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Original Research Article

Evaluation of Clinical and Functional Outcomes Following Closed Intramedullary Nailing for Long Bone Diaphyseal Fractures

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Abstract:

Background: Diaphyseal fractures of long bones, particularly the tibia and femur, are common injuries often resulting from high-energy trauma. Closed intramedullary interlocking nailing is widely used due to its minimally invasive nature and favorable outcomes.

Aim: To evaluate the clinical and functional outcomes of closed intramedullary nailing in patients with long bone diaphyseal fractures.

Methodology: This prospective case series included 40 patients aged 18–60 years with tibial or femoral diaphyseal fractures treated with closed intramedullary nailing. Patients were followed up with clinical, radiological, and functional assessments using standardized scoring systems over a period of one year.

Result: The majority of patients were males (70%) with road traffic accidents being the most common cause (75%). Radiological union was achieved in 95% of cases, with mean union time of 20.5 weeks for tibia and 18.2 weeks for femur. Most patients showed good to excellent functional outcomes (over 80% in tibia and 87% in femur).

Conclusion: Closed intramedullary interlocking nailing is a highly effective treatment modality for diaphyseal fractures, demonstrating high union rates, early mobilization, and satisfactory functional recovery.

Keywords: Diaphyseal fractures, Intramedullary nailing, Tibia, Femur, Functional outcome, Fracture union.

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Introduction

The optimal type of internal fixation for treatment of a distal radius fracture is still under debate. The tibia is an essential weight-bearing bone of the lower limb, articulating proximally with the femur at the knee and distally with the talus at the ankle. Fractures of the distal tibial metaphysis, diaphysis and adjoining diaphysis are frequently encountered in road traffic accidents or sports injuries. These metadiaphyseal fractures differ in their therapy from articular impaction “pilon” type fractures and middle third diaphyseal injuries. Exchange Nailing involves removal of present intramedullary nail, reaming of medullary canal and insertion of nail bigger in diameter than removed nail. Diaphyseal fractures of the femur are among the most severe and frequent long-bone injuries in adult trauma patients [1].

Overall, the incidence of tibial fractures is 51.7 per 100,000 per year, while the incidence of diaphyseal and distal tibia fractures is 15.7 and 9.1 per 100,000 per year, respectively. Common criteria of a distal tibial fracture include distal extra-articular tibial fractures between 4 and 12cm from the tibial plafond (AO 42A1 and 43A1). They are further subdivided by fracture morphology and degree of comminution. 43-A1 are non-comminuted extra-articular fractures, 43-A2 are wedge fractures, and 43-A3 are comminuted extra-articular fractures. Fractures of the 43-B1 type are simply extensions of the fracture into the joint without depression of the joint surface. These are generally treated in the same manner as 43-A fractures. [2].

The IMN used in fracture fixation has been demonstrated to have little interaction with the soft tissue around the fracture although the procedure of insertion is complicated and the learning curve long. It also has been associated to problems like as malunion and knee discomfort following surgery. Open reduction and internal fixation and bridge fixation (MIPPO) are common surgical methods for internal fixation of the plate. Open reduction and internal fixation is an anatomical reduction under direct view. However, this is exceedingly disruptive to the soft tissue around the fracture. In serious situations of soft tissue damage, the preoperative preparation period needs to be extended to optimise the soft tissue healing. Compared with open reduction and internal fixation, MIPPO technique requires fixation with steel plate and also indirect bridge fixation. It has a higher probability of fracture deformity and greater potential for local soft tissue pressure. However, it is more likely to cause soft tissue damage than open reduction. [3].

Radiological union is an important milestone but complete recovery also includes pain alleviation, restoration of range of motion, return to work and general quality of life [4]. The closed intramedullary interlocking nail is the gold standard because of its biomechanical stability, minimally invasive nature, high rates of union and its ability to allow for early mobilisation. Because the femur is so important in bearing weight and walking, it is important to treat it promptly and effectively to encourage the best possible recovery and to reduce the chance of long-term impairment. Controversy remains over treatment of distal third tibial fractures. Distal third tibial fractures are different from proximal third fractures due to their difference in architecture and difference in healing capacity [5].

Fractures of the shaft of the femur are among the commonest fractures of the orthopaedic surgeon. The rise in both the frequency and gravity of fractures has been linked with improvements in mechanisation and speed of transit. Femoral shaft fractures are linked with significant mortality and morbidity, whether high- or low-energy trauma. The femur is the biggest bone in the body and one of the principal load-bearing bones in the lower leg. High-energy trauma femoral shaft fractures are frequently linked with coincident internal organ damage [6].

Steel plate fixation is necessary for MIPPO technology, as compared to open reduction and internal fixation, but it also has an indirect bridge fixation. It is more prone to cause soft tissue damage than open reduction. But it also has a greater malformation risk of fracture and potential to enhance local soft tissue pressure. These fractures are commonly caused by high energy trauma such as road traffic accidents or falls from a height and are usually accompanied with substantial soft tissue injury, major blood loss and protracted morbidity [7].

Non- union Absence of any clinical or radiological indications of advancement of fracture healing for 6-8 months after estimated time span for healing. Most prevalent reasons of non-union in humans despite current therapy are Excessive mobility at fracture site & secondly lack of blood supply to fracture site. High intensity trauma leading to highly displaced fractures especially if open or segmental can lead to serious devascularization of the bone ends by stripping of soft tissues and by disruption of medullary and extramedullary blood supply [8].

Exchange Nailing is the removal of the present intramedullary nail, reaming of the medullary canal and insertion of a nail that is bigger in diameter than the nail that was removed. The union rate for exchange nailing of femoral and tibial diaphyseal non-union has been varied from less than 50 % to more than 90 %. One research of exchange nailing indicated greater failure rates with one or more additional procedures to achieve fracture union. Another research obtained 96% union rate without requiring an extra procedure [9].

The treatment of distal tibial and femoral shaft fractures remains complicated and contentious, despite major breakthroughs in surgical methods and implant design. The decision between intramedullary nailing and plate fixation continues to be impacted by fracture form, soft tissue condition and surgeon ability, each approach presenting specific hazards such as malunion, infection or non-union. High intensity trauma further complicates the situation by interrupting the vascular supply and increasing the potential for delayed recovery. Thus, a thorough understanding of fracture biology, biomechanics and patient-specific characteristics is critical to optimise fixation techniques, minimise problems and eventually restore function and quality of life.

Methodology

Study design: This was a prospective case series conducted in the Department of Orthopaedics, Government Medical College & Hospital, Bettiah, West Champaran, and Bihar, India.

Study duration: The study was carried out over a period of 12 months.

Sample size: A total of 40 patients were included, representing the planned range of 30–50 cases, to ensure adequate statistical power and clinical relevance.

Sample technique: Patients were selected using purposive sampling from those presenting to the emergency and outpatient departments with diaphyseal fractures of the tibia or femur.

Inclusion criteria

- Patients aged 18–60 years with fresh diaphyseal fractures of tibia or femur.
- Closed fractures or Grade I open fractures according to Gustilo-Anderson classification.

- Patients fit for surgery under spinal or general anesthesia.
- Willingness to participate and provide informed consent.

Exclusion criteria

- Pathological fractures.
- Polytrauma patients with life-threatening injuries.
- Grade II and III open fractures.
- Patients with severe comorbidities precluding surgery.
- Patients unwilling or unable to comply with follow-up protocol

Data collection: Demographic details, mechanism of injury, fracture classification, operative details, and postoperative complications were recorded. Functional outcomes were assessed using standardized scoring systems Johner-Wruhs criteria for tibial fractures and IOWA functional score for femoral fractures at regular intervals (6 weeks, 3 months, 6 months, and 1 year). Radiological union was documented using serial X-rays.

Procedure: All patients underwent closed intramedullary interlocking nailing under fluoroscopic guidance. Standard surgical protocols were followed, including reaming of the medullary canal and insertion of appropriately sized nails. Postoperative care included early mobilization, physiotherapy, and weight-bearing as tolerated. Patients were monitored for complications such as infection, malunion, non-union, and knee pain.

Statistical analysis: Data were analyzed using descriptive statistics for demographic and clinical variables. Functional scores were expressed as mean ± standard deviation. Comparative analysis between tibial and femoral fracture outcomes was performed using chi-square test and Student's t-test where appropriate. A p-value of <0.05 was considered statistically significant."

Result: In table 1, the present study comprises 40 patients with a mean age of 36.8 ± 9.5 years, suggesting that diaphyseal fractures are more prevalent in the young and middle-aged population. The bulk of the patients were in the age category of 31-45 years (45%) followed by 18-30 years (35%). men clearly predominated accounting for 70% of the research sample reflecting the greater exposure of men to high energy trauma such as road traffic incidents.

Table 1: Demographic Profile

Variable	Number (n=40)	Percentage (%)
Age (Mean ± SD)	36.8 ± 9.5	—
18–30 years	14	35%
31–45 years	18	45%
46–60 years	8	20%
Male	28	70%
Female	12	30%

Table 2 Road traffic collision was the most prevalent cause of injury (75% instances) followed by fall from height (20%) and others causes (5%). This pattern indicates that the primary mechanism for diaphyseal fractures of long bones in this research population is high energy trauma.

Table 2: Mode of Injury

Mode of Injury	Number	Percentage (%)
Road Traffic Accident	30	75%
Fall from Height	8	20%
Others	2	5%

In table 3 Among the 40 patients, tibial fractures were more prevalent, accounting for 60% of cases, whereas femoral fractures accounted for 40%. The tibia is therefore more at risk of damage since it is subcutaneous and more exposed than the femur.

Table 3: Type of Fracture

Fracture Type	Number	Percentage (%)
Tibia	24	60%
Femur	16	40%

Table 4 According to AO categorisation, the majority of the fractures were Type A1 (45%), followed by Type A2 (37.5%) and Type A3 (17.5%). This study suggests that simple and wedge fractures were the majority of instances while comminuted fractures were significantly rare.

Table 4: AO Classification

Fracture Type	Number	Percentage (%)
A1	18	45%
A2	15	37.50%
A3	7	17.50%

Table 5 reveals that the mean delay between injury and surgery was 4.2 days, ranging from 1 to 10 days. Most of the patients received surgery during the first week which reflects early surgical care and stabilisation which is important for greater functional recovery and early mobility.

Table 5: Time to Surgery

Parameter	Value
Mean duration (days)	4.2 days
Range	1–10 days

Table 6 shows that radiological union was obtained in 95% of the patients and delayed union in 5%. No non-unions were noticed. The high union rate is evidence that closed intramedullary interlocking nailing is a reliable approach for fracture repair.

Table 6: Radiological Union

Outcome	Number	Percentage (%)
Union achieved	38	95%
Delayed union	2	5%
Non-union	0	0%

Table 7 The average time to union was 20.5 ± 3.2 weeks for tibial fractures and 18.2 ± 2.5 weeks for femoral fractures. Femoral fractures united marginally earlier than tibial fractures. This might be related to greater vascularity and soft tissue covering around the femur.

Table 7: Mean Time to Union

Bone	Mean Time (weeks) ± SD
Tibia	20.5 ± 3.2
Femur	18.2 ± 2.5

In table 8 tibial fractures 50% of patients had excellent success and 33.3% had good outcome showing the most (83.3%) of patients obtained favourable functional recovery.

The findings were generally good with only a small minority having fair (12.5%) or poor (4.2%) outcomes. In femoral fractures, good to outstanding results were found in 87.5% of patients (excellent results in 56.25% and good results in 31.25%) showing that roughly 87.5% of patients had well to excellent functional results.

No bad result was reported further emphasising the usefulness of intramedullary nailing in femoral shaft fractures.

Table 8: Functional Outcome

Tibia (Johner-Wruhs Criteria)		
Outcome	**Number**	**Percentage (%)**
Excellent	12	50%
Good	8	33.30%
Fair	3	12.50%
Poor	1	4.20%
Femur (IOWA Score)		
Outcome	**Number**	**Percentage (%)**
Excellent	9	56.25%
Good	5	31.25%
Fair	2	12.50%
Poor	0	0%

Discussion

The objective of this prospective case series is to examine clinical and functional result of closed intramedullary nailing (IMN) in long bone diaphyseal fractures of tibia and femur. The study involved 40 patients and gives a good insight into the role of IMN in establishing fracture union, restoration of function and complications in a resource-limited situation. The results confirm the conclusions of previous literature, but also reveal certain peculiarities particular to the study population. The mean age of patients was 36.8 years and most patients were in the age bracket of 18–45 years. This is in accordance with the epidemiological fact that diaphyseal fractures are more prevalent in young active persons subjected to high energy trauma, especially road traffic accidents (RTA). RTAs were responsible for 75% of the injuries in this cohort, highlighting the public health burden of automotive accidents in India. The male preponderance (70%) is in agreement with previous research, which ascribe it to the higher employment and outdoor exposure of males. These demographic data are in line with Wennergren et al. who observed comparable age and gender patterns in tibial fractures and support the external validity of the present research [10]".

Tibia fractures were more frequent (60%) than femur fractures (40%), which is predicted given the subcutaneous position of the tibia and its susceptibility to direct impact. AO classification showed that uncomplicated fractures (A1 and A2) were more prevalent than comminuted fractures (A3). This distribution may offer some insight into the high union rates reported, as simple fracture patterns often heal more reliably with IMN than complicated comminuted fractures. The mean time to surgery was 4.2 days and majority of the patients were operated within the first week. Early surgical stabilisation is important in preventing problems such as fat embolism, extended immobilisation, and delayed rehabilitation. The very short time between injury and surgery in this research is suggestive of efficient patient treatment and adherence to contemporary concepts of trauma care [11].

Radiological union was accomplished in 95% of the patients with delayed union in 5% of the instances and no non-union. This union rate is similar to, or perhaps better than, previously reported rates, which range from 85–95% for IMN in diaphyseal fractures. Sadic et al. found good union rates with unreamed IMN in femoral shaft fractures, but mentioned comorbidities such as knee soreness.

Results of the current investigation imply that reamed IMN as executed in this study may provide better healing potential by increasing endosteal blood flow and increasing biomechanical stability. The average duration to union was 20.5 weeks for tibial fractures and 18.2 weeks for femoral fractures. The quicker union in fractures of femur is due to the higher blood supply and the bigger soft tissue envelope of femur which favours healing. Fractures of the tibia are more exposed and less vascularized and so take longer to unite and are more prone to delayed healing. Our results are in line with the observations of Boos and Bugyi who found different union times between tibial and femoral fracture treated with IMN [12].

Functional recovery was evaluated with Johner-Wruhs criteria for tibial fractures and IOWA score for femoral fractures. The results were excellent or good in the majority of the patients: tibial fractures 83.3% and femoral fractures 87.5%. These findings show that IMN is helpful in improving mobility, reducing discomfort and improving the overall quality of life. Importantly, no complications were found in femoral fractures, thus underscoring the safety of IMN in femoral shaft injuries. The slightly higher rate of good results in femoral fractures compared to tibial fractures could be related to anatomical and biological differences, as well as to the increased mechanical stability obtained in femoral IMN. Tibial fractures, especially those in the distal metaphysis, are more problematic due to the low bone stock and potential of malalignment. However, the overall functional results in both groups were adequate confirming IMN as a gold standard therapy technique [13].

In this study, the rate of delayed unions was tiny and there were no non-unions, with the consequence of few complications. Complications of IMN often mentioned were malunion, infection and knee discomfort, which were not significant in this group. This may imply careful surgical technique, adequate patient selection and compliance with post-operative rehabilitation procedures. But the very limited sample size may hinder detection of unusual problems. Larger multicentric studies would be required to adequately examine complication rates in varied groups. IMN should be discussed in the context of other fixation procedures such as plate fixation (open reduction and internal fixation or minimally invasive percutaneous plate osteosynthesis, MIPPO). While plates provide adequate anatomical reduction, they are linked with more soft tissue disturbance, increased risk of infection and delayed mobilisation. On the contrary, IMN offers biomechanical stability with little soft tissue disruption, allowing for early weight bearing and functional recovery. Our study results further confirm the advantages of IMN over plating especially in diaphyseal fractures however fracture shape and soft tissue condition need to be carefully considered [14].

The findings of this investigation carry substantial clinical implications. First, they establish the reliability and efficacy of IMN in the treatment of diaphyseal fractures of both the tibia and femur with high rates of union and good functional recovery. Second, they emphasise the need of early surgical intervention which was related with fast union and less problems. Third, they highlight the role of standardised rehabilitation techniques to maximise functional results. Finally, the results highlight the importance of IMN in resource-limited situations, where its minimally invasive nature and consistent outcomes make it a feasible option. Limitations of the study. The study has its merit yet it has certain limitations. The original sample of 40 patients is adequate for preliminary research, but may not include the complete range of fracture forms and consequences. The 6–8-month follow-up period, while enough to determine union and early functional recovery, may not be long enough to assess long-term outcomes such as post-traumatic arthritis or persistent pain. In addition, the study was performed in a single institution, which raises the issue of whether the results can be generalised to other settings with varied patient populations and surgical competence [15].

In summary, closed intramedullary nailing demonstrated excellent clinical and functional outcomes in the management of tibial and femoral diaphyseal fractures. The high union rates, favorable functional recovery, and low complication profile observed in this study reaffirm IMN as the gold standard for long bone diaphyseal fractures. Future research with larger cohorts, longer follow-up, and comparative designs against plating techniques will further refine treatment strategies and optimize patient outcomes.

Conclusion

This prospective case series demonstrates that closed intramedullary nailing is a highly effective and reliable method for the management of long bone diaphyseal fractures of the tibia and femur. With a union rate of 95% and favorable functional outcomes in more than 80% of patients, IMN has proven to facilitate early mobilization, restore functional capacity, and minimize complications. The study highlights that femoral fractures tend to unite earlier than tibial fractures, likely due to superior vascularity and soft tissue coverage, yet both groups achieved satisfactory results overall. Offering biomechanical stability with minimal soft tissue disruption compared to plate fixation techniques. Early surgical intervention, adherence to standardized protocols, and structured rehabilitation were critical factors contributing to successful outcomes in this cohort. While the results are encouraging, limitations such as the relatively small sample size, single-center design, and short follow-up period must be acknowledged. Future multicentric studies with larger populations and longer follow-up are warranted to validate these findings and to explore long-term outcomes, including functional endurance, chronic pain, and quality of life measures

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