

Complication Profile of Intramedullary Nailing in Tibial Shaft Fractures: A Retrospective Study

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Abstract

Background: Intramedullary nailing is considered the most effective method in the treatment of tibial shaft fractures. Despite its advantages, many complications may occur during and after surgery. Awareness about such complications plays a vital role in improving surgical and post-surgical practices.

Aim: In order to estimate the incidence, classification, and risk factors for complications following intramedullary nailing of tibial diaphyseal fractures.

Methodology: The research design used was an observational, retrospective study conducted at a hospital in the Orthopaedics Department for a period of one year. The number of patients involved in the study was 150, who were intramedullary nailed because they had tibial shaft fractures. Data collection was done using the structured proforma that had demographic details, details on fracture characteristics, surgical details, and details on the complications. Statistical analysis was conducted using SPSS version 25.0, and results were considered significant if $p < 0.05$.

Results: Anterior knee pain (46%), infection (18%), delayed union (16%), and malunion (10%), were the most common complications. There were significant associations between open fractures and infection ($p = 0.002$), and delayed surgery and delayed union ($p = 0.01$).

Conclusion: Intramedullary nailing is an excellent method to apply; however, there have been reported cases of post-surgical knee pain, infection and delayed bone healing. Prompt treatment, proper surgery and after surgery care play a major role in minimizing complications.

Keywords: Tibial shaft fracture, Intramedullary nailing, Complications, Delayed union, Infection.

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Introduction

Tibial shaft fractures represent some of the most frequent injuries sustained involving the long bones and cause a considerable percentage of hospital admissions due to trauma [1]. The tibia is a subcutaneous bone that has little coverings of soft tissues anteriorly and medially, making it highly susceptible to injury [2]. These injuries occur due to trauma related to high energy mechanisms such as road traffic accidents, falling from heights, and sport related injuries, particularly among the economically productive population.

IMN has proven to be the method of choice for treating tibial shaft fractures over recent decades. Some of the benefits associated with this technique are that it preserves the periosteal blood flow, minimizes the disturbance of the surrounding soft tissues, early weight-bearing and better fracture stabilization [3]. Moreover, intramedullary fixation provides the possibility of biological healing by the use of controlled micromotion at the fracture site,

hence the high rates of union and a shorter hospitalization [4].

In spite of these advantages, intramedullary nailing is not completely without complications [5]. The intraoperative and postoperative complications that can be experienced by patients include infection, delayed union, non-union, malalignment, implant failure and persistent anterior knee pain [6]. Of them, anterior knee pain is one of the most frequent ones which can also have a considerable impact on functional outcomes. These complications can lead to prolonged recovery, repeated surgery, high healthcare costs, and lower quality of life. This is why a detailed analysis of the complication is important to attain the best treatment outcomes and minimize any negative consequences [7].

Background of the Study: Tibia shaft fractures have become a significant global health issue borne by the blistering urbanization, motorization, and industrialization, particularly in developing nations such as India [8]. The chief cause has been road

traffic accidents, which have led to a high rate of high-energy injuries and open fractures [9]. These wounds are usually linked to a large area of the soft tissue damage, which predisposes the patient to postoperative complications.

Intramedullary nailing has revolutionized the management of such fractures owing to their biomechanical stability and early ambulation [10]. However, the outcome from such a technique is determined by numerous other considerations such as fracture classification into either open or closed, the extent of injury to the soft tissues, the timing and type of surgery and other patient-related characteristics such as age, underlying medical conditions, and nutritional condition.

It is evident that there is considerable variability of the complication rate between patients and settings [11]. This points out the significance of assessing complications and related risk factors systematically. Increased awareness regarding complications and the factors associated with them would be beneficial for developing preventative measures and making decisions concerning surgery [12].

Complication Profile in Tibial Shaft Fractures:

The intramedullary nailing of the tibial shaft fractures may result in complications that are categorizable into early, late, and procedure-related groups with different etiological and clinical implications [13].

Complications that are likely to arise in the early stages include surgical site infection and compartment syndrome that normally arise in the period immediately after the surgery. Infection can be superficial wound infection, to deep-seated osteomyelitis especially in open fractures. Compartment syndrome is a rare surgical emergency that can cause muscle and nerve damage that is irreversible in the event that this condition is not addressed.

Late complications are delayed union, non-union and malunion [14]. Delayed union is the process of taking longer than normal to heal a fracture, and non-union is failure of a fracture to heal. Angular deformity or rotational deformity is caused by malunion and it may interfere with the functioning of the limbs and walking.

The complications related to the procedures directly depend on the types of surgical procedure and the characteristics of the implants. The most commonly reported complication is anterior knee pain that is commonly due to irritation of nail entry points, injury to intra-articular structures, or hardware prominence [15]. Even though a rare occurrence, failure of implants can take place owing to mechanical stress, improper fixation, or early weight-bearing.

The etiology of such complications is multidimensional and creates a confluence of biologic (vascu-

larization and bone healing ability) and mechanical (fixation stability) factors in the procedure. The identification of these determining factors is crucial for reducing the incidence of such complications.

Research Objectives

The present study was undertaken with the following objectives:

- To examine the demographic and clinical profiles of patients who have intramedullary nailing to treat tibial shaft fractures.
- To establish the incidence and trend of postoperative complications related to this procedure.
- To determine and assess the risk factors which cause these complications.
- To determine how fracture (e.g. open or closed fracture) and occurrence of complications relate.

Methodology: The present study was carried out to critically assess the complication profile of intramedullary nailing of tibia shaft fractures. The research process was carried out in a systematic and organized manner to achieve accuracy, reliability and reproducibility of the findings.

Study Design: This study was developed in the form of a hospital-based retrospective observational study. It entailed examination and evaluation of pre-recorded clinical data of patients who had undergone intramedullary nailing procedure due to tibial shaft fractures. The retrospective design of the study enabled the assessment of actual clinical outcomes and patterns of complication without affecting treatment regimens.

Study Area: The study was carried out in the Department of Orthopaedics, ICARE Institute of Medical Sciences and Research, Dr. Bidhan Chandra Roy Hospital, Haldia, West Bengal, India

Study Duration: The timeframe used for this study was 12 months.

Study Participants: A proper inclusion-exclusion criterion was used in order to ensure that there is homogeneity in the research participants

Inclusion Criteria

- Individuals within the age group of 18 to 65 years.
- Subjects with tibia shaft fractures treated through intramedullary nailing.
- Subjects having a complete medical history that can be obtained.

Exclusion Criteria

- Patients having pathological fractures (due to tumors or metabolic bone diseases)
- Previous surgery performed on the involved tibia of the patient.

- Patients with incomplete/missing clinical information.
- Patients not traceable before outcome evaluation

Sample Size: In this study, the sample size was determined by taking into consideration 150 subjects that met the criteria for inclusion in the study. The number of cases available for the study as well as chances of complete access to data were the determinants of sample size. A convenient sampling method was used, which made sure that all the possible cases were included to increase representativeness.

Procedure: The data were collected by means of thorough examination of hospital medical records, operative notes, discharge reports, and follow-up reports. Data collection was done using a pre-structured and standardized proforma to ensure uniformity.

The following parameters were recorded:

- **Demographic details:** age, gender and patient background.
- **Fracture characteristics:** type of fracture (open or closed), place and degree.
- **Mechanism of injury:** traffic accidents, falls, or other reasons.
- **Surgical details:** timing of operation (early or late), method of operation and intraoperative observations.
- **Postoperative outcomes:** incidence of complications like infection, delayed union, non-union, malunion, anterior knee pains and implant failure

Hospital protocols were followed to follow up patients and complications were recorded according to clinical examination and radiological results. Complications (e.g., delayed union defined as failure to heal after expected time, non-union as failure to heal after long period) were defined by standard definitions.

All data gathered were thoroughly checked and put into database to be analyzed.

Statistical Analysis: Statistical Package of Social Sciences (SPSS) version 25.0 was used to code, tabulate and analyze the collected data.

- **Descriptive statistics** to summarize the data such as frequencies, percentages, means and standard deviations were used.
- **Inferential statistics**, especially the chi-square test was employed to establish the connection between categorical variables such as types of fractures, surgery duration, and complication occurrence or non-occurrence
- A **p-value of less than 0.05** proved to be statistically significant, which suggests that there existed a relationship between variables

The results were presented in the form of tables and charts for better clarity and interpretation.

Results

The total number of participants included in this research is 150, and all the patients had experienced intramedullary nailing for tibial shaft fractures within a year. The obtained data were evaluated in a systematic manner to assess the demographic composition, fracture nature, and complication occurrence and the risk factors related to it. The findings are organized in a systematic format by using tables and figures to further explain and interpret.

First, demographic characteristics of the study population were measured to be acquainted with the age and gender distributions of patients. This was then accompanied by assessment of fracture types, which gives a clue on the type and extent of injuries. The frequency and pattern of postoperative complications were then run through to determine the most prevalent adverse outcomes that were related to intramedullary nailing. Finally, the study involved inferential statistical tests for examining whether any significant relationships existed among a selection of variables, which included fracture type, timing of the surgery, and complications.

Table 1: Study Participants' Age and Gender Distribution

Variable	Category	Frequency (n=150)	Percentage (%)
Age	18–30	40	26.7%
	31–50	70	46.7%
	51–65	40	26.7%
Gender	Male	110	73.3%
	Female	40	26.7%

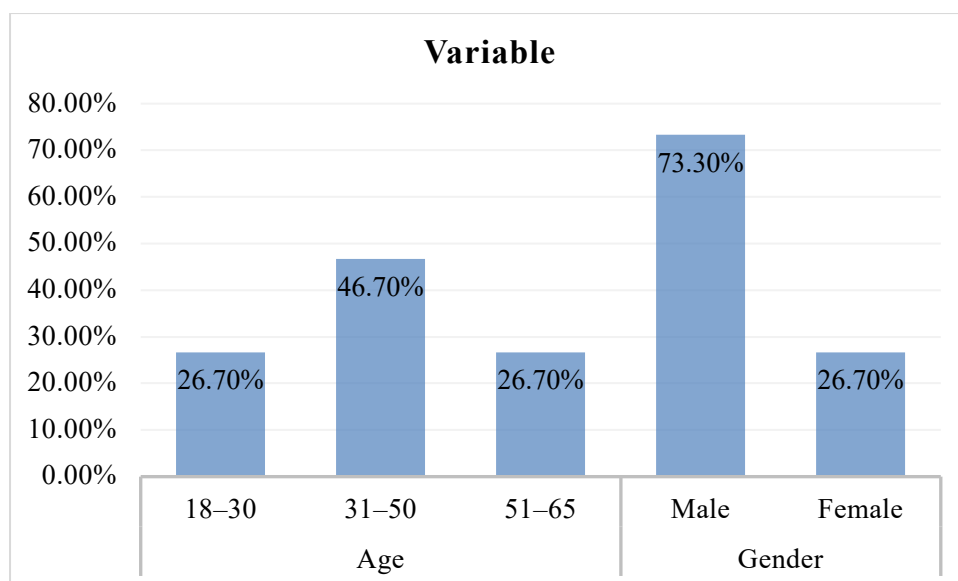


Figure 1: Age and Gender Distribution of Patients with Tibial Shaft Fractures

The age group was found to be mostly concentrated in the age group of 31-50 years, with 46.7% (n=70), demonstrating the high prevalence of tibial shaft fractures among individuals who are most productive and active. The age groups of younger (18 years to 30 years old) and older individuals (51 years to 65 years old) were equally represented (26.7% each) which posits that there is a wide age range where such fractures occur.

The distribution of gender was significantly male dominated (73.3% n=110) as opposed to female dominated (26.7% n=40). This difference can be explained by the fact that males are more exposed to risk taking behaviors like road traffic accidents, work hazards and outdoor physical labor. The results point to the demographic susceptibility of middle-aged men to tibial shaft fractures.

Table 2: Distribution of Study Participants According to Fracture Type

Fracture Type	Frequency	Percentage
Closed	100	66.7%
Open	50	33.3%

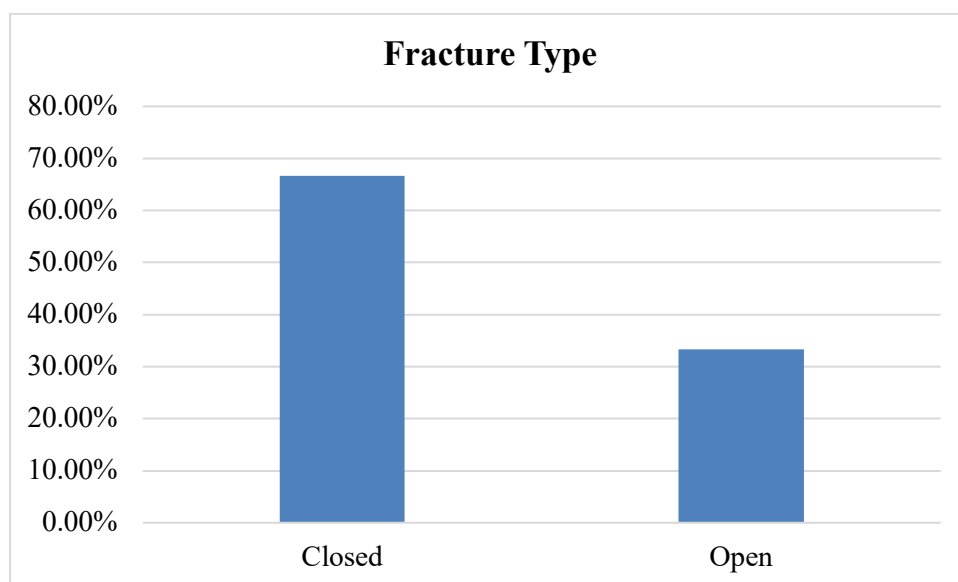


Figure 2: Proportion of Closed and Open Tibial Shaft Fractures

Fractures mainly were closed fractures (66.7%, n=100), with the rest of the cases being open fractures (33.3% n=50). Even though there is quite a

significant percentage of open fractures, the number of closed fractures is more significant, indicat-

ing that there is a large number of patients having high energy injuries in this sample.

This is because open fractures usually have associated with them the problem of extensive soft tissue

injury as well as delayed healing, which makes them at higher risk of developing infections and other complications.

Table 3: Frequency Distribution of Postoperative Complications

Complication	Frequency	Percentage
Anterior knee pain	69	46.0%
Infection	27	18.0%
Delayed union	24	16.0%
Malunion	15	10.0%
Non-union	10	6.7%
Implant failure	5	3.3%

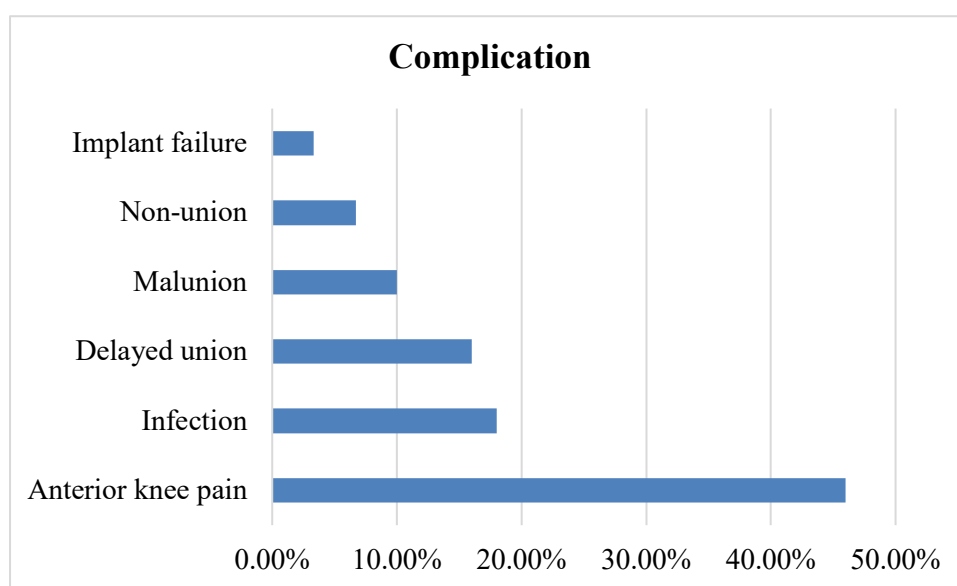


Figure 3: Distribution of Postoperative Complications Following Intramedullary Nailing

Anterior knee pain was the most common complication reported with almost half of the patients (46.0%, n=69). This observation shows the prominent functional effect of intramedullary nailing, which may have been associated with the irritation of surgical entry points or the prominence of hardware.

The second most prevalent complication was infection (18.0, n=27) and delayed union (16.0, n=24). These complications indicate both biological and surgical factors that affect the healing of the frac-

ture. Malunion (10.0%), and non-union (6.7%) were also noted which showed problems with alignment and bone healing. The least widespread complication was implant failure (3.3%), indicating that the mechanical stability of the implant was not usually a problem.

In general, the complication profile indicates that, although intramedullary nailing is effective, the morbidity in the postoperative period is still high especially in functional discomfort and delayed healing.

Table 4: Association Between Fracture Type and Infection

Fracture Type	Infection Present	Infection Absent	P-value
Open	20	30	0.002
Closed	7	93	

High infection rates were noted in patients who had open fractures (n=20) than in those with closed fractures (n=7). The findings of the study revealed that there is a significant correlation (p=0.002) between fracture and infection types.

This means in this case that the main risk factor for postoperative infections can be open fractures, which is likely connected with contamination of the bones and soft tissues with external agents, and higher tissue injury. Therefore, it becomes obvious how important is the correct approach to treating open fractures.

Table 5: Association Between Surgical Timing and Delayed Union

Timing of Surgery	Delayed Union	No Delayed Union	P-value
Early (<24 hrs)	5	60	0.01
Late (>24 hrs)	19	66	

Late union was much more frequent in patients who received late surgical intervention (>24 hours) (n=19) than in patients who received early surgical intervention (n=5). It is significantly correlated with a statistical significance (p=0.01). This means that surgeries at an early stage are very essential for achieving the optimal healing of bones. Late operations may cause more harm to soft tissues, vascularity problems, and other complications which affect bone healing.

The results of the current study suggest that tibial shaft fractures are mostly prevalent among the middle-aged males, with closed fractures being more frequent. But in open fractures, the risk of infection is much greater.

Anterior knee pain, infection, and delayed union were the most common complications which showed that both functional and biological complications cause postoperative morbidity. Moreover, it was found that there were significant correlations between fracture type and infection, and surgical timing and delayed union.

These findings support the use of early intervention, proper surgical practice, and proper postoperative care in the reduction of complications and improvement in patient outcomes following intramedullary nailing.

Discussion

The present study was designed to measure the complication pattern related to intramedullary nailing of tibial shaft fractures and define the factors that impact these data (Kariya et al., 2020) [16]. The results shed valuable light to the population distribution, trend of complications and risk factors associated with the same. Tibial shaft fractures were observed to be more common among the male patients (73.3%), especially in the 31-50 years age category. This finding is in line with the available literature, which explains the greater occurrence among males by the high-energy trauma experienced by them including road traffic accidents, work-related hazards, and outdoor physical activities (Metsemakers et al., 2015) [17]. The same has been recorded in various epidemiological studies, which have underscored the fact that tibial fractures mostly impact the economically productive population. In terms of postoperative complications, the most frequent complication was anterior knee pain (46.0%). This is not new since other researchers have reported anterior knee pain as a common side effect of intramedullary nailing. The etiology of this complication is multifactorial and can comprise

of irritation at the nail entry point, patellar tendon damage, intra-articular process, or implant prominence (Potgieter et al., 2020) [18]. Persistent knee pain, though viewed as a minor complication, may have severe consequences in terms of functional outcomes and patient satisfaction.

The second most frequent complication noted in this study was infection (18.0%), with the open fractures and infection statistically significantly related (p=0.002). This result is clinically significant and consistent with the existing evidence that open fractures are more susceptible to infection because of the destruction of soft tissues, contamination, and poor vascularity. The findings indicate the paramount significance of early wound debridement, proper use of antibiotic treatment, and a compliance with aseptic surgical practice in decreasing the rate of infection.

Delayed union was found in 16.0% and a positive relationship was found between delayed surgical intervention and delayed union (p=0.01). The subjects who underwent the operation after 24 hours exhibited higher rates of delayed recovery compared to the subjects who underwent the surgery at an earlier age. It is evident that early surgical intervention is critical for preserving vascularity, preventing tissue damage, and ensuring proper bone repair. Similar results have been found in another research conducted in orthopedics (Huang et al., 2018) [19]. Delayed surgical intervention might adversely affect the result of the healing process. Malunion (10.0%), non-union (6.7%), and implant failure (3.3) were relatively less common. The causes of these complications normally relate to issues like poor reduction of the fracture, poor choice of placement of the implant, mechanical instability, and patient-related issues such as poor compliance or comorbidity. The reported low rate of implant failure in the present study indicates that intramedullary nailing offers sufficient mechanical stability in cases where it is done with an appropriate surgical technique. Generally, the results of the current study are similar with already published orthopedic literature, which has always documented anterior knee pain, infection and delayed union as the most frequent complications following intramedullary nailing of tibial fractures. Despite all the advantages of the method in terms of bone stability and mobility, there is a possibility of occurrence of complications.

The study proved that the interaction of various factors such as fractures themselves (open or closed), surgery factors (timing and method) and

individual factors of patients can result in the development of complications (Yang et al., 2018) [20]. It means that an appropriate approach is necessary to minimize their occurrence.

Conclusion

This study suggests that IM nailing is a safe and effective method for treating tibia fracture cases, because it offers adequate stability and mobilization. The process, however, is coupled with a significant rate of postoperative complication which may influence patient recovery and functional outcome. The results of the study show that tibial shaft fracture is common among middle-aged men, which is an indication of greater exposure to high-energy trauma. The most frequent complications that were experienced included anterior knee pain, infection and delayed union. These complications point to some biological and functional issues with the treatment method. Open fractures and infections after surgery had a strong connection, which proves that this kind of injury is more vulnerable, as there are more injuries of soft tissue. In addition, timely surgery was connected to timely union, which proves that in order to increase the chances of optimal recovery, it is essential to make sure that the surgery will take place on time. Overall, the article shows that although intramedullary nailing is a golden standard for treatment, the probability of complications depends on different factors, including the kind of fracture, the timing of surgery, and other aspects. Thus, to avoid complications and provide better outcomes, it is important to provide timely treatment, proper surgical practices, proper infection prevention measures, and monitoring of patients. In conclusion, a comprehensive and patient-oriented approach is required to make intramedullary nailing more effective and decrease the number of postoperative complications.

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