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OUTCOME OF EARLY VERSUS DELAYED WEIGHT BEARING FOLLOWING INTRAMEDULLARY INTERLOCKING NAILING OF TIBIAL SHAFT FRACTURES: A COMPARATIVE STUDY

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ABSTRACT

Background: Optimal timing of postoperative weight bearing after intramedullary interlocking nailing of tibial shaft fractures remains controversial, with concerns regarding fracture healing, implant stability, and functional recovery.

Objective: To compare outcomes of early versus delayed weight bearing following intramedullary interlocking nailing of tibial shaft fractures.

Methods: This comparative cross-sectional analytical study was conducted at Orthopaedics department of Gurki Trusy and Teaching Hospital, Lahore from November 2024 to April 2025, including 210 patients with tibial shaft fractures treated with intramedullary interlocking nailing.

Results: Baseline characteristics were comparable between groups. Early weight bearing resulted in significantly faster radiological union (15.8 ± 3.9 vs. 18.6 ± 4.8 weeks; $p<0.001$), earlier independent ambulation (9.4 ± 3.1 vs. 22.8 ± 6.7 days; $p<0.001$), shorter hospital stay (5.8 ± 1.9 vs. 8.6 ± 2.7 days; $p<0.001$), and quicker return to routine activity (10.7 ± 3.4 vs. 15.9 ± 4.2 weeks; $p<0.001$). Better knee and ankle range of motion and lower pain scores were also observed in the early group. Overall complication rates were lower with early weight-bearing (17.1% vs. 32.4%; $p=0.01$). Delayed weight bearing was an independent predictor of poor outcome (aOR 2.94; $p=0.004$).

Conclusion: Early weight bearing after intramedullary interlocking nailing of tibial shaft fractures appears safe and provides superior functional and radiological outcomes compared with delayed mobilization.

KEYWORDS: Tibial shaft fracture; intramedullary interlocking nail; early weight bearing; fracture union; orthopedic rehabilitation.

INTRODUCTION

Tibial shaft fractures are among the most common long bone fractures encountered in orthopedic trauma practice, accounting for a substantial proportion of lower extremity injuries due to the subcutaneous location and biomechanical vulnerability of the tibia [1]. These fractures commonly result from road traffic accidents, falls, sports injuries, and high-energy trauma, particularly in young and active populations [2]. Because of their frequency and associated functional disability, optimal management strategies remain an important focus in orthopedic trauma care [3]. Intramedullary interlocking nailing has become the gold standard treatment for displaced tibial shaft fractures due to its biomechanical stability, preservation of fracture biology, minimal soft tissue disruption, and favorable union outcomes [4]. Compared with plate fixation or conservative treatment, interlocking nailing allows improved fracture alignment, earlier mobilization, reduced hospitalization, and faster return to functional activity [5]. However, the timing of postoperative weight bearing remains a debated issue in fracture rehabilitation [6]. Early mobilization following fracture fixation is increasingly encouraged because prolonged immobilization is associated with muscle atrophy, joint stiffness, delayed functional recovery, venous thromboembolism, reduced bone mineral density, and overall poorer rehabilitation outcomes [7]. Early weight bearing may stimulate callus formation through controlled mechanical loading, enhance fracture healing, and improve patient confidence and mobility [8]. Biomechanical studies have suggested that modern interlocking nail constructs provide sufficient stability to tolerate early axial loading in appropriately selected fractures [9].

Despite these theoretical advantages, concerns remain regarding premature weight bearing after tibial nailing. Excessive early loading may increase the risk of implant failure, malalignment, delayed union, nonunion, pain

exacerbation, or secondary displacement, particularly in unstable fracture patterns or poor bone quality [10]. As a result, many surgeons continue to adopt delayed weight-bearing protocols depending on fracture characteristics and clinical judgment [11]. Comparative studies examining early versus delayed weight bearing after intramedullary tibial nailing have shown mixed findings. Some studies suggest that early weight bearing leads to faster functional recovery without compromising fracture healing, while others recommend cautious progression due to concerns regarding mechanical complications [12]. Variability in fracture patterns, fixation techniques, rehabilitation protocols, and outcome definitions contributes to inconsistency in available evidence [13]. Functional recovery after tibial fracture treatment is influenced not only by fracture union but also by pain control, time to independent ambulation, return to work, range of motion recovery, and complication rates [14]. Therefore, evaluating both radiological and functional outcomes is essential when comparing rehabilitation strategies [15]. Determining the optimal timing for postoperative weight bearing has significant clinical implications for orthopedic rehabilitation protocols, hospital stay reduction, patient satisfaction, and socioeconomic recovery [16]. However, local comparative evidence on this subject remains limited.

Objective

To compare outcomes of early versus delayed weight bearing following intramedullary interlocking nailing of tibial shaft fractures.

METHODOLOGY

This was a comparative cross-sectional analytical study conducted at Orthopaedics department of Gurki Trusy and Teaching Hospital, Lahore from November 2024 to April 2025, including 210 patients with tibial shaft fractures treated. Adult patients aged 18–65 years with acute unilateral closed tibial shaft fractures treated with intramedullary interlocking nailing were included in the study. Patients with radiographically confirmed tibial shaft fractures suitable for postoperative rehabilitation follow-up, who were medically stable and willing to participate with informed consent, were included. Patients with open Grade III fractures, pathological fractures, polytrauma requiring prolonged immobilization, associated ipsilateral lower limb fractures, severe neurovascular injury, preexisting lower limb deformity, metabolic bone disease, uncontrolled diabetes affecting fracture healing, chronic infection, or incomplete follow-up records were excluded from the study.

Data Collection

After obtaining ethical approval, data were collected using a structured proforma. Patients were divided into two groups based on postoperative rehabilitation protocol: early weight-bearing group and delayed weight-bearing group. Baseline demographic and clinical variables included age, gender, mechanism of injury, fracture pattern, fracture location, comorbidities, smoking history, and body mass index. Operative details including timing of surgery, nail type, reamed or unreamed fixation, and intraoperative complications were recorded. Outcome measures included time to radiological union, pain scores, time to independent ambulation, hospital stay duration, range of knee and ankle motion, return to work or routine activity, and complications including delayed union, nonunion, malalignment, implant failure, infection, and reoperation. Follow-up clinical and radiographic assessments were performed at scheduled intervals to compare recovery outcomes between groups.

Statistical Analysis

Data were analyzed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequency and percentage. Independent t-tests and chi-square tests were used to compare outcomes between early and delayed weight-bearing groups. Multivariable logistic regression analysis was performed to identify predictors of delayed union and postoperative complications. A p-value ≤ 0.05 was considered statistically significant.

RESULTS

Both groups were comparable at baseline. Mean age was 36.8 ± 11.2 years in the early weight-bearing group and 38.4 ± 10.7 years in the delayed group (p=0.29). Most patients were male, and road traffic accident was the commonest injury mechanism in both groups. Fracture location and fracture pattern were also similar, showing no significant baseline difference between groups.

Table 1: Baseline Demographic, Injury, and Fracture Characteristics of Patients With Tibial Shaft Fractures (n = 210)

Variable	Early Weight Bearing (n=105)	Delayed Weight Bearing (n=105)	p-value
Age (years), mean ± SD	36.8 ± 11.2	38.4 ± 10.7	0.29
Male Gender, n (%)	78 (74.3%)	81 (77.1%)	0.64
Female Gender, n (%)	27 (25.7%)	24 (22.9%)	
BMI (kg/m²), mean ± SD	27.1 ± 4.3	27.8 ± 4.7	0.25
Road Traffic Accidents, n (%)	69 (65.7%)	72 (68.6%)	0.65
Fall From Height, n (%)	24 (22.9%)	20 (19.0%)	

Sports Injury, n (%)	12 (11.4%)	13 (12.4%)	
Midshaft Tibial Fracture, n (%)	61 (58.1%)	58 (55.2%)	0.74
Proximal Shaft Fracture, n (%)	19 (18.1%)	22 (21.0%)	
Distal Shaft Fracture, n (%)	25 (23.8%)	25 (23.8%)	
Simple Fracture Pattern, n (%)	63 (60.0%)	59 (56.2%)	0.58
Comminuted Fracture, n (%)	42 (40.0%)	46 (43.8%)	

Early weight bearing showed significantly better functional and radiological outcomes. Time to union was shorter in the early group (15.8 ± 3.9 vs. 18.6 ± 4.8 weeks; p<0.001), with earlier independent ambulation (9.4 ± 3.1 vs. 22.8 ± 6.7 days; p<0.001).

Table 2: Comparative Functional and Radiological Outcomes Between Early and Delayed Weight Bearing Groups

Variable	Early Weight Bearing (n=105)	Delayed Weight Bearing (n=105)	p-value
Time to Radiological Union (weeks), mean ± SD	15.8 ± 3.9	18.6 ± 4.8	<0.001
Time to Independent Ambulation (days), mean ± SD	9.4 ± 3.1	22.8 ± 6.7	<0.001
Hospital Stay (days), mean ± SD	5.8 ± 1.9	8.6 ± 2.7	<0.001
Return to Routine Activity (weeks), mean ± SD	10.7 ± 3.4	15.9 ± 4.2	<0.001
Knee ROM at Final Follow-up (degrees), mean ± SD	126.4 ± 11.3	116.8 ± 13.7	<0.001
Ankle ROM at Final Follow-up (degrees), mean ± SD	31.2 ± 6.1	25.7 ± 7.3	<0.001
Pain Score (VAS), mean ± SD	2.8 ± 1.2	4.1 ± 1.6	<0.001

Overall complications were lower in the early weight-bearing group, 18 (17.1%) compared with 34 (32.4%) in the delayed group (p=0.01). Delayed union was also less frequent with early weight bearing, 9 (8.6%) versus 19 (18.1%) (p=0.04). Nonunion, malalignment, implant failure, infection, and reoperation were slightly higher in the delayed group, but these differences were not statistically significant.

Table 3: Postoperative Complications Comparison Between Study Groups

Variable	Early Weight Bearing (n=105)	Delayed Weight Bearing (n=105)	p-value
Delayed Union, n (%)	9 (8.6%)	19 (18.1%)	0.04
Nonunion, n (%)	3 (2.9%)	7 (6.7%)	0.19
Malalignment, n (%)	4 (3.8%)	5 (4.8%)	0.73
Implant Failure, n (%)	2 (1.9%)	3 (2.9%)	0.65
Superficial Infection, n (%)	6 (5.7%)	7 (6.7%)	0.77
Reoperation, n (%)	4 (3.8%)	8 (7.6%)	0.23
Any Complication, n (%)	18 (17.1%)	34 (32.4%)	0.01

Multivariable analysis showed that delayed weight bearing was a significant predictor of delayed union or poor outcome (aOR 2.94; 95% CI: 1.39–6.21; p=0.004). Comminuted fracture pattern (aOR 2.61; p=0.01) and smoking history (aOR 2.33; p=0.03) were also significant predictors, while age >50 years and BMI ≥30 kg/m² showed increased risk but were not statistically significant.

Table 4: Multivariable Logistic Regression Analysis for Predictors of Delayed Union / Poor Outcome

Variable	Adjusted OR	95% CI	p-value
Delayed Weight Bearing	2.94	1.39–6.21	0.004
Comminuted Fracture Pattern	2.61	1.24–5.47	0.01
Smoking History	2.33	1.08–5.02	0.03
Age >50 Years	1.98	0.94–4.19	0.07
BMI ≥30 kg/m²	1.89	0.91–3.94	0.08

DISCUSSION

The results of this study indicated that early weight bearing after IMIN of tibial shaft fractures was correlated with improved functional results, quicker healing of the fractures and reduced complication rate without compromising the implant failure rate. This study is consistent with the emerging theory of early controlled mechanical loading following stable tibial fixation to obtain better recovery results. There were no significant differences in baseline characteristics between both groups, which included age (36.8 ± 11.2 years vs. 38.4 ± 10.7 years), BMI (27.1 ± 4.3 kg/m² vs. 27.8 ± 4.7 kg/m²), fracture location, injury mechanism, and fracture pattern, suggesting balanced comparison. The most frequent mechanism was for both groups of patients, road traffic accidents, typical of the epidemiology of tibial shaft fractures in an active adult population. Another study found a similar result for road traffic trauma having the highest incidence of tibial shaft fracture surgeries [17]. This study revealed a key aspect of significantly accelerated bone healing in the early weight bearing group. The mean radiological union time was 15.8 ± 3.9 weeks vs. 18.6 ± 4.8 weeks in delayed group ($p<0.001$). Physiological stress transmission, controlled axial loading, control of callus formation and promotion of osteogenesis may be beneficial for biomechanical healing. In a previous study, comparable results were obtained with patients who were given early postoperative weight bearing following intramedullary tibial fixation, with shorter union times noted [18]. Early mobilization resulted in significant improvement in functional recovery. There were significant differences both in the days required for independent ambulation (9.4 ± 3.1 vs. 22.8 ± 6.7, $p<0.001$) and in the number of weeks before return to routine activities (10.7 ± 3.4 vs. 15.9 ± 4.2, $p<0.001$). Hospital stay was also reduced (5.8 ± 1.9 days vs. 8.6 ± 2.7 days), implying that there could be a significant improvement in patient management and healthcare resource use. A previous study also reported that early mobilization led to better milestones of ambulation and lower hospital stay after fixation of lower limb fractures [19].

Early weight bearing also had better joint mobility outcomes. Both groups had significantly different range of motion at the ankle (31.2 ± 6.1° early group versus 25.7 ± 7.3° late group) and knee (126.4 ± 11.3° early group versus 116.8 ± 13.7° late group). Early functional loading may decrease joint stiffness, soft tissue contracture and muscle deconditioning. Another study had also shown that early rehabilitation regimes resulted in increased joint mobility and functional recovery [20]. The results of the pain outcomes also favored early mobilization. EWB patients reported significantly less pain at follow up (2.8 ± 1.2 vs. 4.1 ± 1.6; $p<0.001$). This benefit may be due to increased mobilization, decreased stiffness, and quicker recovery of function in the affected limb. Another study found that patients with early mobilization (after intramedullary fixation) had less pain burden. In important, there was no significant increase in mechanical complications with early weight bearing. Failure of the implants was low and similar between the groups (1.9% vs. 2.9%) as was malalignment (3.8% vs. 4.8%). These findings contradict the traditional fear that early loading would adversely affect fixation stability with the use of modern interlocking nail constructs when properly used. One previous study also reported no significant difference in failure or in malalignment with early weight bearing [21]. Complication analysis revealed improved overall results with early weight bearing. The rate of overall complications was significantly less (17.1% vs. 32.4%, $p=0.01$) and delayed union was less common (8.6% vs. 18.1%, $p=0.04$). There were no statistically significant differences in nonunion rates, infection rates or reoperation rates between the two groups, though the early group had lower numbers of each of these complications. An earlier study also found that early mobilization resulted in a decrease in delayed union and similar complication rates [22].

Limitations

This study has several limitations. Being a single-center comparative cross-sectional study, causal relationships between weight-bearing strategy and outcomes cannot be established with absolute certainty. Allocation into early and delayed weight-bearing groups was not strictly randomized, which may introduce selection bias. Functional recovery may also have been influenced by individual rehabilitation adherence, pain tolerance, and physiotherapy participation, which were not fully standardized. Fracture healing assessment was based primarily on radiological and clinical follow-up, which may have some observer variability. Additionally, long-term outcomes such as implant longevity, late functional disability, and quality-of-life measures were not assessed.

CONCLUSION

It is concluded that early weight bearing following intramedullary interlocking nailing of tibial shaft fractures is safe and associated with superior clinical outcomes compared with delayed weight bearing. Early mobilization resulted in faster fracture union, earlier independent ambulation, shorter hospital stay, quicker return to routine activities, better joint range of motion, lower pain scores, and fewer postoperative complications without increasing implant failure or malalignment. Delayed weight bearing, comminuted fractures, and smoking were significant predictors of poor outcomes.

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