

Comparative Functional Outcomes of Early vs Delayed Weight-Bearing after Intramedullary Nailing of Tibial Shaft Fractures

Dr. Vinay Kumar Guwalani¹ (Assistant Professor), Dr. Usha²

(Medical Officer) & Dr. Anil Daswani³ (Consultant),

Dept. of Orthopaedics, Amaltas Institute of Medical Sciences, Dewas, M.P.¹

Corresponding Author: Dr. Vinay Kumar Guwalani

Abstract

Background: Initiation of weight-bearing following intramedullary nailing (IMN) of tibial shaft fractures remains controversial. Early weight-bearing (EWB) may accelerate rehabilitation but could risk implant failure whereas delayed weight-bearing (DWB) may protect fixation at the expense of stiffness and delayed recovery.

Objective: To compare functional outcomes of EWB versus DWB after tibial shaft fracture fixation by IMN.

Methods: Sixty adult patients with closed, unilateral tibial shaft fractures treated with IMN were prospectively enrolled and randomized 1:1 to EWB (partial weight-bearing from 2 weeks; full by 6 weeks) or DWB (non-weight-bearing for 6 weeks; then gradual progression). Outcomes included time to radiographic union, return to work/activity, functional scores (Lower Extremity Functional Score [LEFS], SF-36), implant-related complications, and pain (VAS).

Results: Patients in the EWB group demonstrated significantly faster radiographic union (mean 14.2 vs 17.8 weeks; $p = 0.002$), earlier return to work (mean 10.8 vs 15.3 weeks; $p < 0.001$), improved LEFS at 12 weeks (mean 68.4 vs 54.7; $p < 0.001$) and comparable complication rates ($p = 0.535$). SF-36 physical component scores were higher in the EWB group at 12 and 24 weeks. There was no difference in pain scores at 6 months.

Conclusion: Early weight-bearing following IMN of tibial shaft fractures yields superior functional outcomes and earlier return to activity with no increased risk of complications. EWB should be considered in stable fracture patterns.

Introduction

Tibial shaft fractures are among the most common long-bone injuries encountered in orthopaedic practice, with an annual incidence of 17 to 40 per 100,000 population.^{1–3} Closed intramedullary nailing (IMN) has become the gold standard for displaced tibial shaft fractures because of its mechanical stability and minimal soft tissue disruption.^{4–6} Postoperative rehabilitation protocols, particularly the timing of weight-bearing, vary widely among surgeons.

Early weight-bearing (EWB) after IMN is increasingly advocated based on the principles of mechanotransduction and Wolff's law, where controlled mechanical loading stimulates callus

formation and accelerates healing.⁷ However, concerns persist that excessive load might compromise fixation integrity, leading to malalignment or implant failure, especially in unstable fracture patterns.⁸ Delayed weight-bearing (DWB) aims to protect the fixation construct but may result in joint stiffness, muscle atrophy, and psychosocial burden due to prolonged restricted mobility.⁹

Despite these considerations, high-quality evidence comparing functional recovery, union rates, and complication profiles between EWB and DWB remains limited. Existing studies often lack randomization, adequate sample sizes, or standardized outcome reporting.^{10–12}

This study was conducted to prospectively compare the functional outcomes, radiographic union, complications, and patient-reported measures in patients treated with EWB versus DWB following IMN for tibial shaft fractures.

Methods

A prospective cohort study was conducted at a Tertiary Care Orthopaedic Centre for 01 Year and written informed consent was obtained from all subjects.

Inclusion criteria:

- Age 18–60 years
- Closed, unilateral tibial shaft fractures (AO/OTA 42-A to C)
- Treated with reamed, statically locked IMN within 48 hours of injury

Exclusion criteria:

- Open fractures Gustilo–Anderson Types II & III
- Pathological fractures
- Polytrauma requiring prolonged immobilization
- Cognitive impairment preventing protocol compliance
- Neuromuscular disorders affecting gait

Randomization and Interventions

After surgery, patients were randomized using sealed envelopes into two groups:

- **EWB Group (n = 30):** Partial weight-bearing (30–50%) initiated at 2 weeks, advanced to full weight-bearing by 6 weeks.
- **DWB Group (n = 30):** Non-weight-bearing for at least 6 weeks; then gradual progression to full weight-bearing by 10–12 weeks.

Both groups received standardized physiotherapy, thromboprophylaxis, analgesia, and follow-up.

Outcome Measures

Primary Outcome:

- Time to radiographic union (bridging callus in ≥ 3 cortices on two views)

Secondary Outcomes:

- Lower Extremity Functional Score (LEFS) at 6, 12, and 24 weeks
- SF-36 physical and mental component scores
- Return to work/activity
- Visual analogue scale (VAS) for pain
- Complications (malunion, nonunion, implant failure, infection)

Statistical Analysis

Data were analyzed using SPSS v27. Continuous variables were compared using independent t-tests or Mann–Whitney U tests, categorical variables by chi-square or Fisher's exact tests. A p-value < 0.05 was considered statistically significant.

Results

Demographics and Baseline Characteristics

Both groups were similar regarding age, gender, smoking status, fracture classification, and surgical details.

Radiographic Outcomes

Mean time to radiographic union was significantly shorter in the EWB group (14.2 ± 2.8 weeks) compared with the DWB group (17.8 ± 3.5 weeks, $p = 0.002$).

Functional Outcomes

EWB patients had significantly higher LEFS and SF-36 physical scores at 12 and 24 weeks. By 24 weeks, the differences narrowed but remained statistically significant for primary functional endpoints.

Return to Activity and Pain

EWB individuals returned to work and unrestricted activity earlier (mean 10.8 vs 15.3 weeks, $p < 0.001$). Pain scores (VAS) were comparable at 6 months.

Complications

Overall complication rates were low and comparable between groups:

- Two cases of delayed union in EWB

- Three cases of delayed union and one superficial infection in DWB
- No implant failures in either group ($p = 0.535$)

Table 1: Baseline Characteristics (n = 60)

Parameter	EWB Group (n = 30)	DWB Group (n = 30)	p-Value
Age (years, mean \pm SD)	38.5 \pm 11.2	37.9 \pm 10.4	0.83
Male (%)	22 (73.3%)	21 (70.0%)	0.78
Smokers (%)	8 (26.7%)	7 (23.3%)	0.77
Fracture type (AO)	42-A: 14; 42-B: 10; 42-C: 6	42-A: 12; 42-B: 11; 42-C: 7	0.91
Time to surgery (hours)	24.6 \pm 10.1	25.1 \pm 9.8	0.85
Nail diameter (mm)	10.0 \pm 0.8	9.9 \pm 0.9	0.62

Table 2: Radiographic Outcomes

Outcome	EWB Group (n = 30)	DWB Group (n = 30)	p-Value
Time to union (weeks, mean \pm SD)	14.2 \pm 2.8	17.8 \pm 3.5	0.002
Nonunion (%)	0	1 (3.3%)	0.31
Malunion (%)	1 (3.3%)	2 (6.7%)	0.55

Table 3: Functional Scores Over Time

Timepoint	LEFS (mean \pm SD)	SF-36 Physical (mean \pm SD)
6 weeks	42.7 \pm 8.5 vs 33.1 \pm 7.9*	48.5 \pm 6.2 vs 41.8 \pm 7.1*
12 weeks	68.4 \pm 9.2 vs 54.7 \pm 10.4*	65.2 \pm 7.8 vs 54.9 \pm 8.6*
24 weeks	78.1 \pm 8.7 vs 72.5 \pm 9.1 †	78.6 \pm 6.5 vs 72.1 \pm 7.3 †

* $p < 0.01$; † $p < 0.05$ between EWB and DWB

Table 4: Return to Activity and Pain Scores

Outcome	EWB Group (n = 30)	DWB Group (n = 30)	p-Value
Return to work (weeks)	10.8 \pm 2.9	15.3 \pm 4.1	<0.001
VAS at 24 weeks	1.9 \pm 0.8	2.2 \pm 1.1	0.28

Discussion

Principal Findings

Our study demonstrates that **early weight-bearing** after IMN for tibial shaft fractures is associated with **faster union, earlier return to work, and superior short-term functional recovery**, without a significant increase in complications compared to delayed weight-bearing.

The accelerated healing in the EWB group may be explained through mechanobiological principles: controlled axial loading stimulates osteogenesis and enhances callus formation, which has been observed in prior biomechanical models.^{13–14} Our results expand on previous work by concretely showing superior patient-centered outcomes in functional domains.

Comparison with Previous Studies

Zelle et al. reported in a retrospective series that early weight-bearing did not increase risk and was associated with shorter time to union.¹⁵ However, their cohort lacked standardized functional scoring. A randomized controlled trial by Smith et al. showed no significant difference in union time with early versus delayed protocols but was limited by small sample size (n = 22).¹⁶

Our findings align with Kubiak et al., who highlighted benefits of early mobilization in lower extremity trauma concerning muscle preservation and gait mechanics.

Clinical Implications

Given comparable complication rates and improved functional outcomes, EWB should be considered in patients with stable fracture patterns and adequate fixation. Early rehabilitation may reduce healthcare burden by shortening convalescence and facilitating earlier return to activities of daily living.

Strengths and Limitations

Strengths include prospective design, standardized rehabilitation regimens, and objective functional scoring. Limitations are single-center design, lack of blinding, and exclusion of high-energy open fractures, which may limit generalizability. Long-term follow-up beyond 24 weeks was not performed.

Conclusion

In patients undergoing IMN for tibial shaft fractures, early weight-bearing results in **significantly better functional outcomes** and **earlier return to work** without a higher complication rate compared to delayed weight-bearing. These findings support a shift toward early rehabilitation protocols in appropriate patients.

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