Comparing the Outcomes of Early vs. Delayed Weight-Bearing in Patients with Tibial Fractures Receiving Physical Therapy

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Abstract

Background: Tibial fractures are common orthopedic injuries requiring effective rehabilitation strategies to optimize recovery outcomes. This study aimed to compare the effects of early versus delayed weight-bearing protocols on fracture healing, pain management, functional recovery, quality of life, and proprioception in patients undergoing physical therapy following surgical intervention.

Methods: A randomized controlled trial was conducted with participants assigned to either an early weight-bearing (EWB) or delayed weight-bearing (DWB) group post-surgery. Outcome measures included radiographic assessment of fracture healing, pain levels using the Visual Analog Scale, functional performance using the Lower Extremity Functional Scale and Timed Up-and-Go test, quality of life using the Short Form-36 questionnaire, and proprioception assessment.

Results: Early weight-bearing significantly accelerated fracture healing, reduced pain intensity, improved functional recovery, enhanced quality of life, and promoted better proprioceptive abilities compared to delayed weight-bearing. Participants in the EWB group achieved higher rates of complete healing, reported lower pain scores, demonstrated better functional outcomes, and reported higher quality of life scores at 12 weeks post-surgery.

Conclusion: Integrating early weight-bearing activities into rehabilitation protocols for tibial fractures appears beneficial in enhancing recovery outcomes and optimizing patient care. Early mobilization strategies should be considered to promote timely healing, reduce pain, improve functional independence, enhance quality of life, and optimize proprioceptive function in patients undergoing rehabilitation following surgical management of tibial fractures.

Keywords: Tibial fractures, early weight-bearing, delayed weight-bearing, rehabilitation, fracture healing, pain management, functional recovery, quality of life, proprioception, physical therapy

Introduction

Tibial fractures are among the most common long bone fractures and often result from high-energy trauma such as road traffic accidents or falls. These fractures can lead to significant morbidity, necessitating comprehensive rehabilitation strategies to optimize recovery outcomes. Traditionally, weight-bearing recommendations for patients with tibial fractures have varied, with some clinicians advocating for early

weight-bearing and others recommending delayed weight-bearing to prevent complications such as non-union or malunion (Simanski et al., 2006).

Early weight-bearing has been suggested to promote bone healing through mechanical stimulation, enhance muscle strength, and improve overall functional recovery (Black et al, 2013). Conversely, delayed weight-bearing is often recommended to protect the healing fracture and prevent displacement or hardware failure, especially in cases involving complex fractures or patients with compromised bone quality (Bhandari et al., 2001).

Physical therapy plays a crucial role in the rehabilitation of patients with tibial fractures, focusing on restoring mobility, strength, and function. The timing of weight-bearing initiation during physical therapy can significantly influence rehabilitation outcomes, yet there remains a lack of consensus on the optimal approach. Therefore, this study aims to compare the outcomes of early versus delayed weight-bearing in patients with tibial fractures receiving physical therapy, assessing parameters such as fracture healing, pain levels, functional performance, and quality of life.

Objectives

1. To evaluate the effects of early versus delayed weight-bearing on fracture healing in patients with tibial fractures.
2. To compare pain levels between patients undergoing early and delayed weight-bearing protocols.
3. To assess the impact of weight-bearing timing on functional performance and mobility.
4. To determine the influence of weight-bearing initiation on patients' quality of life during rehabilitation.

Literature Review

Introduction

Tibial fractures are a significant cause of morbidity and often require surgical intervention followed by a comprehensive rehabilitation program. The timing of weight-bearing initiation during rehabilitation remains a topic of debate, with varying opinions on the benefits and risks of early versus delayed weight-bearing. This literature review explores existing research on the outcomes of different weight-bearing protocols in patients with tibial fractures, focusing on fracture healing, pain levels, functional performance, and overall quality of life.

Fracture Healing

Several studies have investigated the impact of weight-bearing timing on fracture healing. Early weight-bearing is believed to promote bone healing through mechanical stimulation, enhancing callus formation and bone remodeling (McIlwraith and Frisbie., 2010). In a study by McKibbin (1978), it was demonstrated that mechanical loading can accelerate the healing process by stimulating osteoblast activity and increasing bone density. More recent research by Claes et al. (2012) supports these findings, indicating that early mechanical loading can improve the biomechanical properties of the healing fracture.

Conversely, there are concerns that early weight-bearing might lead to complications such as non-union, malunion, or hardware failure, especially in cases with complex fractures or poor bone quality (Orthopaedic Trauma Association, 2010)). A systematic review by Bhandari et al. (2001) found no significant difference

in the rate of non-union between early and delayed weight-bearing groups, suggesting that with appropriate surgical fixation, early weight-bearing may not compromise fracture healing.

Pain Levels

Pain management is a crucial aspect of rehabilitation following tibial fractures. Early weight-bearing has been associated with reduced pain levels, potentially due to improved circulation and muscle activation (Kubiak et al., 2013). In a randomized controlled trial by Costa et al. (2012), patients who commenced early weight-bearing reported lower pain scores and required fewer analgesics compared to those in the delayed weight-bearing group.

However, some studies indicate that early weight-bearing may initially increase pain due to the stress on the healing fracture site (Wukich & Kline, 2008). This transient increase in pain is typically short-lived and tends to subside as the fracture stabilizes and healing progresses.

Functional Performance

Functional recovery is a primary goal of rehabilitation in patients with tibial fractures. Early weight-bearing has been shown to enhance functional outcomes by promoting muscle strength, joint mobility, and overall physical activity. A study by Black et al. (2013) found that patients who began early weight-bearing achieved faster improvements in walking speed, balance, and lower limb strength compared to those who delayed weight-bearing.

In contrast, delayed weight-bearing protocols may lead to muscle atrophy, joint stiffness, and prolonged rehabilitation periods (Sarmiento et al., 1984). The delayed resumption of weight-bearing activities can result in a slower return to pre-injury levels of function and increased dependency on assistive devices.

Quality of Life

The timing of weight-bearing initiation can also impact the overall quality of life for patients with tibial fractures. Early weight-bearing has been associated with improved patient-reported outcomes, including higher satisfaction levels and better mental health scores (Jürgens et al., 2006). Patients who are able to resume weight-bearing activities sooner tend to experience less frustration and anxiety related to mobility limitations.

However, the potential risks associated with early weight-bearing, such as increased pain or complications, must be carefully weighed against the benefits. A balanced approach that considers individual patient factors, such as fracture type, surgical fixation stability, and overall health, is essential for optimizing rehabilitation outcomes (Bhandari et al., 2001).

The existing literature suggests that early weight-bearing can offer significant benefits in terms of fracture healing, pain reduction, functional performance, and quality of life in patients with tibial fractures. However, the decision to initiate early weight-bearing should be individualized based on patient-specific factors and the stability of the surgical fixation. Further research is needed to establish standardized guidelines and identify optimal weight-bearing protocols for different fracture types and patient populations.

Methodology

Study Design

A randomized controlled trial (RCT) was conducted to compare the outcomes of early versus delayed weight-bearing in patients with tibial fractures receiving physical therapy. The study was carried out at military hospital over a period of 18 months.

Participants

A total of 120 participants with tibial fractures were recruited from the hospital's orthopedic department. Inclusion criteria were:

- Age between 18 and 65 years.
- Diagnosed with a unilateral tibial fracture.
- Underwent surgical fixation with intramedullary nailing or plate fixation.
- No prior history of lower extremity fractures or significant comorbidities that could affect fracture healing.

Exclusion criteria included:

- Open fractures with severe soft tissue damage.
- Multiple fractures.
- Cognitive impairments that could affect adherence to rehabilitation protocols.

Randomization and Blinding

Participants were randomly assigned to one of two groups: early weight-bearing (EWB) or delayed weight-bearing (DWB). Randomization was performed using a computer-generated sequence, and allocation was concealed using sealed envelopes. Both patients and physiotherapists were blinded to group assignments until the initiation of the weight-bearing protocol.

Interventions

Early Weight-Bearing Group (EWB)

Participants in the EWB group began partial weight-bearing (up to 50% of body weight) within the first week post-surgery, progressing to full weight-bearing as tolerated by the end of the fourth week. Weight-bearing progression was monitored and adjusted based on pain levels and radiographic evidence of fracture healing.

Delayed Weight-Bearing Group (DWB)

Participants in the DWB group were instructed to remain non-weight-bearing for the first six weeks post-surgery. After six weeks, they began partial weight-bearing, gradually increasing to full weight-bearing by the end of the twelfth week. Progression was similarly monitored and adjusted based on clinical and radiographic assessments.

Physical Therapy Protocol

Both groups received a standardized physical therapy program that included:

- Range of motion (ROM) exercises.
- Strengthening exercises for the quadriceps, hamstrings, and calf muscles.
- Balance and proprioception training.
- Functional training such as gait training and activities of daily living (ADL) exercises.

Therapy sessions were conducted three times a week for 12 weeks. Compliance was monitored through therapy attendance records and self-reported adherence to home exercises.

Outcome Measures

Primary and secondary outcomes were assessed at baseline, 6 weeks, and 12 weeks post-surgery.
Primary Outcome Measures
1. Fracture Healing: Evaluated using radiographic assessment to determine the presence of bridging callus and fracture consolidation.
2. Pain Levels: Assessed using the Visual Analog Scale (VAS).

Secondary Outcome Measures
1. Functional Performance: Measured using the Lower Extremity Functional Scale (LEFS) and timed up-and-go (TUG) test.
2. Quality of Life: Assessed using the Short Form-36 (SF-36) questionnaire.
3. Proprioception: Evaluated using a joint position sense test.

Data Analysis
Data were analyzed using SPSS software (version 26.0). Descriptive statistics were used to summarize demographic and baseline characteristics. Independent t-tests and chi-square tests were used to compare baseline characteristics between the two groups. Repeated measures ANOVA was used to evaluate changes in outcome measures over time and between groups. Statistical significance was set at $p<0.05$.

Ethical Considerations
The study was approved by ethics committee . Informed consent was obtained from all participants prior to enrollment.

Findings

Participant Characteristics
Table 1 summarizes the baseline characteristics of participants in the early weight-bearing (EWB) and delayed weight-bearing (DWB) groups. The groups were well-matched in terms of age, gender distribution, fracture type, and comorbidities, ensuring the comparability of baseline factors.

Table 1: Participant Characteristics

Characteristic	Early Weight-Bearing Group	Delayed Weight-Bearing Group
Age (years), Mean ±SD	42.5 ±8.3	43.2 ±7.9
Gender (M/F), n	28/22	30/20
Fracture Type		
- Closed (n)	45	48
- Open (n)	5	2
Comorbidities	Hypertension (n=12), Smoking (n=12)	Diabetes (n=10), Smoking (n=10)

The balanced distribution of participant characteristics between the EWB and DWB groups supports the validity of comparing outcomes between the two interventions without confounding factors.

Fracture Healing

Table 2 presents the radiographic assessment of fracture healing outcomes at 6 and 12 weeks post-surgery.

Table 2: Radiographic Assessment of Fracture Healing

Time Point	Early Weight-Bearing Group (Complete Healing %)	Delayed Weight-Bearing Group (Complete Healing %)
6 weeks	76%	60%
12 weeks	96%	80%

Early weight-bearing significantly accelerated fracture healing compared to delayed weight-bearing. By 12 weeks, 96% of EWB participants achieved complete healing, compared to 80% in the DWB group. This indicates that early mobilization may promote faster bone remodeling and consolidation, reducing recovery time and potential complications.

Pain Levels

Table 3 summarizes the pain levels reported using the Visual Analog Scale (VAS) at 6 and 12 weeks post-surgery.

Table 3: Pain Levels (Visual Analog Scale)

Time Point	Early Weight-Bearing Group (Mean ±SD)	Delayed Weight-Bearing Group (Mean ±SD)
6 weeks	3.5 ±1.2	4.8 ±1.1
12 weeks	1.8 ±0.9	3.2 ±1.0

Participants in the EWB group reported significantly lower pain levels compared to the DWB group at both 6 weeks (3.5 vs. 4.8) and 12 weeks (1.8 vs. 3.2) post-surgery. This suggests that early weight-bearing interventions contribute to improved pain management outcomes during rehabilitation, potentially enhancing patient comfort and reducing reliance on pain medications.

Functional Performance

Table 4 presents the functional performance measures assessed using the Lower Extremity Functional Scale (LEFS) and the Timed Up-and-Go (TUG) test at 6 and 12 weeks post-surgery.

Table 4: Functional Performance Measures

Measure	Early Weight-Bearing Group (Mean ±SD)	Delayed Weight-Bearing Group (Mean ±SD)
LEFS	12 weeks: 82.5 ±6.4	12 weeks: 69.3 ±7.2
TUG Test	12 weeks: 7.2 ±1.2 s	12 weeks: 10.8 ±1.8 s

Early weight-bearing significantly improved functional recovery compared to delayed weight-bearing. By 12 weeks, EWB participants achieved higher LEFS scores (82.5 vs. 69.3) and faster TUG test completion

times (7.2 seconds vs. 10.8 seconds) compared to the DWB group. These results indicate that early mobilization and weight-bearing contribute to enhanced mobility, balance, and overall functional independence following tibial fractures.

Quality of Life

Table 5 presents the quality of life scores assessed using the Short Form-36 (SF-36) questionnaire at 12 weeks post-surgery.

Table 5: Quality of Life Scores (Short Form-36)

Domain	Early Weight-Bearing Group (Mean ±SD)	Delayed Weight-Bearing Group (Mean ±SD)
Physical Functioning	12 weeks: 89.2 ±7.1	12 weeks: 72.1 ±8.3
Mental Health	12 weeks: 81.6 ±6.9	12 weeks: 64.8 ±7.4

EWB participants reported significantly higher scores in physical functioning (89.2 vs. 72.1) and mental health (81.6 vs. 64.8) domains compared to DWB participants at 12 weeks post-surgery. These findings indicate that early weight-bearing interventions not only enhance physical capabilities but also improve psychological well-being and overall quality of life during the recovery period.

Proprioception

Table 6 presents the joint position sense test results at 6 and 12 weeks post-surgery.

Table 6: Joint Position Sense Test Results

Time Point	Early Weight-Bearing Group (Mean ±SD)	Delayed Weight-Bearing Group (Mean ±SD)
6 weeks	3.5 ±0.6	3.1 ±0.5
12 weeks	| 3.9 ±0.4	3.3 ±0.4

EWB participants demonstrated significantly improved proprioceptive abilities compared to DWB participants at both 6 weeks (3.5 vs. 3.1) and 12 weeks (3.9 vs. 3.3) post-surgery. This improvement suggests that early weight-bearing interventions contribute to better sensorimotor integration and joint stability, crucial for optimal functional outcomes and long-term joint health.

Discussion

The current study aimed to investigate the effects of early versus delayed weight-bearing protocols on various outcomes in patients recovering from tibial fractures. The findings reveal significant advantages associated with early initiation of weight-bearing activities across multiple domains, including fracture healing, pain management, functional recovery, quality of life, and proprioception.

Fracture Healing

The accelerated fracture healing observed in the early weight-bearing (EWB) group underscores the potential benefits of early mobilization following surgical intervention for tibial fractures. Our results are consistent with previous studies suggesting that controlled early weight-bearing can promote callus formation and bone remodeling without compromising stability or increasing complication rates (Adams et

al., 2001). The higher rates of complete healing in the EWB group at both 6 and 12 weeks post-surgery highlight the clinical significance of early weight-bearing in facilitating timely recovery and minimizing the duration of immobilization.

Pain Management

Effective pain management is crucial for optimizing patient comfort and adherence to rehabilitation programs. The significantly lower pain levels reported by participants in the EWB group align with studies demonstrating that early activity and weight-bearing contribute to reduced pain perception and improved functional outcomes (Hagen et al., 2012; Auais et al., 2012). Early mobilization may mitigate pain-related complications associated with prolonged immobilization, thereby enhancing patient satisfaction and compliance with therapy protocols.

Functional Recovery

Functional recovery, assessed through validated measures such as the Lower Extremity Functional Scale (LEFS) and Timed Up-and-Go (TUG) test, showed substantial improvements in the EWB group compared to the delayed weight-bearing (DWB) group. This finding supports the hypothesis that early weight-bearing enhances muscle strength, joint mobility, and overall functional independence early in the rehabilitation process (Kubiak et al., 2013). The faster recovery observed in the EWB group underscores the potential role of early mobilization in restoring patients' daily activities and reducing dependency on assistive devices.

Quality of Life

Quality of life assessments using the Short Form-36 (SF-36) questionnaire revealed superior physical functioning and mental health scores among participants in the EWB group. These findings are consistent with literature indicating that early rehabilitation interventions lead to improved overall well-being, reduced psychological distress, and enhanced social participation (Morris et al., 1990; Mundi et al., 2009). Early engagement in weight-bearing activities may contribute to greater self-efficacy and perceived control over recovery outcomes, thereby enhancing patients' psychosocial adjustment during the healing process.

Proprioception

Enhanced proprioceptive abilities observed in the EWB group suggest that early weight-bearing promotes sensorimotor integration and joint stability. Studies have indicated that proprioception plays a critical role in joint protection, balance control, and functional performance following orthopedic injuries (Häger-Ross and Schieber, 2000; Riemann & Lephart, 2002). The improved proprioceptive outcomes in the EWB group highlight the potential long-term benefits of early mobilization in reducing the risk of secondary injuries and optimizing long-term joint function.

Clinical Implications

The findings of this study have several important clinical implications for the management of patients with tibial fractures. Early initiation of controlled weight-bearing activities should be considered as an integral component of rehabilitation protocols to promote faster recovery, reduce pain intensity, enhance functional outcomes, improve quality of life, and optimize proprioceptive function. These benefits underscore the importance of individualized treatment plans that incorporate early mobilization strategies tailored to the patient's specific fracture type, surgical procedure, and overall health status.

Limitations and Future Directions

Several limitations warrant consideration in interpreting the results of this study. The sample size, although sufficient for detecting significant differences, may limit the generalizability of findings to larger populations or different clinical settings. Future research should explore the long-term effects of early weight-bearing on joint stability, recurrence rates, and patient-reported outcomes beyond the 12-week follow-up period. Additionally, comparative studies incorporating different surgical techniques or rehabilitation protocols could provide further insights into optimal strategies for enhancing recovery outcomes in patients with tibial fractures.

Conclusion

In conclusion, this study provides compelling evidence supporting the benefits of early weight-bearing in patients recovering from tibial fractures. Early initiation of weight-bearing activities accelerates fracture healing, reduces pain levels, improves functional recovery, enhances quality of life, and promotes proprioceptive rehabilitation. These findings underscore the importance of integrating early mobilization strategies into clinical practice to optimize outcomes and improve patient care following surgical management of tibial fractures.

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