

Association Between Fracture Pattern and Union Outcome Following Tibial Interlocking Nailing

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ABSTRACT

Background: Tibial fractures are common long-bone injuries that are particularly susceptible to delayed healing, infection, and non-union because of their subcutaneous location, limited soft tissue coverage, and tenuous blood supply. Although rigid intramedullary nailing is widely used for tibia shaft fractures, the relationship between fracture pattern and union outcome remains insufficiently established. **Objective:** The aim of the study was to assess the association between fracture pattern and union outcome following tibial interlocking nailing. **Methods & Materials:** This retrospective observational study was conducted in the Department of Orthopaedic Surgery, Rajshahi Medical College Hospital, Rajshahi, Bangladesh, from September 2018 to August 2020, involving 70 patients with tibial fractures treated with tibial interlocking nailing. Clinical, radiological, fracture-related, union, and postoperative complication data were collected and analyzed using SPSS. Fisher's exact test assessed the association between fracture pattern and union outcome, with $p < 0.05$ considered statistically significant. **Results:** Among 70 participants, the mean age was 33.5 ± 10.3 years, with male predominance (59, 84.3%). Right-sided fractures (38, 54.3%) and comminuted fractures (22, 31.4%) were most common, while middle-third fractures predominated (37, 52.9%). Union within 24 weeks was achieved in 60 (85.7%), with delayed union in 10 (14.3%); the association with fracture pattern was not significant ($p = 0.295$). Postoperative complications were uncommon, with 65 (92.9%) having none. **Conclusion:** Tibial interlocking nailing provides favorable union outcomes with low postoperative complications, while fracture pattern is not

significantly associated with union outcome.

Key words: Fracture Pattern, Union Outcome, Tibial Interlocking Nailing

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INTRODUCTION

Tibial fractures are among the most frequently encountered long-bone injuries in trauma practice and constitute a considerable proportion of orthopaedic admissions worldwide. The high prevalence of these fractures is related in part to the subcutaneous position of the tibia, which makes it susceptible to high-energy mechanisms, including road traffic collisions, as well as low-energy torsional forces commonly occurring during athletic and domestic injuries [1]. Tibia shaft fractures are considered the most common fractures involving the long bones [2]. The incidence of tibial diaphyseal fractures has been reported as 26 per 100,000 persons per year in an average population, representing the highest incidence among long bone fractures [3]. These fractures commonly affect young and active individuals and frequently result from high-energy trauma, including motor vehicle accidents, sports injuries, and falls from height. Direct trauma, such as road traffic accidents, may also produce associated severe soft tissue damage and is frequently accompanied by open fractures [4].

Tibial fractures are susceptible to a prolonged healing course because of the long subcutaneous border of the tibia and its tenuous blood supply [5,6]. Limited soft tissue coverage and inadequate blood supply of the tibial shaft further increase the susceptibility of these fractures to infection and non-union [7]. As severe injuries, tibial shaft fractures can result in permanent disability. Although implant designs and surgical techniques have advanced, delayed fracture healing remains an important clinical problem. The development of delayed union is influenced by complex interactions involving patient-related factors, characteristics of the injury, the biological milieu, and mechanical stability at the fracture site. Current evidence indicates that fracture configuration, soft tissue injury, smoking, nutritional status, metabolic abnormalities, and surgical factors may collectively affect the healing process, highlighting the multifactorial nature of delayed union [8].

A range of treatment modalities has been employed for tibia fractures, including casting, external fixation, plate fixation, and intramedullary fixation, with variable success [9,10]. Among these approaches,

rigid intramedullary nailing has become the most frequently used fixation method for tibia shaft fractures and has demonstrated effectiveness and safety across most fracture patterns [11]. Intramedullary nailing provides a centrally positioned, loadsharing construct that is particularly suited to diaphyseal fracture patterns. IMN is associated with earlier weight-bearing, less soft-tissue morbidity, smaller surgical incisions, and a lower risk of infection in stable fracture configurations [12]. From a biomechanical perspective, intramedullary nails act as load-sharing devices by directing stresses centrally along the mechanical axis. This arrangement preserves the fracture hematoma and protects the periosteal blood supply, thereby supporting secondary bone healing through callus formation [13,14].

Fracture patterns and locations may require particular consideration by orthopedic providers because of their potential relationship with nonunion and malunion. Clinical evidence has demonstrated variable results according to fracture morphology, soft-tissue condition, and surgical expertise. Large-scale studies have reported that the nonunion rate may be related to fracture location in various

fractures [15]. Other investigations have examined multiple factors that may influence the union rate of tibia fractures [16]. Published evidence also indicates that IMN may promote earlier weight-bearing and better early gait mechanics. A multicenter trial by Passias et al. demonstrated that IMN was associated with shorter time to union and lower reoperation rates in many diaphyseal fractures [17]. Although previous studies have investigated factors associated with nonunion and reoperation rates in tibia fractures, the relationship between tibia fracture pattern and outcomes following rigid intramedullary nailing remains an important area of investigation. Therefore, this study was conducted to assess the association between fracture pattern and union outcome following tibial interlocking nailing.

OBJECTIVE

To assess the association between fracture pattern and union outcome following tibial interlocking nailing.

METHODS & MATERIALS

This retrospective observational study was conducted in the Department of Orthopaedic Surgery, Rajshahi Medical College Hospital, Rajshahi, Bangladesh, from September 2018 to August 2020. A total of 70 patients with tibial fractures treated with tibial interlocking nailing were included, selected based on specific

inclusion criteria. Data were collected to assess the association between fracture pattern and union outcome following tibial interlocking nailing.

Inclusion Criteria

- Patients with tibial fractures treated with tibial interlocking nailing.
- Patients with adequate clinical and radiological follow-up to assess fracture union.
- Patients with complete relevant demographic, clinical, and radiological records.

Exclusion Criteria

- Patients with incomplete clinical or radiological follow-up data.
- Patients with incomplete records regarding fracture pattern or union outcome.
- Patients who did not undergo tibial interlocking nailing.

Data Collection and Study Variables

Demographic characteristics, affected side, fracture pattern, fracture level, time to union, union outcome, and postoperative complications were recorded for all included participants. Fracture patterns were categorized as transverse, oblique, spiral, or comminuted, while fracture level was classified as upper, middle, or lower third of the tibia.

Assessment of Fracture Union

Fracture union was assessed clinically and radiologically during follow-up. The time to union was recorded in weeks and

categorized as ≤ 16 weeks, 17–20 weeks, 21–24 weeks, and > 24 weeks. Union within 24 weeks was considered timely union, while union occurring after 24 weeks was considered delayed union.

Assessment of Postoperative Complications

Postoperative complications were documented during follow-up and categorized as superficial infection, deep infection, implant-related complications, or no complication.

Statistical Analysis

Data were entered, processed, and analyzed using Statistical Package for the Social Sciences (SPSS). The association between fracture pattern and union outcome was assessed using Fisher's exact test. A p-value of < 0.05 was considered statistically significant.

RESULTS

Table I presents the demographic characteristics of the study participants ($n = 70$), including 59 males (84.3%) and 11 females (15.7%), with a mean age of 33.5 ± 10.3 years. The largest proportion of participants belonged to the 21–30-year age group (24, 34.3%), followed by the 31–40-year age group (21, 30.0%), 41–50-year age group (11, 15.7%), ≤ 20 -year age group (8, 11.4%), and > 50 -year age group (6, 8.6%).

Table I

Demographic Characteristics of the Study Population ($n = 70$).

Category	Variable	Frequency (n)	Percentage (%)
Age Group (Years)	≤ 20	8	11.4
	21–30	24	34.3
	31–40	21	30.0
	41–50	11	15.7
	> 50	6	8.6
	Total	70	100.0
Mean age (Years)		33.5 ± 10.3	
Sex	Male	59	84.3
	Female	11	15.7
	Total	70	100.0

Table II presents the distribution of tibial fractures according to the affected side and fracture pattern. Right-sided fractures were observed in 38 participants (54.3%), while

left-sided fractures were observed in 32 (45.7%). Comminuted fractures were the most common pattern, occurring in 22 participants (31.4%), followed by

transverse fractures in 18 (25.7%), oblique fractures in 16 (22.9%), and spiral fractures in 14 (20.0%).

Table II

Distribution of Tibial Fractures According to Side and Fracture Pattern ($n = 70$).

Category	Variable	Frequency (n)	Percentage (%)
Side of Fracture	Right	38	54.3
	Left	32	45.7
Fracture Pattern	Transverse	18	25.7
	Oblique	16	22.9
	Spiral	14	20.0
	Comminuted	22	31.4
	Total	70	100.0

Table III presents the distribution of tibial fractures according to fracture level and time to union. Middle-third fractures were observed in 37 participants (52.9%),

followed by lower-third fractures in 18 (25.7%) and upper-third fractures in 15 (21.4%). Regarding time to union, 12 participants (17.1%) achieved union within

≤16 weeks, 27 (38.6%) within 17–20 weeks, 21 (30.0%) within 21–24 weeks, and 10 (14.3%) required >24 weeks for union.

Table III
Distribution of Tibial Fractures According to Fracture Level and Time to Union (*n* = 70).

Category	Variable	Frequency (n)	Percentage (%)
Fracture Level	Upper third	15	21.4
	Middle third	37	52.9
	Lower third	18	25.7
Time to Union	≤16 weeks	12	17.1
	17–20 weeks	27	38.6
	21–24 weeks	21	30.0
	>24 weeks	10	14.3
	Total	70	100.0

Table IV presents the association between fracture pattern and union outcome following tibial interlocking nailing. Union within 24 weeks was observed in 17 participants (94.4%) with transverse fractures, 14 (87.5%) with oblique fractures, 12 (85.7%) with spiral fractures, 12 (85.7%) with spiral fractures,

and 17 (77.3%) with comminuted fractures. Delayed union (>24 weeks) occurred in 1 participant (5.6%) with a transverse fracture, 2 (12.5%) with oblique fractures, 2 (14.3%) with spiral fractures, and 5 (22.7%) with comminuted fractures. Overall, 60 participants (85.7%) achieved

union within 24 weeks and 10 (14.3%) experienced delayed union. The association between fracture pattern and union outcome was not statistically significant (*p* = 0.295).

Table IV
Association Between Fracture Pattern and Union Outcome Following Tibial Interlocking Nailing (*n* = 70).

Fracture Pattern	Union ≤24 Weeks, n (%)	Delayed Union >24 Weeks, n (%)	Total	p-value
Transverse	17 (94.4)	1 (5.6)	18	0.295
Oblique	14 (87.5)	2 (12.5)	16	
Spiral	12 (85.7)	2 (14.3)	14	
Comminuted	17 (77.3)	5 (22.7)	22	
Total	60 (85.7)	10 (14.3)	70	

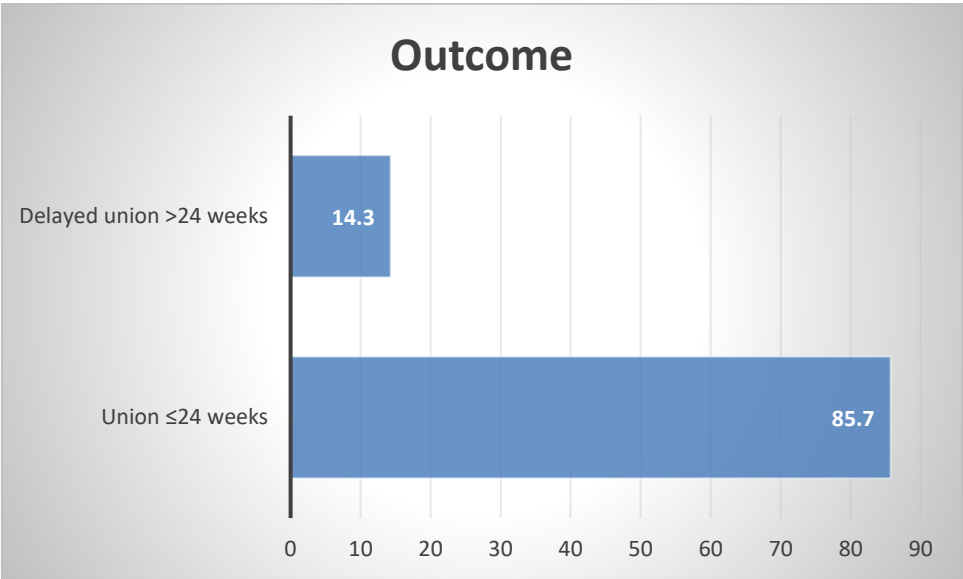


Figure 1: Distribution of Study Participants According to Union Outcome Following Tibial Interlocking Nailing (*n* = 70).

Figure 1 presents the distribution of study participants according to union outcome following tibial interlocking nailing. Union within 24 weeks was achieved in 60 participants (85.7%), while delayed union

(>24 weeks) was observed in 10 participants (14.3%).

Table V presents the distribution of postoperative complications among the study participants. No postoperative

complication was observed in 65 participants (92.9%). Superficial infection occurred in 3 participants (4.3%), while deep infection and implant-related complications were each observed in 1 participant (1.4%).

Table VDistribution of Study Participants According to Postoperative Complications ($n = 70$).

Postoperative Complication	Frequency (n)	Percentage (%)
No complication	65	92.9
Superficial infection	3	4.3
Deep infection	1	1.4
Implant-related complication	1	1.4
Total	70	100.0

DISCUSSION

In this retrospective observational study of patients undergoing tibial interlocking nailing, most participants were young males, with middle-third and comminuted fractures being the predominant patterns. The majority achieved union within 24 weeks, while delayed union was observed in a smaller proportion; although delayed union was more frequent among comminuted fractures, fracture pattern was not significantly associated with union outcome.

The demographic profile of the present study showed a predominantly young adult and male population, with a mean age of 33.5 ± 10.3 years and 59 (84.3%) participants being male. The largest proportion belonged to the 21–30-year age group (24, 34.3%), followed by 31–40 years (21, 30.0%). This age distribution was comparable to the findings of Bombah et al., who reported a mean age of 34.0 ± 12.6 years, while the present study also showed a similar male predominance (84.3% vs. 72.7%) [18]. Similarly, Shah et al. reported a relatively young study population with a mean age of 28.65 ± 8.77 years and a male predominance of 58.3% [19]. The predominance of young adult males in both the present and previous studies indicates a broadly similar demographic profile among patients undergoing treatment for tibial fractures.

The present study showed a slight predominance of right-sided tibial fractures, observed in 38 (54.3%) participants, compared with 32 (45.7%) with left-sided fractures. Comminuted fractures were the most common pattern, occurring in 22 (31.4%) participants, followed by transverse fractures in 18 (25.7%), oblique fractures in 16 (22.9%), and spiral fractures in 14 (20.0%). The side distribution was comparable with Gupta et al., who reported right-sided fractures in 52% and left-sided fractures in 48% [20]. Regarding fracture pattern, Gupta et al. reported oblique fractures as the most frequent (36%), followed by transverse (32%), comminuted (20%), spiral (8%), and segmental fractures (4%), whereas the present study demonstrated a higher proportion of comminuted fractures and lower proportions of oblique and transverse fractures [20]. Similarly, Venkata et al., in their study of isolated tibial diaphyseal fractures treated with IMIL nails, reported a distribution of fracture patterns across

different morphological types, supporting the occurrence of varied fracture configurations among patients managed with intramedullary nailing [21].

The present study demonstrated that middle-third tibial fractures were the most common, occurring in 37 (52.9%) participants, followed by lower-third fractures in 18 (25.7%) and upper-third fractures in 15 (21.4%). This finding was directly comparable with Bari et al., who also reported the highest proportion of fractures in the middle third of the tibia [22]. Regarding healing, 12 (17.1%) fractures united within 16 weeks, 27 (38.6%) within 17–20 weeks, and 21 (30.0%) within 21–24 weeks, indicating that 60 (85.7%) fractures achieved union within 24 weeks, while 10 (14.3%) showed delayed union beyond 24 weeks. Bari et al. reported a mean union time of 16 weeks, with a range of 12–20 weeks, reflecting a relatively similar pattern of union within the early postoperative period [22]. Similarly, Solooki et al., in patients with complex tibial and femoral fractures treated with static interlocking intramedullary nails, reported union of all tibial fractures within 12–28 weeks, with a mean union time of 13.4 weeks; although four patients developed delayed union, all subsequently united without additional intervention [23]. These findings support the observation in the present study that the majority of tibial fractures achieved union within the first several months following interlocking nailing.

The present study demonstrated that union within 24 weeks was achieved in 17 (94.4%) transverse fractures, 14 (87.5%) oblique fractures, 12 (85.7%) spiral fractures, and 17 (77.3%) comminuted fractures, while delayed union occurred in 1 (5.6%), 2 (12.5%), 2 (14.3%), and 5 (22.7%) cases, respectively. Although the association between fracture pattern and union outcome was not statistically significant ($p = 0.295$), the higher proportion of delayed union among comminuted fractures was consistent with the findings of Karim et al., who reported delayed union in 3/17 (17.6%) transverse, 2/22 (9.0%) oblique, and 4/13 (30.8%) comminuted fractures, while all 8 (100%) spiral fractures united [24]. Similarly, Venkata et al., in a study of 120 tibial shaft fractures treated with closed intramedullary interlocking nails, reported delayed union in 27 (23%) patients and noted that

displaced and comminuted fractures appeared to be associated with prolonged union and nonunion [21]. Thus, the present findings similarly showed a greater proportion of delayed union among comminuted fractures (22.7%) compared with transverse (5.6%), oblique (12.5%), and spiral fractures (14.3%), although this observed variation did not reach statistical significance.

The present study demonstrated favorable union outcomes following tibial interlocking nailing, with 60 (85.7%) participants achieving union within 24 weeks and 10 (14.3%) experiencing delayed union beyond 24 weeks. This finding was comparable with Balaji et al., who reported that 42 of 50 patients (85%) achieved union without further intervention following reamed intramedullary interlocking nailing of isolated tibial shaft fractures, while 9 (15%) experienced union-related problems, including delayed union and nonunion [25]. The proportion achieving successful union in the present study (85.7%) was therefore very similar to that reported by Balaji et al. (85%), supporting the generally favorable union outcomes associated with intramedullary interlocking nailing of tibial shaft fractures. The present study demonstrated a low frequency of postoperative complications following tibial interlocking nailing, with 65 (92.9%) participants experiencing no complication. Superficial infection occurred in 3 (4.3%) participants, deep infection in 1 (1.4%), and implant-related complications in 1 (1.4%). These findings were comparable with Lee et al., who reported four early complications (10%) in the interlocked-nail group, including one superficial infection, one deep infection, and two broken locking screws [26]. The infection rates in the present study were slightly lower, with superficial and deep infections occurring in 4.3% and 1.4% of participants, respectively, compared with the corresponding complications reported by Lee et al. [26]. Similarly, Potarlanka et al. reported a 6% superficial infection rate and a 2% implant failure rate among 50 patients treated with intramedullary interlocking nails, which were broadly comparable to the 4.3% superficial infection and 1.4% implant-related complication rates observed in the present study [27]. Overall, the low complication rates and the high proportion of participants without postoperative

complications in the present study are consistent with the favorable safety profile reported in previous studies of intramedullary interlocking nailing for tibial shaft fractures.

LIMITATIONS

The study had a few limitations:

- Single-center study, limiting the generalizability of the findings.
- Relatively small sample size, which may limit the statistical power and representativeness of the study.

CONCLUSION

Tibial shaft fractures are commonly managed with interlocking nailing to achieve stable fixation and promote fracture healing. The present study demonstrated favorable union outcomes, with most participants achieving union within 24 weeks and a smaller proportion experiencing delayed union. Although delayed union was more frequent among comminuted fractures than other fracture patterns, the association between fracture pattern and union outcome was not statistically significant. Postoperative complications were uncommon, with most participants experiencing no complications. Overall, tibial interlocking nailing was associated with favorable union outcomes and a low rate of postoperative complications, while fracture pattern was not significantly associated with union outcome.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

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