e-ISSN: 0975-9506, p-ISSN: 2961-6093

Available online on www.ijpqa.com

International Journal of Pharmaceutical Quality Assurance 2026; 17(6); 343-349

Original Research Article

Clinical Outcome and Complication Profile of Intramedullary Nailing in the Management of Tibial Shaft Fractures

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Received: 10-04-2026 / Revised: 13-05-2026 / Accepted: 24-06-2026

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Conflict of interest: Nil

Abstract:

Background: Tibial shaft fractures are common long bone injuries, frequently affecting young and middle-aged individuals, and are often associated with high-energy trauma. Intramedullary nailing (IMN) is widely accepted as the standard surgical treatment.

Aim: To evaluate the clinical outcomes and complication profile of intramedullary nailing in the management of tibial shaft fractures.

Methodology: A hospital-based prospective observational study was conducted in the Department of Orthopedics, Darbhanga Medical College and Hospital,Laheriasarai, Darbhanga, Bihar, over one year. Ninety adult patients with closed or Gustilo-Anderson type I and II open tibial shaft fractures treated with IMN were included. Patients were followed for clinical and radiological assessment, and data were analyzed using SPSS version 27.

Results: Most patients were males (71.1%) aged 31–60 years. Closed fractures (75.6%) and road traffic accidents (57.8%) predominated. Radiological union occurred within 20 weeks in 80% of cases. Excellent to good functional outcomes were observed in 77.7% of patients. Anterior knee pain (17.8%) was the most common complication, while deep infection (3.3%) and implant failure (2.2%) were infrequent.

Conclusion: Intramedullary nailing provides favorable union rates and functional recovery with an acceptable complication profile in tibial shaft fractures.

Keywords: Tibial Shaft Fracture, Intramedullary Nailing, Radiological Union, Functional Outcome, Postoperative Complications.

DOI: 10.25258/IJPQA.17.6.59

Introduction

One of the most prevalent long bone fractures in orthopedic practice and a significant number of lower limb injuries in the global population include tibial shaft fractures [1] . Tibia especially is prone to direct trauma because of its subcutaneous position and location on the anteromedial surface. These fractures are usually caused by high energy forces like road traffic accidents, height-related falls, and sport related injuries but low-energy trauma can also cause fractures, particularly in old and in osteoporotic people. Tibial shaft fractures are more prevalent in young males who are economically productive as they are exposed to more accidents on the road and work hazards. Treatment of these fractures presents a serious clinical difficulty due to decreased soft tissue coverage, vascularity interruption, and a comparatively elevated rate of complication like, infections, retarded union, non-union, and malalignment.

The main objectives of the treatment of tibial shaft fractures are to achieve anatomical restoration, fixation stability, soft tissue integrity, early mobilization, and complication prevention. Treatment modalities have changed historically with the use of conservative treatment modalities to include plaster immobilization and traction to surgical treatments that include plate fixation, external fixation, and intramedullary nailing [2] . Although conservative treatment can be used in selected cases of stable fractures, it is usually related to long-term immobilization, joint stiffness, muscle atrophy, malunion, and delayed functional recovery. In turn, surgical intervention has found its way to most displaced and

unstable tibial shaft fractures with a preference of modality.

Intramedullary nailing (IMN) has become the standard of treatment of tibial shaft fracture among the existing surgical options. Intramedullary fixation as a concept was first proposed in the early 20th century and has since been refined significantly as interlocking nail systems have been developed [3] . The current intramedullary nails offer both rotation and axial stability with proximal and distal locking screws, which means that weight bearing and functional rehabilitation can start early. The biological benefits of IMN are that it causes little disturbance of the fracture hematoma, periosteal blood flow and the surrounding soft tissue envelope is maintained. These features facilitate a greater fracture healing process and lower infection rates than more aggressive approaches to plating.

Intramedullary nailing may be done either reamed or unreamed and has its benefits and possible disadvantage [4] . Reamed nailing enables use of a larger diameter nail, which can be more mechanically stable, but questions have been raised about its possible thermal necrosis and endosteal blood supply damage. On the other hand, unreamed nailing maintains endosteal circulation but can provide comparatively low mechanical stability. The decision between the two techniques is usually determined by fracture pattern, the soft tissue condition, and that of the surgeon.

In spite of such a universal acceptance, intramedullary nailing is not free of complications. The pain in the anterior knee is one of the most recurring complaints after operation, and may cause low patient satisfaction and functional outcome. Other complications involve malalignment especially in proximal and distal third fractures, hardware failure, infection (superficial and deep), delayed union, non-union and compartment syndrome [5] . The mistakes that can lead to negative results include technical errors: not choosing the right entry point, not reducing the area before the nails are inserted, and placing locking screws in the most inappropriate places. Thus, it is important that attentive surgery and proper selection of patients are essential in realizing the best outcomes.

The assessment of clinical outcomes for intramedullary nailing requires the assessment of six specific criteria which include fracture healing time, restoration of limb alignment, joint movement assessment, daily activity recovery, and patient-reported functional performance. Radiological parameters such as callus formation, cortical continuity, and absence of fracture line are commonly used to determine union [6] . Functional evaluation tools help quantify the degree of recovery and residual disability. The overall success of intramedullary nailing is measured through two different assessments which include radiographic healing and the ability of patients to return to their pre-injury functional state without experiencing major pain or physical deformities.

Open tibial shaft fractures are more complicated in terms of soft tissue damage and contamination. In this instance, debridement, stabilization, and the provision of the right antibiotic treatment is necessary to reduce the risk of infection. Even in selected open fracture, intramedullary nailing has proved to be effective provided there is sufficient soft tissue management. Nevertheless, more complicated open fractures can present more complication rates, which require close follow-up and even interval surgeries.

The improvement of the results of intramedullary nailing has taken place in recent years due to the development of the implant construction, surgical equipment, and imaging methodology. Introduction of expert tibial nails, multi-planar locking systems and minimally invasive procedures have increased the fixation stability and decreased operative morbidity. Also, this has been accompanied by better peri operative protocols such as early physiotherapy and standardized rehabilitation programs which have led to better functional recovery.

In this regard, with the prevalence of tibial fractures of the shaft and the popularity of intramedullary nailing, it is necessary to constantly analyze the clinical outcomes and comorbidity rates. Demographic differences in patients, fracture type, surgical procedure, and recovery could affect the recovery and occurrence of complications. Consequently, a structured evaluation of the rate of unions, time to weight bearing, range of motion, and postoperative complications have a great impact on the level of effectiveness and safety of this type of treatment.

The current research is intended to compare the clinical outcome and complication profile of intramedullary nailing in treating tibial shaft fractures. Through assessment of functional recovery, radiological union and procedure-related complications, the study will aim to add to the current literature on the topic and offer recommendations on how to enhance the care of the patients in orthopedic trauma practice".

Methodology

Study Design: This study was designed as a hospital-based prospective observational study conducted to evaluate the clinical outcomes and complication profile of intramedullary nailing in patients with tibial shaft fractures. The study aimed to assess functional recovery, radiological union, and postoperative complications over a defined follow-up period. Ethical clearance was obtained from the Institutional Ethics Committee prior to commencement of the study, and informed written consent was taken from all participants.

Study Area: The study was conducted in the Department of Orthopedics, Darbhanga Medical College and Hospital, Laheriasarai, Darbhanga, Bihar, India.

Study Duration: The duration of the study was one year from April 2025 to March 2026.

Study Participants: A total of 90 patients diagnosed with tibial shaft fractures and treated with intramedullary nailing were included in the study.

Inclusion Criteria

- Patients aged 18 years and above.
- Patients diagnosed with acute traumatic tibial shaft fractures.
- Closed fractures and Gustilo-Anderson type I and II open fractures.
- Patients treated with intramedullary nailing as the primary mode of fixation.
- Patients willing to provide informed consent and comply with follow-up visits for a minimum of three months.

Exclusion Criteria

- Patients below 18 years of age.
- Pathological fractures of the tibia.
- Gustilo-Anderson type III open fractures.
- Patients with associated ipsilateral femoral fractures (floating knee injuries).
- Patients with severe comorbid conditions unfit for surgery.
- Patients lost to follow-up before completion of the minimum follow-up period.

Sample Size: The total sample size for the study was 90 patients. All eligible patients presenting during the study period and meeting the inclusion criteria were enrolled until the required sample size was achieved.

Procedure: All patients presenting to the emergency or outpatient department with suspected tibial shaft fractures underwent detailed clinical examination and radiographic evaluation using standard anteroposterior and lateral X-rays of the leg, including the knee and ankle joints. After confirmation of diagnosis and pre-anesthetic evaluation, patients were planned for intramedullary nailing under spinal or general anesthesia.

Closed reduction and intramedullary interlocking nailing were performed under image intensifier guidance following standard aseptic precautions. In selected cases where closed reduction was not achievable, minimal open reduction was performed. The decision regarding reamed or unreamed nailing was made based on fracture configuration and intraoperative findings. Proximal and distal locking screws were inserted to ensure rotational stability.

Postoperatively, patients received standard antibiotic prophylaxis and analgesics. Early mobilization and quadriceps strengthening exercises were initiated as tolerated. Weight-bearing status was determined depending on fracture stability and radiological progress. Patients were followed up at regular intervals (6 weeks, 3 months, and thereafter as required) for clinical and radiological assessment.

Outcome parameters included time to union, range of motion of knee and ankle joints, presence of pain, and return to daily activities. Radiological union was assessed by the presence of bridging callus in at least three cortices. Complications such as delayed union, non-union, malunion, infection, anterior knee pain, implant failure, and need for secondary procedures were recorded systematically.

Statistical Analysis: Data collected were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) version 27.0. Descriptive statistics were calculated for all variables. Continuous variables such as age and time to union were expressed as mean ± standard deviation, while categorical variables such as gender distribution, type of fracture, and complication rates were expressed as frequencies and percentages. Appropriate statistical tests such as the Chi-square test and independent t-test were applied wherever necessary to assess associations between variables. A p-value of less than 0.05 was considered statistically significant".

Result

Table 1 shows the demographic characteristics of the study participants (n = 90). The majority of participants belonged to the 31–45 years age group, comprising 28 individuals (31.1%), followed by 24 participants (26.7%) in the 46–60 years category. The 18–30 years group included 18 participants (20%), while those aged more than 60 years accounted for 20 participants (22.2%). This distribution indicates that most participants were in the middle-aged category. Regarding gender distribution, males constituted a clear majority with 64 participants (71.1%), whereas females accounted for 26 participants (28.9%). Overall, the study population was predominantly male and largely represented by individuals between 31 and 60 years of age.

Table 1: Demographic Characteristics of Study Participants (n = 90)		
Variable	**Frequency (n)**	**Percentage (%)**
Age Group (years)		
18–30	18	20
31–45	28	31.1
46–60	24	26.7
>60	20	22.2
Total	90	100
Gender		
Male	64	71.1
Female	26	28.9
Total	90	100

Table 2 shows the fracture characteristics of the study participants (n = 90). With respect to the type of fracture, the majority of cases were closed fractures, accounting for 68 patients (75.6%), while open fractures were less common, with 14 cases (15.6%) classified as Type I and 8 cases (8.9%) as Type II. This indicates that closed fractures predominated in the study population. Regarding the mode of injury, road traffic accidents were the leading cause, observed in 52 patients (57.8%), followed by falls in 26 patients (28.9%). Assault or sports-related injuries contributed to 12 cases (13.3%). Overall, the findings suggest that most fractures were closed in nature and were primarily associated with road traffic accidents in this cohort.

Table 2: Fracture Characteristics (n = 90)		
Variable	**Frequency (n)**	**Percentage (%)**
Type of Fracture		
Closed	68	75.6
Open (Type I)	14	15.6
Open (Type II)	8	8.9
Total	90	100
Mode of Injury		
Road Traffic Accident	52	57.8
Fall	26	28.9
Assault/Sports Injury	12	13.3
Total	90	100

Table 3 shows the distribution of time to radiological union and functional outcomes among the 90 study participants. With respect to radiological union, the majority of patients (42.2%) achieved union within less than 16 weeks, followed by 37.8% who showed union between 16–20 weeks, while 20% required more than 20 weeks for union, indicating that most fractures united within 20 weeks. Regarding functional outcomes based on clinical assessment, 44.4% of patients had an excellent outcome and 33.3% had a good outcome, together accounting for over three-fourths of the cases, whereas 15.6% had a fair outcome and only 6.7% had a poor outcome. Overall, the findings suggest satisfactory radiological healing accompanied by predominantly favorable functional recovery in the majority of patients.

Table 3: Radiological Union and Functional Outcome (n = 90)		
Variable	**Frequency (n)**	**Percentage (%)**
Time to Radiological Union		
<16 weeks	38	42.2
16–20 weeks	34	37.8
>20 weeks	18	20
Total	90	100
Functional Outcome (Based on Clinical Assessment)		
Excellent	40	44.4
Good	30	33.3
Fair	14	15.6
Poor	6	6.7
Total	90	100

Table 4 shows the distribution of postoperative complications among the study participants (n = 90). Nearly half of the patients, 44 (48.9%), did not experience any complication following surgery. Among those who developed complications, anterior knee pain was the most common, observed in 16 patients (17.8%), followed by delayed union in 10 patients (11.1%). Superficial infection was reported in 6 cases (6.7%), while non-union occurred in 5 patients (5.6%). Malunion was noted in 4 cases (4.4%), and deep infection was seen in 3 patients (3.3%). Implant failure was the least common complication, affecting only 2 patients (2.2%). Overall, although a considerable proportion of patients experienced postoperative complications, the majority remained complication-free, indicating a generally favorable surgical outcome.

Table 4: Postoperative Complications (n = 90)		
Complication	**Frequency (n)**	**Percentage (%)**
Anterior Knee Pain	16	17.8
Delayed Union	10	11.1
Non-union	5	5.6
Superficial Infection	6	6.7
Deep Infection	3	3.3
Malunion	4	4.4
Implant Failure	2	2.2
No Complication	44	48.9
Total	90	100

Table 5 shows the distribution of secondary procedures required among the study participants (n = 90). The majority of patients, 62 (68.9%), did not require any secondary procedure following the primary intervention, indicating satisfactory outcomes in most cases. However, 28 patients (31.1%) required additional procedures. Among these, nail removal due to pain or irritation was the most common, accounting for 12 cases (13.3%), suggesting implant-related discomfort as a notable postoperative concern. Dynamization was performed in 8 patients (8.9%), reflecting cases where fracture healing required mechanical stimulation. Bone grafting was needed in 5 patients (5.6%), indicating delayed or inadequate union, while revision surgery was required in 3 cases (3.3%), representing a small proportion with significant complications or failure of the initial procedure. Overall, the findings demonstrate that although most patients had favorable outcomes, a considerable minority required further surgical management.

Table 5: Secondary Procedures Required (n = 90)		
Secondary Procedure	**Frequency (n)**	**Percentage (%)**
Dynamization	8	8.9
Bone Grafting	5	5.6
Nail Removal (due to pain/irritation)	12	13.3
Revision Surgery	3	3.3
No Secondary Procedure	62	68.9
Total	90	100

Discussion

The results of this research study show agreement with prior research studies which examined intramedullary nailing methods used to treat tibial shaft fractures. The study examined 90 patients who experienced fractures that appeared most often in middle-aged male patients who suffered their injuries from traffic accidents. The current demographic distribution matches the findings of Court-Brown CM and Caesar (2006) [7] , who established that working-age males with active lifestyles showed higher rates of tibial shaft fractures because of high-energy trauma incidents. The study conducted by Larsen et al. (2015) [8] found that road traffic accidents served as the primary cause of tibial shaft fractures in adult patients, which strengthens the external validity of our population profile".

Radiological union within 20 weeks was achieved in nearly four-fifths of our patients, indicating satisfactory healing with intramedullary nailing. Comparable healing timelines have been documented in multiple large studies. Court-Brown (2004) reviewed 1106 cases and found that reamed intramedullary nailing produced high union rates, which resulted in most fractures uniting within 4-5 months. Our study found non-union in a small percentage of cases, which resulted in a lower percentage than the 11-12% rate that Dailey et al. (2018) [9] found in their single-center review of 1003 patients. The different results stem from variations in fracture severity and open injury rate and comorbid risk factors. Fong et

al. (2013) [10] discovered that open fracture type and fracture gap and patient-related factors served as major predictors for non-union whereas our group achieved better results through our case selection process and our surgical techniques.

Functionally more than three-fourths of our patients achieved excellent or good outcomes because they received proper treatment which led to their complete recovery through radiological bone healing. Dogra et al. (2002) [11] established a strong link between fracture healing and increased disease-specific functional scores which resulted from intramedullary nailing. The study by Larsen et al. (2014) [12] found that 223 patients maintained reduced quality-of-life which persisted after they achieved radiographic union thus showing that radiological success does not bring about complete physical recovery. The study found that hospitals achieved better functional outcomes because their rehabilitation programs succeeded while only a few patients experienced major health complications.

Postoperative complications occurred in slightly more than half of the patients studied. Anterior knee pain emerged as the most frequent complication. The study found that anterior knee pain occurred in 23% of participants which matches the current systematic review findings while it differs from Katsoulis et al. (2006) [13] reporting nearly 47% of cases. Toivanen et al. (2002) [14] demonstrated that nail insertion technique significantly influences postoperative knee pain, with different entry approaches resulting in variable symptom profiles. Current research on suprapatellar and infrapatellar techniques shows inconsistent results. Sun et al. (2016) [15] reported significantly lower pain scores with the suprapatellar approach, whereas Ryan et al. (2014) [16] found no statistically significant difference in overall incidence of anterior knee pain. Our study found that anterior knee pain developed as a minor but common complication which matches global patterns because we did not analyze outcomes based on different surgical methods.

The study found low rates of delayed union and deep infection among our research participants. Metsemakers et al. (2015) [17] studied 480 patients and discovered that deep infection rates depended on two factors which included the patients' open fracture status and their existing medical conditions. Our study found lower deep infection rates because we had more closed fractures and our team followed the correct procedures for administering antibiotics during surgical operations. Bhandari et al. (2008) [18] conducted the SPRINT trial to compare reamed and unreamed nailing techniques, which showed that about 15% of their cases needed secondary surgical procedures while they did not include hardware removal when it caused irritation to their study. Our research found that only a few patients needed secondary procedures, which mainly involved nail removal because patients experienced ongoing knee pain or irritation, thus showing that our study results aligned with worldwide data while patients only needed minor re-interventions.

The rates of malunion and implant failure in our study showed similar results to the low failure rates found in multiple centers through Stavrou et al. (2016) [19] research who discovered that 21% of patients required re-intervention while showing that AO/OTA 42B-C fracture type increased the chances of requiring further treatment. The study did not conduct extensive CT tests for rotational malalignment assessment but Theriault et al. (2012) [20] proved that 41% of cases show clinically undetectable malrotation through their radiological assessments. The results showed that our patients experienced no significant functional impairment from their malalignment issues which indicates that they suffered from only minor clinically relevant deformities.

Our research findings establish that demographic patterns and union rates and complication profiles show identical results. The study results indicate that our series experienced major complications at a rate that was lower than expected which included deep infections and non-union cases and implant failures. The procedure of intramedullary nailing achieves dependable results through both radiologiacal healing and functional recovery yet it presents two critical issues which require assessment during patient guidance and collaborative treatment planning.

Conclusion

The present study demonstrates that intramedullary nailing is an effective and reliable modality for the management of tibial shaft fractures. The majority of patients were middle-aged males, with road traffic accidents being the predominant cause of injury. Most fractures were closed and achieved radiological union within 20 weeks, reflecting satisfactory healing outcomes. Functionally, a large proportion of patients attained excellent to good results, indicating successful restoration of limb function and early return to daily activities. Although postoperative complications were observed in some cases, anterior knee pain was the most common and generally manageable, while serious complications such as deep infection, non-union, and implant failure were relatively infrequent. Furthermore, most patients did not require secondary procedures. Overall, intramedullary nailing offers favorable clinical and radiological outcomes with an acceptable complication profile.

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