RESULTS OF TIBIAL FRACTURE FIXATION USING INTRAMEDULLARY NAIL UNDER FLUOROSCOPIC IMAGE INTENSIFIER AT THAI BINH GENERAL PROVINCIAL HOSPITAL

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ABSTRACT

Objective: To evaluate the surgical outcomes of tibial fracture fixation using an intramedullary nail under fluoroscopic guidance at Thai Binh Provincial General Hospital in 2023.

Methods: A cross-sectional study was conducted on 89 patients from September 2022 to March 2023 at the Department of Orthopedics and Burns, Thai Binh Provincial General Hospital.

Results: The mean postoperative hospitalization duration was 3.64 ± 0.99 days. Superficial infections occurred in 3.4% of cases, with no deep infections or chronic osteomyelitis. Most patients achieved excellent surgical outcomes, bone healing, and functional recovery at rates of 93.3%, 97.8%, and 92.1%, respectively.

Conclusion: The surgical fixation of tibial shaft fractures using a closed intramedullary nail with locking screws under fluoroscopic guidance resulted in excellent outcomes, a short postoperative period, and minimal complications. Bone alignment and functional recovery were correlated with the severity of the fracture.

Keywords: Tibial shaft fracture, bone fixation, intramedullary nail, fluoroscopic imaging.

INTRODUCTION

Tibial shaft fractures (TSF) are among the most common long bone fractures, accounting for approximately 2% of all fractures in adults [1]. Tibial shaft fractures have an incidence of 16.9 per 100,000 annually, with a distinct bimodal age distribution, peaking in young adults around 20 years old, often due to high-energy trauma such as motor vehicle accidents, and in older adults near 50 years of age, typically resulting from low-energy falls [2]. The tibia's subcutaneous position and limited soft tissue coverage present unique challenges in the management of these fractures, influencing both treatment choice and outcomes. Due to unique anatomical characteristics and varying injury mechanisms, the extent of damage in TSF is highly diverse. Accurate assessment of anatomical damage is crucial for determining appropriate treatment.

Currently, the treatment of TSF varies depending on the type and location of the fracture. The trend in TSF treatment is towards minimally invasive surgery, with closed reduction and locked intramedullary nailing being widely used. This technique is less invasive, minimizes soft tissue damage, and preserves hematomas essential for fracture healing. It has advantages such as good bone healing, early functional recovery, fewer complications, and minimal scarring. However, a proportion of patients still experience infections, delayed healing, and moderate functional recovery.

Intramedullary nailing (IMN) has become the gold standard for treating tibial shaft fractures due to its biomechanical advantages, including load-sharing stability, minimal soft tissue disruption, and high union rates [3]. Compared to plate fixation or external fixation, IMN allows for earlier weight-bearing and lower infection rates, particularly in open or comminuted fractures. The procedure is typically performed under fluoroscopic guidance, which aids in accurate nail placement, fracture reduction, and avoidance of malalignment. However, challenges such as radiation exposure, technical difficulties in proximal/distal fractures, and postoperative knee pain remain concerns.

In Vietnam, particularly at Thai Binh Provincial General Hospital, IMN is increasingly used for tibial fractures, but local data on surgical outcomes, complications, and patient recovery are limited. Most existing studies come from high-income countries, and results may not fully reflect the socioeconomic conditions, patient demographics, and surgical resources in Vietnamese healthcare settings. Therefore, evaluating the efficacy, safety, and functional outcomes of closed IM nailing under fluoroscopy in this context is essential for optimizing

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treatment protocols and improving patient care. This study aims to evaluate the surgical outcomes of tibial shaft fractures treated with closed intramedullary nailing under fluoroscopic guidance at Thai Binh Provincial General Hospital.

II. SUBJECTS AND METHODS

2.1. Subject:

Patients diagnosed with closed or Gustilo Grade I open tibial shaft fractures, with or without fibular fractures, treated with locked intramedullary nailing under fluoroscopic guidance.

Inclusion criteria: Age ≥18 years, fractures located within 7 cm below the knee joint and 4 cm above the ankle joint, passive knee flexion >90°, complete medical records, and a follow-up period of at least 6 months.

Exclusion criteria: Tibial fractures with major vascular or nerve injuries requiring repair, polytrauma, pathological fractures, chronic diseases affecting bone healing, or infected open fractures.

Study Design and Sample Size:

A cross-sectional study design was used. A convenience sample of 89 patients meeting the inclusion criteria were selected to participate in the study.

2.2. Data Collection and Analysis:

Clinical examination and X-ray evaluation.

Preoperative assessment and surgical planning.

Postoperative follow-up: wound condition, complications, periodic evaluations at 2 weeks, 1 month, and 3-6 months.

Fractures were classified according to the AO classification: The AO classification is a widely used system for classifying fractures. It provides a standardized and comprehensive way to describe fractures, which is essential for communication among healthcare professionals and for research purposes. The AO classification categorizes fractures based on: The bone involved; The location of the fracture; The type of fracture (e.g., simple, wedge, complex); The severity of the fracture; It uses alphanumeric codes to represent these characteristics, making it relatively easy to understand and use. The AO classification helps: Standardize fracture descriptions; Guide treatment decisions; Facilitate research and data collection; Improve communication between medical professionals; Functional recovery was assessed using Larson and Bostman criteria [4].

Calculate percentages for qualitative variables. Calculate mean (TB), standard deviation (SD), maximum (Max), minimum (Min), 95% confidence interval for quantitative variables. Use $\chi 2$ test to compare proportions. The difference is statistically significant when $p < 0.05$.

2.3. Ethics in Biomedical Research

Certificate of the Ethics Council in Biomedical Research, Thai Binh University of Medicine and Pharmacy No. 462/TBUMP-IRB. Keep information confidential, respect, sympathize, and share with patients and their families. Ensure professional ethics, and take good care of patients' health.

III. RESULTS

Characteristics of Study Subjects

The average age was 38.91 ± 14.32 years (ranging from 18 to 77 years), with a predominance of males (82%). The 18-30 age group had the highest proportion, and the majority of cases resulted from traffic accidents (84.3%). Among 89 patients with tibial shaft fractures, right-leg fractures accounted for 51.7%, while left-leg fractures made up 48.3%. Fractures in the upper third of the tibia were the most common (46.1%), while segmental fractures occurred in 4 patients (4.5%).

Table 1. AO Fracture Classification

Fracture Classification		Frequence	Percentage (%)	Total
Type A	A1	21	23,6	73
	A2	23	25,8	
	A3	29	32,6	
Type B	B 1	5	5,6	11
	B 2	5	5,6	
	B 3	1	1,1	
Type C		5	5,6	5

The majority of patients (73) were classified as Type A fractures, indicating mainly transverse and oblique fractures, with simple fractures (A3) accounting for 32.6%. Complex Type C fractures were observed in 5 patients (5.6%).

Treatment of Tibial Shaft Fractures

The average preoperative treatment duration was 3.36 ± 1.94 days (range: 1-11 days). All patients (100%) underwent spinal anesthesia. Closed reduction under fluoroscopic guidance was successfully performed in all cases (100%).

Table 2. Locking Screw Technique Based on Fracture Morphology

Locking Screws		Both Ends		Peripheral End Only		Total	
		Frequence	%	Frequence	%	Frequence	%
Locking Screws	Transverse <30°	6	20,7	23	79,3	29	100
	Oblique ≥30°	5	21,7	18	78,3	23	100
	Spiral	17	81	4	19	21	100
	Butterfly	11	100	0	0	11	100
	Complex	5	100	0	0	5	100
Fracture Location	Upper Third	11	100	0	0	11	100
	Middle Third	12	29,3	29	70,7	41	100
	Lower Third	17	51,5	16	48,5	33	100
	Segmental	4	100	0	0	4	100

All patients with butterfly and complex fractures received locking screws at both ends. Patients with peripheral end-only locking (50.6%) had stable fractures (transverse, simple, short oblique). All patients with upper third fractures and segmental fractures received locking screws at both ends. Among middle third fractures, 29 out of 41 cases, and among lower third fractures, 16 out of 33 cases, received peripheral end-only locking. The average surgery duration was 40.67 ± 10.83 minutes (range: 25-70 minutes). Overall surgical complications occurred in 5.6% of cases, including bone fracture (2.2%) and saphenous vein injury (3.4%).

Treatment Outcomes

Short-Term Results:

- The average postoperative hospital stay was 3.64 ± 0.99 days (range: 3-8 days).

- Superficial infections occurred in 3 cases (3.4%), with no cases of deep infection, chronic osteomyelitis, or compartment syndrome.

- Reduction outcomes were excellent in 93.3% of cases and good in 6.7%, with no cases of significant displacement.

Long-Term Results:

- All patients (100%) attended follow-up, with an average follow-up period of 6 ± 0.11 months.

- No cases of nail bending, nail fracture, or screw breakage were observed.

Functional Recovery at 6 Months:

- Knee joint mobility was rated as excellent in 96.6% of patients and good in 3.4% (3 cases). No cases of moderate or severe stiffness were observed.

- One patient (1.1%) had a mild limitation in ankle dorsiflexion (5-10°), while 98.9% had normal ankle motion.

- Postoperative knee pain during strenuous activities was reported in 3.4% of cases, while the remaining patients experienced no pain.

- Muscle atrophy was absent in 95.5% of cases, with mild atrophy observed in 4 patients (4.5%).

- At the 6-month follow-up, one patient (1.1%) had a limb length discrepancy of less than 1 cm.

Based on the Ter. Schiphort functional recovery assessment scale:

- Excellent outcomes: 92.1%
- Good outcomes: 7.9%
- No moderate or poor outcomes.

Table 3. Correlation Between Fracture Classification and Reduction Outcome

Fracture Classification	Reduction Outcome				Total		p
	Excellent		Good				
	Frequence	%	Frequence	%	Frequence	%	
A	73	100	0	0	73	100	0,01
B	8	72,7	3	27,3	11	100	
C	2	40	3	60	5	100	
Total	83	93,3	6	6,7	89	100	

All Type A fractures had excellent reduction outcomes. 72.7% of Type B fractures had excellent reduction outcomes. There was a statistically significant correlation between fracture type and reduction outcome ($p < 0.05$).

Table 4. Correlation Between Fracture Classification and Functional Recovery Outcome

Outcome / Fracture Classification	Excellent		Good		Total		p
	Frequence	%	Frequence	%	Frequence	%	
A	71	97,3	2	2,7	73	100	0,01
B	9	81,8	2	18,2	11	100	
C	2	40	3	60	5	100	

Among 73 Type A fractures, 97.3% had excellent functional recovery. Among Type C fractures, 60% had good outcomes. There was a statistically significant correlation between fracture type and functional recovery outcome ($p < 0.05$).

IV. DISCUSSION

Treatment of Tibial Shaft Fractures

In our study, 100% of patients underwent elective surgery. In the study by Nguyen Hanh Quang at Saint Paul Hospital, 50.5% of patients underwent surgical intervention within the first 24 hours. This difference can be attributed to the fact that Saint Paul Hospital is one of the leading orthopedic trauma centers in the country, located in a major city like Hanoi, with a high patient load and limited emergency operating rooms. As a result, all patients in our study underwent scheduled surgery [5].

According to our perspective, the appropriate timing for surgical intervention depends on various factors, including the patient's condition, local injuries, associated injuries, and the availability of operating room equipment.

Surgical Issues

In our study, 100% of patients underwent successful closed reduction, with no cases requiring conversion to open surgery. In contrast, Le Minh Hoan reported a 6.35% conversion rate to open surgery, mainly for fractures in the proximal third (A2 and B2 types) and C2-type fractures in the middle third [6].

In this study, 94.4% of patients underwent closed intramedullary nailing without reaming. Before surgery, the nail size was measured on X-rays. In 5 cases (5.6%), reaming was necessary due to a narrow medullary canal; all these cases were anticipated preoperatively. In the study by Nguyen Quoc Hung, 2 out of 42 cases required reaming with an 8-mm drill before nailing [7]. Nguyen Hanh Quang reported good outcomes with modified Küntscher nailing without reaming [5]. Schemitsch and colleagues also confirmed that reamed intramedullary nailing can significantly impact bone blood supply and increase the risk of infection compared to unreamed nailing [8].

Treatment Outcomes

Short-Term Outcomes

The average postoperative hospital stay was 3.64 ± 0.99 days, which aligns with findings from

Le Xuan Hong and Truong Xuan Quang at Viet Đuc Hospital [9]. This duration was shorter than that reported by Nguyen Hanh Quang at Saint Paul Hospital (6 days) and Le Minh Hoan at Hue Central Hospital (5.2 days) [5, 6].

This shorter duration can be explained by the minimally invasive nature of closed intramedullary nailing, which causes minimal soft tissue damage. We observed superficial surgical site infections in three cases (3.4%), all of which were open fractures. There were no cases of deep infection. This infection rate is similar to those reported by Le Xuan Hong (2.3%) and Nguyen Quoc Hung (4.2%) [7, 9]. In Le Minh Hoan's study of 63 tibial shaft fracture patients at Hue Central Hospital, the rate of superficial infections was 6.78% [6].

Postoperatively, fracture alignment was classified as very good in 93.3% of cases and good in 6.7%. These results are comparable to those of Le Minh Hoan, who reported 93.23% very good and 6.77% good outcomes [6].

Long-Term Outcomes

Bone Healing

At follow-up, patients underwent anteroposterior and lateral X-rays of the tibia. Radiographic bone healing was classified as very good in 98.8% of cases, and good in 2.2%, based on the criteria of JL Haas and JY De la Caffinière. According to international studies, tibial shaft fractures treated with intramedullary nailing have high bone healing rates and low infection rates, with Bhandari and Mohit reporting healing rates of 96–100% [10].

Knee Pain at 6-Month Follow-Up

At the 6-month follow-up, 96.6% of patients reported no pain, while 3.4% experienced pain only during exertion. These results are consistent with those of Le Minh Hoan, who reported that 91.67% of patients had no pain and 8.33% experienced pain with exertion [6].

Range of Motion in the Knee and Ankle

At the 6-month follow-up, 98.9% of patients had a normal ankle range of motion. In Le Minh Hoan's study, 100% of patients had normal ankle mobility at 6 months [6]. We believe that intramedullary nailing of the tibia involves minimal intervention in the knee joint, preserving articular surfaces and surrounding structures. Additionally, early postoperative rehabilitation helps restore functional mobility.

Muscle Atrophy at 6-Month Follow-Up

At the 6-month follow-up, 95.5% of patients had no muscle atrophy, while 4.5% had mild atrophy. Muscle atrophy was also reported in Nguyen Quoc Hung's 2014 study [7]. However, it is generally considered temporary, as muscle function improves with rehabilitation and regular activity.

Functional Recovery of the Lower Leg

Functional recovery after locked intramedullary nailing was classified as very good in 92.1% of cases and good in 7.9%, with no cases of moderate or poor outcomes. These results align with those of Le Xuan Hong, who reported 94.5% very good, 5.5% good, and no moderate or poor recovery cases [9]. Similarly, in the study by Le Minh Hoan and Nguyen Van Hy, functional recovery after SIGN nailing was very good or good in 95.6% of cases, moderate in 3.2%, and poor in 1.2% [6].

Our study found a significant correlation between fracture type (AO classification) and overall outcomes. Patients with simple transverse fractures (Type A) had significantly better outcomes after surgery (p=0.01). Furthermore, patients with Type A fractures also demonstrated better functional recovery compared to other fracture types (p=0.01).

V. CONCLUSION

The treatment of tibial shaft fractures using locked intramedullary nailing without opening the fracture site is a minimally invasive technique with numerous advantages. This method provides elastic stabilization and promotes indirect bone healing via bridge plating, accelerating the healing process. Early postoperative rehabilitation is recommended to optimize functional recovery.

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