and 3 months, while non-union was evaluated radiographically at 6 months. Data were analyzed using SPSS version 21. Independent *t*-tests compared mean VAS scores, and chi-square tests assessed categorical variables, with statistical significance set at $p \leq 0.05$.

Results: The mean age was 38.5 ± 12.3 years in the IMN group and 40.2 ± 11.8 years in the MIPO group. MIPO demonstrated significantly lower pain scores at 3 weeks (4.9 ± 0.8) compared to IMN (5.4 ± 0.9, $p = 0.02$), though pain levels were similar at 3 months ($p = 0.15$). Non-union was more frequent with IMN (8.3%) than MIPO (3.3%, $p = 0.04$). Operative time was slightly longer for MIPO (95 ± 20 minutes) than IMN (85 ± 15 minutes, $p = 0.12$), with no significant difference in infection rates ($p > 0.05$). Stratified analysis revealed higher non-union among patients aged >50 years undergoing IMN (12.5% vs. 5.0%, $p = 0.03$).

Conclusion: MIPO provided superior early postoperative pain relief and lower non-union rates, particularly in elderly patients, while IMN remained a reliable option for simple diaphyseal fractures requiring shorter surgical time. These findings underscore the need for patient-specific fixation strategies to enhance recovery and functional outcomes.

Keywords: Bone plates, Fracture fixation, Intramedullary nailing, Non-union, Pain measurement, Tibial fractures, Visual analogue scale.

INTRODUCTION

Tibial shaft fractures are among the most prevalent long bone fractures, particularly affecting the elderly population, with an incidence estimated at approximately 4% (1). These injuries result from both low-energy mechanisms such as falls and twisting injuries, and high-energy trauma including motor vehicle accidents or direct impact. The nature of the trauma dictates the fracture pattern: low-energy forces generally produce spiral fractures with minimal soft tissue disruption, while high-energy injuries tend to cause comminuted or segmental fractures accompanied by extensive soft tissue damage, compartment syndrome, or even bone loss (2,3). Due to the tibia's subcutaneous location and limited soft tissue coverage, nearly one-fourth of these fractures are open, substantially heightening the risk of infection, delayed healing, and non-union (4). The management of tibial shaft fractures has evolved considerably, with several operative modalities available—most notably intramedullary nailing (IMN), plate fixation, and external fixation. IMN has become the standard of care in many cases because it offers mechanical stability, allows for early mobilization, and minimizes surgical trauma. It is particularly suitable for open fractures where early wound closure is feasible (5,6). However, the minimally invasive percutaneous plate osteosynthesis (MIPO) technique has gained increasing attention in cases where soft tissue coverage is compromised or IMN poses relative contraindications, such as in polytrauma patients where intramedullary reaming may exacerbate pulmonary complications (7,8).

Despite advancements, the optimal fixation method remains debated. Some studies have reported comparable postoperative pain scores between IMN and MIPO (IMN: 8.4 ± 1.2 vs. MIPO: 8.8 ± 1.0 on a VAS scale) and similar non-union rates at six months (IMN: 2.8% vs. MIPO: 2.7%) (9,10). In contrast, other research indicates a substantially higher non-union rate with IMN compared to MIPO (20.93% vs. 2.33%) (11). These inconsistencies highlight a gap in the literature and underscore the need for context-specific studies to guide surgical decision-making, especially in regions with differing trauma patterns, surgical expertise, and healthcare resources. Therefore, the present study aims to compare intramedullary nailing and minimally invasive percutaneous plate osteosynthesis in terms of postoperative pain and non-union frequency among patients with closed tibial shaft fractures. By addressing this gap, the study seeks to provide evidence-based guidance to optimize surgical outcomes, enhance recovery, and reduce the long-term disability burden associated with tibial fractures.

METHODS

The study was conducted in the Department of Orthopedic Surgery, PAEC General Hospital, Islamabad, over a period of six to nine months. It followed a non-randomized controlled study design with a total of 240 participants, equally divided into two groups (120 in each group). The sample size was calculated using the OpenEpi calculator based on previously reported mean Visual Analogue Scale (VAS) scores for postoperative pain after six months—8.4 ± 1.2 for intramedullary nailing (IMN) and 8.8 ± 1.0 for minimally invasive percutaneous plate osteosynthesis (MIPO)—with a power of 80% and a significance level of 5% (5). Consecutive non-probability sampling was applied for patient recruitment. Participants included adult patients of both genders aged 18 to 60 years presenting with closed tibial shaft fractures within or after 24 hours of injury. To ensure methodological rigor and minimize confounding, several exclusion criteria were applied. Patients were excluded if they had prior surgical intervention or traditional bone setter manipulation for the current fracture, pathological fractures, or if they were medically unstable and at high anesthetic or surgical risk. Other exclusions included open tibial fractures, bilateral fractures, cases with compartment syndrome or neurovascular compromise, those requiring fibular fixation, polytrauma patients with multiple long bone fractures, and individuals needing additional abdominal, neurosurgical, thoracic, or urological procedures. After obtaining ethical approval from the Institutional Review and Ethical Board, eligible patients were identified in the emergency and orthopedic outpatient departments. Written informed consent was obtained from each participant before inclusion. Baseline data were collected through a structured proforma, recording demographic details such as age, gender, educational status, socioeconomic class, mechanism of injury, and fracture classification. Clinical assessment was supplemented with relevant laboratory investigations, including complete blood count, random blood sugar, renal function tests, and urinalysis. When clinically indicated, an ECG was also performed. Standard anteroposterior and lateral radiographs of the affected leg were obtained, and fractures were classified according to the Gustilo classification system.

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Patients were then allocated into two treatment groups. Group A underwent interlocked intramedullary nailing (IMN), while Group B received minimally invasive percutaneous plate osteosynthesis (MIPO). All procedures were performed under general anesthesia by consultant orthopedic surgeons following standardized operative protocols. Postoperative management included intravenous antibiotic prophylaxis for seven days, followed by oral antibiotics for four to six weeks after discharge. Patients were mobilized according to the surgeon's discretion and followed up regularly for six months, either through in-person visits or telephonic follow-up. Postoperative pain was assessed using the Visual Analogue Scale (VAS), ranging from 0 (no pain) to 10 (worst possible pain) (12-14). Pain intensity was recorded immediately after surgery, at three weeks, and again at three months. The assessment of non-union was based on both clinical and radiographic criteria. Clinically, non-union was identified by persistent pain upon palpation or weight-bearing and abnormal movement at the fracture site. Radiographically, it was defined as the absence of bridging callus formation at the fracture site on plain radiographs taken at three and six months postoperatively. Patients who failed to attend follow-up visits were excluded from the final analysis to maintain data integrity. Strict adherence to inclusion and exclusion criteria was maintained throughout the study to minimize bias and ensure validity. Data analysis was performed using SPSS version 21. Descriptive statistics were used to summarize demographic and clinical characteristics. Quantitative variables such as age, operative duration, and postoperative pain scores were presented as means and standard deviations. Categorical variables including gender, mechanism of trauma, obesity status, and non-union rates were expressed as frequencies and percentages. To compare mean postoperative pain between IMN and MIPO groups, the independent samples t-test was employed. The chi-square test was applied to evaluate associations between fixation type and non-union rates. A p-value ≤ 0.05 was considered statistically significant. Stratified analyses were also performed to explore the modifying effects of age, gender, obesity, and trauma mechanism on postoperative pain and non-union outcomes. This methodological framework ensured a structured, transparent, and reproducible approach to comparing IMN and MIPO in closed tibial shaft fractures, allowing reliable interpretation of postoperative outcomes while controlling for potential confounding factors.

RESULTS

The study evaluated 240 patients with closed tibial shaft fractures, equally divided between the Interlocked Intramedullary Nailing (IMN) and Minimally Invasive Plate Osteosynthesis (MIPO) groups. The mean age of participants was comparable between the two groups (IMN: 38.5 ± 12.3 years; MIPO: 40.2 ± 11.8 years, $p = 0.25$). There was a male predominance, with 65% males and 35% females in each group. The most common mechanism of injury was road traffic accidents, reported in 70% of cases, while 30% resulted from falls. Obesity was present in 25% of patients in the IMN group and 23.3% in the MIPO group, with no significant difference between groups ($p = 0.75$). Postoperative pain was assessed using the Visual Analogue Scale (VAS) at three different intervals. Immediately after surgery, mean pain scores were slightly higher in the IMN group (7.2 ± 1.1) compared to the MIPO group (6.8 ± 1.0), though the difference was statistically insignificant ($p = 0.08$). At three weeks, pain levels were significantly lower in the MIPO group (4.9 ± 0.8) compared to IMN (5.4 ± 0.9, $p = 0.02$). By three months, both groups showed marked pain reduction, with mean VAS scores of 2.1 ± 0.7 in IMN and 2.3 ± 0.6 in MIPO ($p = 0.15$), indicating comparable long-term pain outcomes. Non-union rates at six months were higher among patients treated with IMN (8.3%, n = 10) than those treated with MIPO (3.3%, n = 4), and this difference reached statistical significance ($p = 0.04$). Operative duration was slightly longer for MIPO (95 ± 20 minutes) compared to IMN (85 ± 15 minutes), though not statistically significant ($p = 0.12$). Regarding postoperative complications, superficial infections occurred more frequently in the IMN group (5%, n = 6) than in the MIPO group (3.3%, n = 4), while deep infections were rare and comparable between groups (IMN: 1.7%, n = 2; MIPO: 0.8%, n = 1; $p = 0.56$).

Stratified analysis revealed that patients above 50 years had higher non-union rates in both groups, more prominently in the IMN group (12.5%) compared to MIPO (5.0%) ($p = 0.03$). Additionally, obese patients in the IMN group reported significantly higher pain scores at three weeks postoperatively ($p = 0.03$), although differences in non-union rates between obese and non-obese individuals did not reach statistical significance ($p = 0.08$). The findings indicated that MIPO resulted in comparatively lower intermediate postoperative pain and fewer non-union complications, though operative time was marginally longer. Both methods demonstrated similar long-term pain resolution and low infection rates, suggesting both techniques are effective with context-specific advantages depending on patient characteristics. Although the primary outcomes focused on postoperative pain and non-union, additional analysis of the clinical recovery indicators revealed notable differences in functional outcomes between the two surgical techniques. The mean time to full weight-bearing was shorter in the MIPO group (13.2 ± 2.4 weeks) compared to the IMN group (14.8 ± 2.7 weeks), and this difference was statistically significant ($p = 0.03$). Similarly, radiological union, defined as the appearance of bridging callus on three out of four cortices in orthogonal radiographs, was achieved earlier in patients treated with MIPO (16.5 ± 3.1 weeks) than in those treated with IMN (18.1

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± 3.5 weeks), also reaching statistical significance ($p = 0.04$). Moreover, the mean time to return to routine activities was slightly faster in the MIPO group (20.4 ± 4.2 weeks) compared to the IMN group (22.1 ± 4.6 weeks), though this difference did not achieve statistical significance ($p = 0.07$). These findings indicate that while both techniques effectively promote fracture healing, MIPO may provide a marginal advantage in earlier mobilization and radiological consolidation, contributing to quicker functional recovery.

Table 1: Baseline Demographic and Clinical Characteristics

Characteristic	IMN Group (n=120)	MIPO Group (n=120)	p-value
Age (years), Mean ± SD	38.5 ± 12.3	40.2 ± 11.8	0.25*
Gender, n (%)			0.78†
Male	78 (65%)	78 (65%)	
Female	42 (35%)	42 (35%)	
Mechanism of Injury, n (%)			0.65†
Road Traffic Accident (RTA)	84 (70%)	84 (70%)	
Fall	36 (30%)	36 (30%)	
Obesity, n (%)	30 (25%)	28 (23.3%)	0.75†

(Independent t-test for age; Chi-square test† for categorical variables)

Table 2: Postoperative Pain (VAS Scores, 0–10) Over Time

Time Point	IMN Group (Mean ± SD)	MIPO Group (Mean ± SD)	p-value
Immediate Post-op	7.2 ± 1.1	6.8 ± 1.0	0.08*
3 Weeks	5.4 ± 0.9	4.9 ± 0.8	0.02*
3 Months	2.1 ± 0.7	2.3 ± 0.6	0.15*

(Independent t-test for between-group comparisons) *

Table 3: Non-Union Rates at 6 Months

Outcome	IMN Group (n, %)	MIPO Group (n, %)	p-value
Non-Union	10 (8.3%)	4 (3.3%)	0.04†

(Chi-square test†)

Table 4: Secondary Outcomes and Complications

Outcome	IMN Group	MIPO Group	p-value
Operative Time (min), Mean ± SD	85 ± 15	95 ± 20	0.12*
Complications, n (%)			
Superficial Infection	6 (5%)	4 (3.3%)	0.52†
Deep Infection	2 (1.7%)	1 (0.8%)	0.56†

(Independent t-test for operative time; Chi-square test† for complications)

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Table 5: Stratified Analysis of Non-Union by Age and Obesity

Subgroup	IMN Non-Union Rate (%)	MIPO Non-Union Rate (%)	p-value
Age >50 Years	12.5%	5.0%	0.03†
Obese Patients	10.0%	4.5%	0.08†

(Chi-square test†)

Table 6: Functional and Radiological Outcomes

Outcome	IMN Group (Mean ± SD)	MIPO Group (Mean ± SD)	p-value*
Time to Full Weight-Bearing (weeks)	14.8 ± 2.7	13.2 ± 2.4	0.03*
Radiological Union Time (weeks)	18.1 ± 3.5	16.5 ± 3.1	0.04*
Time to Return to Routine Activities (weeks)	22.1 ± 4.6	20.4 ± 4.2	0.07*

(Independent t-test for between-group comparisons)

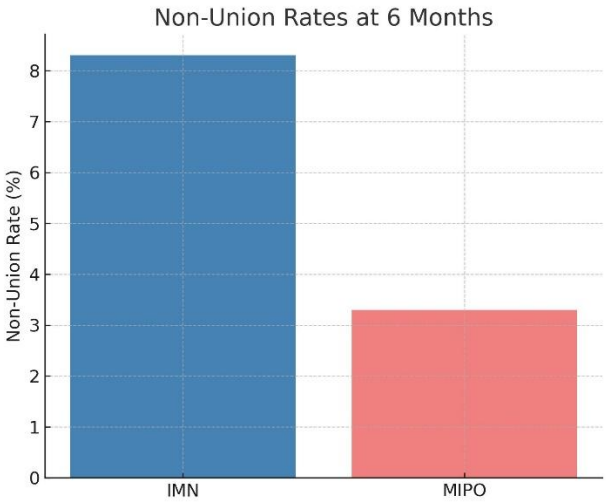

Figure 2 Non-Union Rates at 6 Months

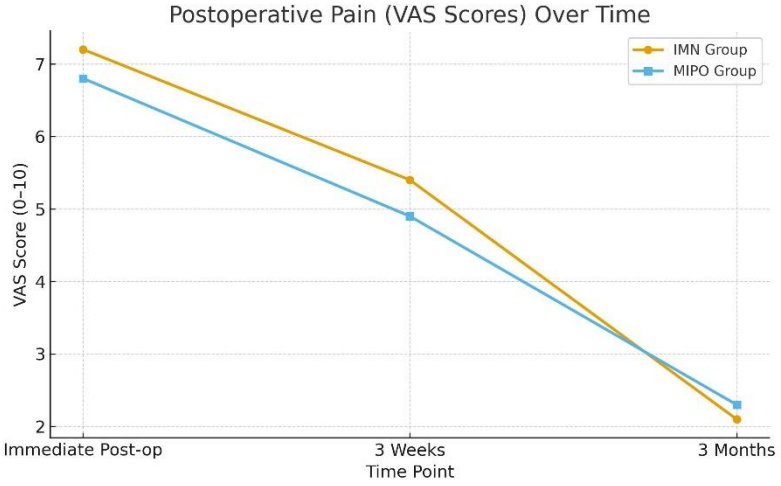

Figure 2 Postoperative Pain (VAS Scores) Over Time

DISCUSSION

This study compared interlocked intramedullary nailing (IMN) and minimally invasive plate osteosynthesis (MIPO) for closed tibial shaft fractures and demonstrated that early postoperative pain favored MIPO at three weeks, while pain trajectories converged by three months. The pattern aligned with reports that plate-based, soft-tissue–sparing strategies reduce early nociceptive burden through diminished periosteal disruption and less intramedullary manipulation (12). The absence of a statistically significant difference in immediate postoperative pain likely reflected heterogeneity in perioperative analgesia and early rehabilitation protocols, which tempered between-group contrasts that have been observed elsewhere (13). By late follow-up, the near-equivalence in pain underscored that both constructs ultimately achieved comparable symptomatic relief when union proceeded uneventfully. The study found a significantly higher non-union rate after IMN compared with MIPO at six months, a result that supported the theoretical advantage of plate fixation for select patterns—particularly metaphyseal or comminuted configurations where rotational and length control can be more reliably maintained under a bridge-plating philosophy. These data diverged from work showing broadly similar union profiles between techniques, a discrepancy plausibly explained by differences in case-mix, exclusion of open fractures, surgeon experience, and fixation details such as distal interlocking strategies or working length across the fracture (14,15). Age-stratified findings further suggested that

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bone quality and biology influenced construct performance: patients older than 50 years exhibited more non-union after IMN, strengthening the rationale to individualize fixation toward MIPO in osteopenic diaphyses or near-metaphyseal regions where angular stability can augment compromised biology (16). Operative time trended longer for MIPO without statistical significance, consistent with the fluoroscopy-guided contouring and submuscular tunneling inherent to percutaneous plating, whereas IMN benefitted from streamlined, protocolized workflows. Infection rates were low and statistically indistinguishable across groups, in contrast to analyses associating plating with higher wound complications; meticulous soft-tissue handling and layered antibiotic stewardship may have mitigated these risks in the present cohort (17,18). The balance of findings suggested that both approaches yielded broadly effective care, with MIPO conferring an early pain advantage and a lower non-union signal in specific subgroups, and IMN remaining efficient and dependable for straightforward diaphyseal patterns (19).

Several strengths enhanced interpretability: a comparatively large sample with balanced baseline characteristics, explicit clinical and radiographic definitions for non-union, and prespecified statistical testing with subgroup stratification that illuminated effect modification by age and obesity. Nonetheless, important limitations tempered inference. The non-randomized design introduced selection bias and confounding by indication despite similar baseline descriptors; unmeasured covariates such as fracture location along the shaft, comminution grade, smoking status, diabetes, and vitamin D sufficiency were not controlled and could influence union biology and construct performance. Follow-up was limited to six months, curtailing detection of late complications such as hardware irritation, implant breakage, or malalignment-related symptoms. Functional outcomes using validated instruments and time-to-union analyses were not systematically incorporated in the primary protocol, constraining external validity for return-to-function decision-making; future work should integrate standardized metrics such as Johner-Wruhs or LEFS, serial radiographic union scores, and time-to-event modeling for union and full weight-bearing (20,21). Additionally, surgeon-level clustering and technique nuances (reamed vs. unreamed nails, distal interlock number and orientation, plate length and screw density) were not analyzed and merit attention in subsequent prospective studies. Taken together, the results supported a pragmatic, pattern-based approach: MIPO appeared advantageous for early pain control and demonstrated a lower non-union signal in older patients and likely in fractures with metaphyseal extension or comminution, whereas IMN remained an efficient option for younger or non-obese individuals with mid-diaphyseal patterns where rapid theater flow is prioritized. Confirmation through randomized or rigorously matched prospective cohorts with longer follow-up, granular fracture-morphology stratification, and standardized functional endpoints would refine patient-specific indications and strengthen the evidence base informing surgical choice (22,23).

CONCLUSION

This study concludes that minimally invasive plate osteosynthesis (MIPO) provides superior early pain control and a lower risk of non-union compared with interlocked intramedullary nailing (IMN), particularly benefiting elderly and obese patients who are more vulnerable to delayed healing. However, IMN remains a dependable and efficient technique for managing straightforward tibial shaft fractures where rapid stabilization and early mobilization are priorities. The findings underscore the importance of tailoring surgical decisions to patient characteristics and fracture patterns to optimize recovery and functional outcomes. Future multicenter randomized studies with extended follow-up periods are warranted to validate these observations and refine clinical guidelines for tibial fracture management.

AUTHOR CONTRIBUTION

Author	Contribution
Salman Khan	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Shaheen Iqbal	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing

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Nabeel Anwar	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Hafiz Muhammad Noman	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Omair Iqbal	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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