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COMPARISON OF RATE OF INFECTION IN INTRAMEDULLARY NAILING AND EXTERNAL FIXATION IN PATIENTS WITH OPEN FRACTURE OF TIBIA

Dr. Afnan Ullah Khan[1], Dr. Syed Dil Bagh Ali Shah[*2]

[1]Postgraduate Resident (FCPS-Orthopedics), TMO Orthopedics, MTI- Khyber Teaching Hospital, Peshawar
[*2]MBBS; FCPS, Associate Prof. of Orthopedic, Khyber Teaching Hospital, Peshawar

[1]afnankhan8710103@gmail.com, [*2]drdilbagh@gmail.com

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Corresponding Author: *
Dr. Syed Dil Bagh Ali Shah

Abstract

Background: *Open tibial fractures represent a significant orthopedic challenge with high risks of infection and nonunion. While both intramedullary nailing (IMN) and external fixation (EF) are established treatments, controversy persists regarding their comparative effectiveness in preventing postoperative infections. This study aimed to compare infection rates between these techniques while identifying patient subgroups that benefit most from each approach.*

Methods: *A prospective descriptive study was conducted at Khyber Teaching Hospital, Peshawar, over six months (November 2024-April 2025). We enrolled 148 male and female patients (18-60 years) with open tibial fractures (Gustilo-Anderson classification). Participants were equally divided into IMN (n=74) and EF (n=74) groups via consecutive sampling. Surgical procedures followed standardized protocols, with postoperative infection (primary outcome) assessed at 15 days using strict clinical criteria (erythema >1cm, tenderness, purulent discharge). Data analysis employed IBM SPSS v25, with chi-square tests ($p \leq 0.05$ significant) and stratification by demographic/clinical variables.*

Results: *The overall post-operative infection rate was 32.4%. The infection rate was significantly lower in IMN (17.6% vs 47.3%, $p<0.001$). Subgroup analyses revealed particularly strong IMN benefits ($p \leq 0.05$) for males, patients with age <40 years, BMI ≥25 kg/m², and delayed surgeries ≥24 hours. Rural residents and non-diabetics also showed superior outcomes with IMN.*

Conclusion: *IMN demonstrates superior infection prevention in open tibial fractures, particularly for males, younger patients, obese individuals, and delayed presentations. These findings support IMN as the preferred fixation method for most patients, though EF remains valuable in specific scenarios (e.g., polytrauma). Future multicenter studies should validate these subgroup-specific recommendations and investigate long-term functional outcomes.*

INTRODUCTION

Fractures of the tibial diaphysis constitute the most commonly observed fractures of long bones. These fractures occur at a frequency of 8.1 to 37 per 100,000 individuals yearly,

representing a considerable public health issue.[1] The susceptibility of these fractures to infection and nonunion is due to inadequate soft tissue coverage and the unique vascular supply to the affected area. Moreover, tibial shaft fractures are categorised as injuries that significantly affect quality of life and may result in lasting impairment.[2]

The conservative care of stable tibial diaphyseal fractures, involving closed reduction and cast immobilization. This approach entails drawbacks, such as an increased risk of deep vein thrombosis, compartment syndrome, soft tissue injury, and chronic discomfort resulting from extended immobilization. Although conservative cast treatment is linked to a reduced infection rate, it simultaneously demonstrates the highest occurrence of delayed union, nonunion, or insufficient union of fractures.[3]

Intramedullary nail fixation presents a beneficial alternative, providing biomechanical stability and a minimally invasive approach. Numerous specialists see intramedullary nails as the definitive treatment for tibial shaft fractures. Comparative studies indicate that intramedullary nail fixation is preferable to external fixation in open tibial shaft fractures, particularly when wound closure is rapidly performed after nail insertion.[4] The Ilizarov technique is examined, highlighting its effectiveness and comparative safety. The distinctive biomechanical characteristics of this approach allow for the use of tensioned wires to ensure secure fixation of bone fragments while promoting dynamization at the fracture site.[5] The Ilizarov approach has significant advantages over closed fixation, including closed reduction, little soft tissue injury, early mobilization, and ease of device removal.[6,7] Desta et al. found that open tibial fractures exhibited a higher infection rate of 18.6%. The infection rate for external fixators was 44.4%, whereas it was 12.5% for intramedullary nailing.[8]

The study delves into the controversy surrounding the choice of the most appropriate technique for stabilizing tibial fractures. The advantages of external fixation, including its straightforward application and little effect on blood supply, are mitigated by an increased incidence of pin tract infections, difficulties in managing soft tissue injuries, and a comparatively high rate of nonunion. In contrast, reamed nails provide enhanced stability but provide a potential risk of heightened infection and nonunion due to the disruption of endosteal blood flow. However, additional researches are needed to validate this assertion, as multiple studies have demonstrated that reamed nails have a greater rate of union than non-reamed nails. The scarcity of publications comparing infection rates in tibial fractures treated with external versus intramedullary treatment highlights the necessity for additional research in this area. Therefore, the study has been planned.

MATERIAL AND METHODS

This descriptive study was conducted over six months (from November 2024 to April 2025) in the Department of Orthopedics at Khyber Teaching Hospital, Peshawar. The study aimed to compare postoperative infection rates between intramedullary nailing (IMN) and external fixation (EF) in open tibial fractures. A sample size of 148 patients was calculated using the WHO sample size formula, with an anticipated infection proportion of 44% in the EF group as described by Desta T et al., a 95% confidence level, and an 8% margin of error. Participants were selected via non-probability consecutive sampling. Eligible participants included patients aged 18–60 years with clinically and radiographically confirmed open tibial fractures, classified using the Gustilo-Anderson system. Exclusion criteria were designed to minimize confounding variables and included pathologic fractures, revisions for non-union, polytrauma patients, fractures with neurovascular injuries, immunocompromised individuals, and patients treated at other centers. Inclusion and exclusion criteria were strictly applied to maintain study integrity. Tibial fractures were diagnosed through clinical examination and X-ray AP views, and postoperative infection defined within 15 days by the presence of erythema extending >1 cm from the wound margin, tenderness, and serosanguinous or purulent discharge. Data collection commenced after obtaining ethical approval and informed consent. Comprehensive baseline data were recorded.

Surgical procedures were performed according to standardized protocols. For IMN, patients were positioned supine with the knee flexed at 90–110°, administered anesthesia as determined by the anesthesiologist, and underwent fluoroscopic-guided nailing over a guidewire, followed by locking and layered closure. For EF, patients were similarly positioned supine with elevated thigh and foot, and the Ilizarov fixator was applied under X-ray guidance using tensioned pins and spacers. All participants received postoperative care that included analgesia, antibiotic prophylaxis, wound dressing, and rehabilitation protocols that prioritised early mobilisation. Patients were monitored until the 15th postoperative day to evaluate the presence of surgical site infections in accordance with predetermined diagnostic criteria. IBM SPSS version 25 was employed to conduct the data analysis. The mean ± standard deviation was used to express quantitative variables, including age, BMI, and fracture duration. Frequencies and percentages were employed to represent qualitative variables, such as gender and infection status. Chi-square tests were employed to compare the groups of IMN and EF, with a p-value of ≤0.05 being considered statistically significant. In order to adjust for potential covariates, infection rates were stratified by age, gender, BMI, fracture duration, laterality, and comorbidities. Throughout the investigation, ethical standards were strictly adhered to. The hospital's research review board granted approval, and all participants provided informed consent, guaranteeing confidentiality and autonomy.

RESULTS

A total of 148 patients with open tibial fractures were included in the study. Of them, 74 patients underwent external fixation, while another 74 underwent intramedullary nailing. With no notable variations observed across groups, the average age of the participants was 39.61 ± 11.67 years. Compared to the external fixation group, which had a BMI of 25.19 ± 3.76, the intramedullary nailing group had a slightly higher BMI of 25.83 ± 3.94, resulting in an average body mass index (BMI) of 25.51 ± 3.85 kg/m². There was no significant difference between the groups in the mean time from fracture to surgery, which was 9.49 ± 5.53 hours. The gender breakdown of the patients was as follows: 66.2% were male, exactly half of the patients were under the age of 40 and half were above 40 year of age. A greater percentage of patients in the intramedullary nailing group had a BMI ≥25 kg/m² (62.2%) compared to the external fixation group (50%). The majority of fractures were surgically addressed 24 hours or more post-injury (68.9%), with no significant difference observed between groups. Demographic and clinical data, including residence, education, profession, financial status, diabetes mellitus, hypertension, and leg laterality, are detailed in table 1.

The overall post-operative infection rate was 32.4% (n=48/148). A significantly higher ($p<0.001$) infection rate was observed in the external fixation group (47.3%) compared to the intramedullary nailing group (17.6%) (figure 1). Stratification analysis revealed that male patients experienced dramatically lower infections ($p<0.001$). patients with age <40 years had substantially better outcomes, with only 8.1% infection rates compared to 32.4% with external fixation ($p=0.009$). Patients with higher BMI i.e. ≥25 kg/m² saw a threefold reduction in infections ($p<0.001$). Delayed surgeries that done after ≥24 hours post-injury still benefited greatly from intramedullary nailing, with infection rates dropping from 62.7% to 19.6% ($p<0.001$). residents of rural area who may face challenges in post-operative care, had significantly better outcomes i.e. less infection rate ($p=0.001$). Patients with higher education and non-diabetics also experienced markedly lower infection risks i.e. $p=0.007$ and $p=0.001$ respectively (table 2).

Table 1: Baseline Characteristics of Patients with Open Tibial Fractures

Variable	Subgroups	External Fixation (n=74)	Intramedullary Nailing (n=74)	Total (n=148)
Gender	Male	49 (66.2%)	49 (66.2%)	98 (66.2%)
	Female	25 (33.8%)	25 (33.8%)	50 (33.8%)
Residence	Rural	38 (51.4%)	38 (51.4%)	76 (51.4%)
	Urban	36 (48.6%)	36 (48.6%)	72 (48.6%)
Education	Illiterate	19 (25.7%)	19 (25.7%)	38 (25.7%)
	School Level	37 (50.0%)	37 (50.0%)	74 (50.0%)
	College/University	18 (24.3%)	18 (24.3%)	36 (24.3%)
Profession	Business	14 (18.9%)	13 (17.6%)	27 (18.2%)
	Housewife	7 (9.5%)	7 (9.5%)	14 (9.5%)
	Job	37 (50.0%)	37 (50.0%)	74 (50.0%)
	Unemployed	16 (21.6%)	17 (23.0%)	33 (22.3%)
Socioeconomic Status	Poor	23 (31.1%)	24 (32.4%)	47 (31.8%)
	Middle Class	37 (50.0%)	37 (50.0%)	74 (50.0%)
	Rich	14 (18.9%)	13 (17.6%)	27 (18.2%)
Diabetes Mellitus (DM)	No	55 (74.3%)	55 (74.3%)	110 (74.3%)
	Yes	19 (25.7%)	19 (25.7%)	38 (25.7%)
Hypertension (HTN)	No	52 (70.3%)	52 (70.3%)	104 (70.3%)
	Yes	22 (29.7%)	22 (29.7%)	44 (29.7%)
Laterality of Leg	Left	37 (50.0%)	37 (50.0%)	74 (50.0%)
	Right	37 (50.0%)	37 (50.0%)	74 (50.0%)

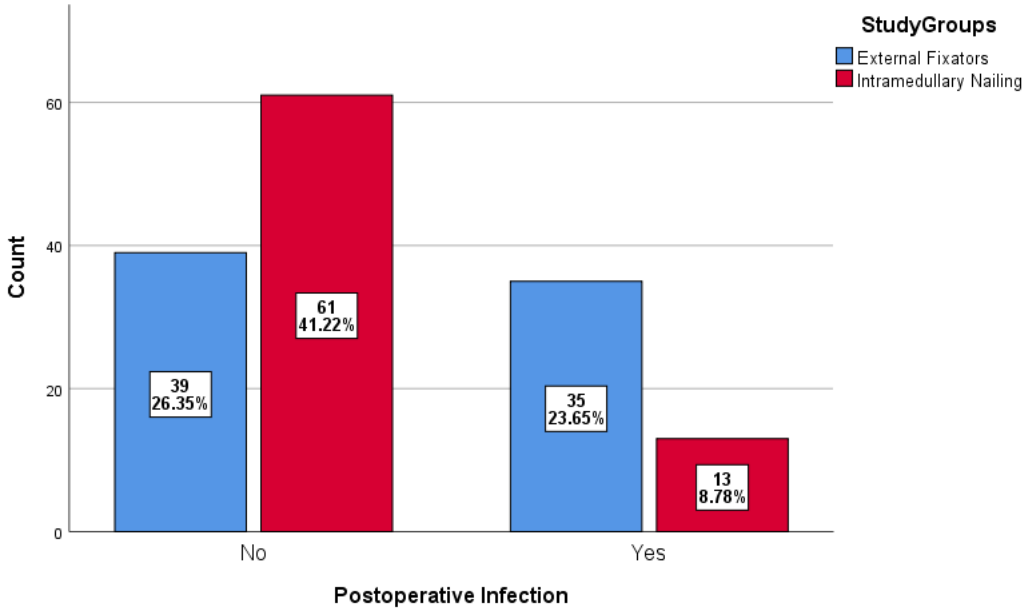

Figure 1: Post-Operative Infection Rates in Both Study Groups

Table 2: Stratified Analysis of Post-Operative Infection Rates Among Both Study Arms (based on various clinical and demographic variables and sub-groups)

Variable	Subgroups	Infection Rate		p-value
		External Fixation	Intramedullary Nailing	
Gender	Female	40.0% (10/25)	20.0% (5/25)	0.123
	Male	51.0% (25/49)	16.3% (8/49)	<0.001
Age Group	<40 years	32.4% (12/37)	8.1% (3/37)	0.009
	≥40 years	62.2% (23/37)	27.0% (10/37)	0.002
BMI Group	<25 kg/m²	32.4% (12/37)	10.7% (3/28)	0.040
	≥25 kg/m²	62.2% (23/37)	21.7% (10/46)	<0.001
Time to Surgery	<24 hours	13.0% (3/23)	13.0% (3/23)	1.000
	≥24 hours	62.7% (32/51)	19.6% (10/51)	<0.001
Residence	Rural	60.5% (23/38)	23.7% (9/38)	0.001
	Urban	33.3% (12/36)	11.1% (4/36)	0.023

Variable	Subgroups	Infection Rate		p-value
		External Fixation	Intramedullary Nailing	
Education	College/University	44.4% (8/18)	5.6% (1/18)	0.007
	Illiterate	68.4% (13/19)	31.6% (6/19)	0.023
	School Level	37.8% (14/37)	16.2% (6/37)	0.036
Profession	Business	57.1% (8/14)	7.7% (1/13)	0.006
	Housewife	57.1% (4/7)	42.9% (3/7)	0.593
	Job	32.4% (12/37)	8.1% (3/37)	0.009
	Unemployed	68.8% (11/16)	35.3% (6/17)	0.055
Socioeconomic Status	Middle Class	32.4% (12/37)	8.1% (3/37)	0.009
	Poor	65.2% (15/23)	37.5% (9/24)	0.057
	Rich	57.1% (8/14)	7.7% (1/13)	0.006
Diabetes Mellitus	No	40.0% (22/55)	12.7% (7/55)	0.001
	Yes	68.4% (13/19)	31.6% (6/19)	0.023
Hypertension	No	46.2% (24/52)	13.5% (7/52)	<0.001
	Yes	50.0% (11/22)	27.3% (6/22)	0.122
Laterality	Left	32.4% (12/37)	8.1% (3/37)	0.009
	Right	62.2% (23/37)	27.0% (10/37)	0.002

DISCUSSION

The treatment of open tibial fractures presents a considerable difficulty in orthopaedic surgery, with postoperative infection being one of the most worrisome consequences.9 This study aimed to compare infection rates between two prevalent fixation procedures, external fixation and intramedullary nailing, while also investigating variations in results across several patient groupings. The findings indicated a distinct and statistically significant benefit of intramedullary nailing in minimising postoperative infections, with an overall infection rate of 17.6% against 47.3% for external fixation ($p < 0.001$). This discovery corroborates existing literature while enhancing prior understanding by a comprehensive subgroup analysis that delineates which patients

derive the greatest benefit from intramedullary nailing.

These findings correspond with numerous outstanding meta-analyses and randomised controlled trials,[4,7,10,12,13,14,15,16] while also offering novel insights via comprehensive subgroup analysis. While intramedullary nailing (IMN) is generally associated with superior infection prevention outcomes, there are a number of factors, including fracture characteristics, patient comorbidities, and surgery time, that should be considered when choosing a fixation approach. The best methods for mending open tibial fractures have been the subject of heated controversy, prompting a slew of comprehensive meta-analyses. Giovannini et al. performed an extensive review of five randomised controlled trials encompassing 239 patients with Gustilo type III open tibial shaft fractures.[17] By showing a significantly lower incidence of pin-site infections and refractures compared to EF, their data strongly supported IMN. This is in complete agreement with our findings and provides strong support for the physiologic advantages of intramedullary fixation. These results are likely improved by mechanical stability provided by IMN, which allows for early weight-bearing and reduces micromotion at the fracture site, thus minimising conditions that promote bacterial colonisation and biofilm growth.

Liu et al. augmented these findings through their meta-analysis of seven research involving 647 cases.[18] Their findings indicated that IMN was linked to significantly reduced rates of superficial infections (RR = 3.15, 95% CI 2.03 to 4.88, P < 0.00001), although notably revealed no substantial difference in deep infection rates between the two techniques (RR = 1.33, 95% CI 0.68 to 2.59, P = 0.40). The differential between superficial and deep infection outcomes holds therapeutic significance, indicating that whereas IMN evidently diminishes surface (pin-site associated) infections, its efficacy in preventing deep osseous infections may be comparatively limited. The overall difference in infection rates in our study likely indicates this dual impact, with the superiority of IMN being most apparent in the prevention of superficial/pin-site problems, while also demonstrating a tendency towards a reduction in deep infections.

Our comprehensive subgroup analyses demonstrated significant disparities in treatment efficacy contingent upon patient variables. The pronounced protective effect of IMN in male patients (16.3% vs 51.0% infection rate, $p < 0.001$) contrasts with the non-significant difference observed in females (20.0% vs 40.0%, $p = 0.123$), necessitating additional examination. This conclusion corroborates the results of Akhtar et al. (2018), who also observed non-significant variations in infection rates between IMN and EF across gender groups in their study involving 40 patients.[19] The biological foundation for this gender differential is ambiguous but may pertain to variations in soft tissue properties, hormonal effects on immune response, or activity levels during recuperation.

The significant decrease in infection risk associated with IMN for individuals with a BMI ≥25 kg/m² (21.7% vs 62.2%, $p < 0.001$) is another therapeutically relevant discovery. This corresponds with clinical observations that external fixation in obese patients presents significant challenges due to soft tissue tension surrounding the pins and difficulties in maintaining frame stability. The meta-analysis conducted by Liu et al. (2023) did not explicitly evaluate outcomes based on BMI; however, their discovery of markedly reduced superficial infection rates associated with IMN corroborates our assertion that this technique may be more beneficial for individuals with higher body mass.[18]

The date of final fixation is another crucial aspect affecting infection rates. Our research revealed significant advantages of IMN in instances where surgical intervention was postponed beyond 24 hours post-injury, as infection rates decreased from 62.7% with EF to 19.6% with IMN ($p < 0.001$). This undermines conventional pedagogy that underscores the significance of prompt definitive fixation for infection prevention. The meta-analysis conducted by Zhao Chen et al. investigated this matter comprehensively, revealing no significant disparity in deep infection rates between IMN and EF (RR 1.06 [0.49, 2.29], P=0.89), while acknowledging considerable heterogeneity among studies that may be attributable to differences in surgical timing protocols.[20]

Giannoudis et al. conducted a thorough analysis of the outcomes associated with immediate versus delayed IMN, highlighting that although early debridement (within 6 hours) is essential, the selection of the definitive fixing method may be more significant than the precise timing in influencing infection risk.[21] This corresponds with our findings that IMN retains its protective impact even in delayed presentations, indicating that the mechanical and biological benefits of intramedullary fixation can mitigate certain hazards linked to delayed therapy.

Limitations of the study

This study offers significant insights into the relative efficacy of intramedullary nailing compared to external fixation in mitigating postoperative infections in open tibial fractures; nonetheless, many limitations should be recognised. The single-center design may restrict the generalisability of our results. The patient demographic, surgical methodologies, and postoperative care protocols at our institution may vary from those at other facilities, especially in areas with disparate healthcare resources or differing rates of antibiotic-resistant illnesses. A multicenter investigation including varied geographic and socioeconomic contexts would enhance the external validity of our findings. Secondly, while our sample size was sufficient for the primary comparison, several subgroup analyses were inadequately powered due to reduced participant numbers. The female subgroup of housewives with high socioeconomic level was insufficiently sized to reach clear conclusions. Third, our study concentrated solely on early postoperative infections, so leaving unresolved issues regarding long-term consequences such as delayed infections, non-unions, or persistent osteomyelitis. Furthermore, we did not consider confounding variables such smoking status, alcohol consumption, or preoperative nutritional status, all of which may affect infection risk. The non-randomized design engenders potential selection bias. A randomised controlled trial (RCT) would alleviate this problem, however it may be unfeasible for infrequent or severe injuries. Ultimately, our investigation was deficient in comprehensive microbiological data regarding infection pathogens, which may have elucidated if infections linked with external fixators were more prone to involve multidrug-resistant organisms or pollutants at the pin sites. Likewise, we did not examine functional outcomes (e.g., range of motion, return to work), which are essential for evaluating the real-world implications of these surgical methods. Notwithstanding these constraints, our results correspond with the extensive literature endorsing intramedullary nailing and offer innovative subgroup-specific insights that may inform clinical practice while underscoring avenues for future investigation. Subsequent studies should address these limitations, especially through multicenter partnerships and extended follow-up, to enhance our comprehension of effective fixation techniques for open tibial fractures.

CONCLUSION

This study offers convincing evidence that intramedullary nailing markedly decreases postoperative infections in open tibial fractures relative to external fixation, especially among males, younger patients, overweight persons, and those with delayed cases. Although external fixation is beneficial in numerous circumstances, intramedullary nailing should be the preferred treatment when possible. These findings may support therapeutic decision-making and enhance patient outcomes in orthopaedic trauma management.

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