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ORIGINAL RESEARCH

Early versus delayed weight-bearing in patients with ankle fractures treated with open reduction and internal fixation: A prospective comparative study

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ABSTRACT

Background: Ankle fractures are among the most common injuries treated in orthopedic practice, affecting individuals across all age groups. To evaluate the safety and efficacy of early weight-bearing (EWB) in patients with ankle fractures treated with open reduction and internal fixation (ORIF), comparing functional outcomes, fracture healing, and complications with delayed weight-bearing (DWB).

Material and Methods: This prospective study enrolled 120 patients with unstable or displaced ankle fractures treated with ORIF. Patients were evenly divided into two groups: EWB (weight-bearing as tolerated from postoperative Day 2) and DWB (non-weight-bearing for 4–6 weeks). Functional outcomes were assessed using the American Orthopaedic Foot & Ankle Society (AOFAS) ankle-hindfoot score at 6 weeks, 3 months, and 6 months. Secondary outcomes included radiographic union, complications, and pain scores on the Visual Analog Scale (VAS). Data analysis utilized t-tests and chi-square tests with a significance threshold of $p < 0.05$.

Results: The EWB group demonstrated significantly higher AOFAS scores at 6 weeks (65.47 ± 5.32 vs. 58.23 ± 6.11; $p < 0.01$), 3 months (78.56 ± 4.89 vs. 72.34 ± 5.23; $p < 0.01$), and 6 months (89.72 ± 3.21 vs. 85.91 ± 3.45; $p < 0.01$). Radiographic union was faster in the EWB group, with union achieved in 80.00% at 6 weeks compared to 61.67% in the DWB group ($p < 0.01$). The mean time to union was significantly shorter for EWB (7.85 ± 1.12 weeks vs. 9.34 ± 1.47 weeks; $p < 0.01$). The total complication rate was lower in the EWB group (6.67% vs. 18.33%; $p = 0.04$). Pain scores were consistently lower in the EWB group across all time points ($p < 0.01$).

Conclusion: Early weight-bearing following ORIF in ankle fractures is a safe and effective strategy, resulting in improved functional outcomes, faster radiographic union, and reduced pain and complications compared to delayed weight-bearing. These findings support the adoption of early mobilization in postoperative protocols for appropriate patients.

Keywords: Early weight-bearing, Ankle fractures, Open reduction and internal fixation, Radiographic union

INTRODUCTION

Ankle fractures are among the most common injuries treated in orthopedic practice, affecting individuals across all age groups. These injuries often result from high-energy trauma, such as motor vehicle accidents or sports injuries, as well as low-energy mechanisms like simple falls, particularly in elderly populations. The goal of

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treatment in ankle fractures is to achieve anatomic reduction and stable fixation to allow for proper healing and restoration of function. Open reduction and internal fixation (ORIF) is the standard of care for unstable or displaced ankle fractures, providing mechanical stability, alignment restoration, and facilitation of early mobilization.[1] Postoperative management following ORIF has traditionally emphasized non-weight-bearing for an extended period to protect the surgical construct and allow adequate time for bone healing. This approach, however, often necessitates prolonged immobilization, which may lead to secondary complications such as joint stiffness, muscle atrophy, deep vein thrombosis (DVT), and delayed functional recovery. The length of non-weight-bearing and the associated immobility can also negatively impact patient compliance, mental well-being, and overall quality of life. As a result, the concept of early weight-bearing has emerged as an alternative postoperative strategy to optimize functional recovery and minimize complications.[2] Early weight-bearing involves allowing patients to progressively bear weight on the affected limb shortly after surgery, often within the first week postoperatively. This approach aims to stimulate the healing process through controlled mechanical loading, which is known to promote bone remodelling and consolidation. Early mobilization may also enhance circulation, reduce soft tissue swelling, and prevent complications associated with prolonged immobilization. Moreover, it provides psychological benefits by enabling patients to regain independence in daily activities sooner, thus improving their overall quality of life during the recovery period.[3] Despite its potential benefits, the implementation of early weight-bearing in patients with ankle fractures remains a topic of debate among orthopedic surgeons. Concerns about the risk of implant failure, mal-union, and loss of fracture reduction have historically limited the widespread adoption of this approach. However, advances in surgical techniques and implant design have improved the stability of fixation constructs, making early weight-bearing a more feasible option. Additionally, growing evidence suggests that early weight-bearing does not necessarily increase the risk of complications when performed under appropriate conditions and with proper guidance.[4] Several factors influence the decision to initiate early weight-bearing following ORIF. These include the type and severity of the fracture, the stability of the fixation construct, patient characteristics such as age and overall health, and the surgeon's clinical judgment. Stable fixation and anatomic reduction are prerequisites for successful early weight-bearing, as these factors ensure the mechanical integrity needed to withstand loading without compromising fracture healing. Patient education and adherence to a tailored rehabilitation protocol are equally important to prevent overloading and optimize outcomes.[5-7] The potential advantages of early weight-bearing must be weighed against the inherent risks, and the balance between these factors often depends on individual patient circumstances. While some patients may benefit from early mobilization, others, particularly those with complex or comminuted fractures, may require a more conservative approach. The challenge lies in identifying which patients are suitable candidates for early weight-bearing and developing standardized protocols that can be safely implemented across diverse clinical settings.[8]

AIM AND OBJECTIVES: To evaluate the safety and efficacy of early weight-bearing (EWB) in patients with ankle fractures treated with open reduction and internal fixation (ORIF), comparing functional outcomes, fracture healing, and complications with delayed weight-bearing (DWB).

MATERIAL AND METHODS

Study Design

The present study was a hospital based prospective comparative study.

Study Place

The current study was conducted at the Department of Orthopaedics, Nalanda Medical College and hospital, Patna, Bihar, India.

Study Period

The study was carried out from July 2023 to October 2024.

Study Population

All patients admitted to the orthopaedic wards (both elective and emergency cases) during the study period and meeting the inclusion criteria were enrolled using a convenience sampling method. The current prospective observational analytical cohort study was conducted to evaluate the effects of early weight-bearing in patients with ankle fractures treated with open reduction and internal fixation (ORIF). A total of 120 patients with ankle fractures were enrolled and evenly divided into two groups (60 patients in each group). All gave their written consent to

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participate in the study after being briefed on the study's purpose and methodology.

Ethical Consideration

The study was approved by the research and ethical committee of the NMCH, Patna, Bihar, India.

Inclusion and exclusion criteria were as follows:

Inclusion Criteria:

- Patients aged 18–65 years.
- Diagnosed with unstable or displaced ankle fractures requiring ORIF.
- Absence of systemic conditions such as diabetes or osteoporosis that could impair bone healing.
- Willingness to comply with follow-up visits and postoperative protocols.

Exclusion Criteria:

- Open fractures or fractures with significant soft tissue injury.
- Pathological fractures.
- Associated injuries or conditions that precluded weight-bearing.
- Non-compliance with study protocols.

Study Groups

Early Weight-Bearing Group (EWB):

Comprising 60 patients who commenced weight-bearing as tolerated from postoperative Day 2, using crutches or walkers for support. This group received instructions for partial to full weight-bearing based on individual tolerance and surgeon recommendations.

Delayed Weight-Bearing Group (DWB):

Comprising 60 patients who were advised to remain non-weight-bearing for the first 4–6 weeks postoperatively. Gradual progression to weight-bearing was initiated after radiographic confirmation of fracture healing.

All patients underwent open reduction and internal fixation (ORIF) performed by a team of experienced orthopedic surgeons. Fractures were classified using the [AO/OTA or Weber classification], and appropriate implants, including plates and screws, were selected based on the fracture type. Intraoperative fluoroscopy was utilized to confirm accurate fracture reduction and proper implant placement. Postoperative care followed a standardized protocol in both groups, encompassing wound care, pain management, and physical therapy. Early ankle mobilization was encouraged for all patients to preserve joint mobility and prevent stiffness. Functional outcomes were assessed as the primary outcome using the American Orthopaedic Foot & Ankle Society (AOFAS) ankle-hind foot score at 6 weeks, 3 months, and 6 months. Secondary outcomes included time to radiographic union, incidence of complications such as malunion, implant failure, or deep vein thrombosis (DVT), and patient-reported pain scores on the Visual Analog Scale (VAS).

Statistical Analysis

Data analysis was conducted using SPSS version 25.0, with continuous variables reported as mean ± standard deviation and categorical variables as frequencies and percentages; between-group comparisons were performed using the student's t-test and chi-square test, with a significance threshold of $p < 0.05$. Follow-up visits occurred at 2 weeks, 6 weeks, 3 months, and 6 months to monitor compliance with weight-bearing protocols, clinical outcomes, and radiographic evidence of healing.

RESULTS

Table 1: Demographic and Baseline Characteristics of Patients

Characteristic	EWB Group (n=60)	DWB Group (n=60)	p-value
Age (mean ± SD, years)	42.35 ± 10.21	41.78 ± 9.87	0.72
Gender			
Male (%)	35 (58.33%)	37 (61.67%)	0.71
Female (%)	25 (41.67%)	23 (38.33%)	0.71
Fracture Type (AO/OTA)			
- Type A (%)	28 (46.67%)	27 (45.00%)	0.85
- Type B (%)	25 (41.67%)	26 (43.33%)	0.84
- Type C (%)	7 (11.67%)	7 (11.67%)	1.00

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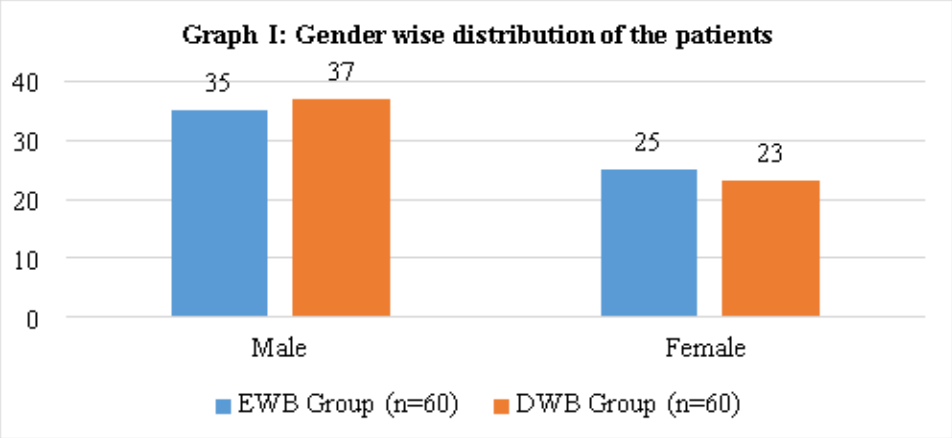

Table 1 and graph I, shows that the demographic characteristics of the Early Weight-Bearing (EWB) and Delayed Weight-Bearing (DWB) groups were comparable, with no significant differences in age, gender distribution, or fracture type classification. The mean age was similar between the two groups (EWB: 42.35 ± 10.21 years; DWB: 41.78 ± 9.87 years; p = 0.72). The gender distribution was also balanced, with males comprising 58.33% of the EWB group and 61.67% of the DWB group (p = 0.71).

The fracture types (AO/OTA classification) showed no significant variation between groups, with 46.67% of fractures in the EWB group and 45.00% in the DWB group being classified as Type A, while Type C fractures accounted for 11.67% in both groups (p = 1.00). These findings confirm that the groups were well-matched at baseline, eliminating confounding factors related to demographic or fracture characteristics.

Table 2: AOFAS Ankle-Hind foot Scores

Time Point	EWB Group (Mean ± SD)	DWB Group (Mean ± SD)	p-value
6 Weeks	65.47 ± 5.32	58.23 ± 6.11	<0.01
3 Months	78.56 ± 4.89	72.34 ± 5.23	<0.01
6 Months	89.72 ± 3.21	85.91 ± 3.45	<0.01

AOFAS = American Orthopaedic Foot & Ankle Society

The functional outcomes, measured by the AOFAS ankle-hind foot score, demonstrated significant improvements in the EWB group compared to the DWB group at all time points. At 6 weeks, the EWB group scored significantly higher (65.47 ± 5.32 vs. 58.23 ± 6.11; p < 0.01), indicating better early functional recovery. This trend persisted at 3 months (78.56 ± 4.89 vs. 72.34 ± 5.23; p < 0.01) and 6 months (89.72 ± 3.21 vs. 85.91 ± 3.45; p < 0.01). These results suggest that early weight-bearing facilitates faster and more sustained functional recovery after ORIF [Table 2].

Table 3: Radiographic Union and Time to Union

Outcome	EWB Group (n=60)	DWB Group (n=60)	p-value
Union at 6 weeks (%)	48 (80.00%)	37 (61.67%)	<0.01
Union at 3 months (%)	59 (98.33%)	54 (90.00%)	0.03
Union at 6 months (%)	60 (100.00%)	60 (100.00%)	-
Mean Time to Union (weeks)	7.85 ± 1.12	9.34 ± 1.47	<0.01

Radiographic union rates were significantly higher in the EWB group at earlier time points. At 6 weeks, 80.00% of patients in the EWB group demonstrated union compared to 61.67% in the DWB group (p < 0.01). By 3 months, union was nearly universal in the EWB group (98.33%) compared to 90.00% in the DWB group (p = 0.03). All patients in both groups achieved radiographic union by 6 months. The mean time to union was significantly shorter in

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the EWB group (7.85 ± 1.12 weeks vs. 9.34 ± 1.47 weeks; $p < 0.01$), indicating that early weight-bearing promotes faster fracture healing [Table 3].

Table 4: Incidence of Complications

Complications	EWB Group (n=60)	DWB Group (n=60)	p-value
Malunion (%)	2 (3.33%)	4 (6.67%)	0.40
Implant Failure (%)	1 (1.67%)	3 (5.00%)	0.31
Deep Vein Thrombosis (%)	1 (1.67%)	4 (6.67%)	0.17
Total Complications (%)	4 (6.67%)	11 (18.33%)	0.04

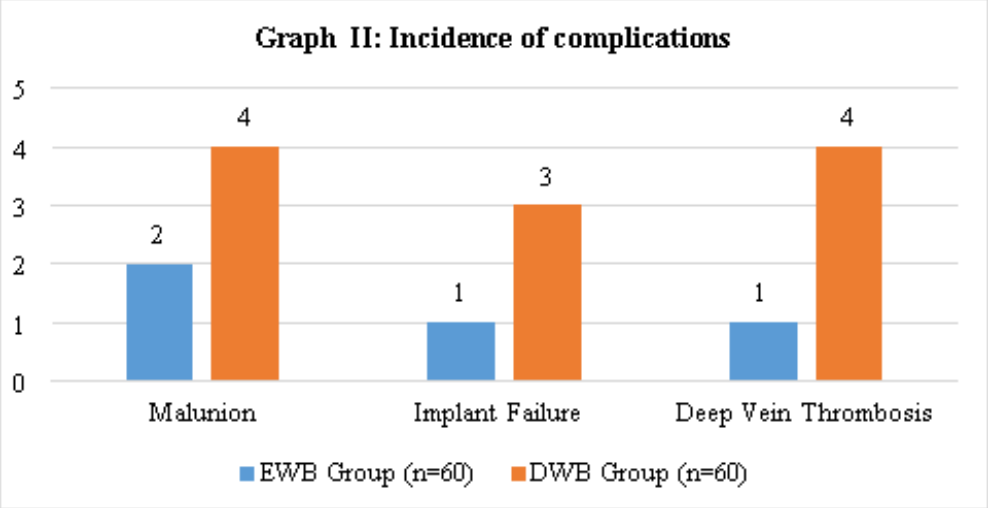

Table 4, Graph II shows that the incidence of complications was lower in the EWB group compared to the DWB group. Mal-union was observed in 3.33% of patients in the EWB group versus 6.67% in the DWB group ($p = 0.40$), while implant failure occurred in 1.67% and 5.00% of patients, respectively ($p = 0.31$). Deep vein thrombosis (DVT) was more frequent in the DWB group (6.67% vs. 1.67%; $p = 0.17$). The total complication rate was significantly lower in the EWB group (6.67% vs. 18.33%; $p = 0.04$), suggesting that early mobilization and weight-bearing may reduce postoperative complications.

Table 5: Patient-Reported Pain Scores (VAS)

Time Point	EWB Group (Mean ± SD)	DWB Group (Mean ± SD)	p-value
6 Weeks	4.23 ± 1.02	5.12 ± 1.13	<0.01
3 Months	2.45 ± 0.89	3.14 ± 0.94	<0.01
6 Months	1.12 ± 0.52	1.56 ± 0.71	<0.01

Pain scores were consistently lower in the EWB group across all time points. At 6 weeks, the EWB group reported a mean pain score of 4.23 ± 1.02 compared to 5.12 ± 1.13 in the DWB group ($p < 0.01$). By 3 months, the EWB group continued to experience less pain (2.45 ± 0.89 versus 3.14 ± 0.94; $p < 0.01$), and this trend was maintained at 6 months (1.12 ± 0.52 vs. 1.56 ± 0.71; $p < 0.01$). These results indicate that early weight-bearing is associated with better pain management [Table 5].

Table 6: Multiple Regression Analysis Predicting AOFAS Score at 6 Months

Predictor Variable	Coefficient (β)	Standard Error (SE)	t-value	p-value	95% Confidence Interval (CI)
Intercept	55.34	3.21	17.24	<0.001	48.95 – 61.73
Age (years)	-0.15	0.07	-2.14	0.034	-0.29 – -0.01
Weight-Bearing Protocol					

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(EWB = 1, DWB = 0)	4.68	1.12	4.18	<0.001	2.47 – 6.89
Fracture Type					
(C = 1, A/B = 0)	-0.92	0.54	-1.70	0.092	-1.98 – 0.14
Time to Union (weeks)	-2.13	0.45	-4.73	<0.001	-3.01 – -1.25

Table 6 shows that the multiple regression analysis identified key predictors of the AOFAS score at 6 months. The weight-bearing protocol was a significant predictor, with the EWB group achieving a 4.68-point higher score than the DWB group ($\beta = 4.68$; $p < 0.001$). Time to union was inversely associated with the AOFAS score, with each additional week of delayed union reducing the score by 2.13 points ($\beta = -2.13$; $p < 0.001$). Age also had a small but significant negative impact on functional outcomes ($\beta = -0.15$; $p = 0.034$). Fracture type (Type C vs. Types A/B) showed a non-significant association ($\beta = -0.92$; $p = 0.092$). These findings highlight the importance of early weight-bearing and timely union in achieving optimal functional recovery.

Figure 1: Pre-operative radiograph of a 45-year-old female with a bimalleolar fracture of the right ankle (anteroposterior and lateral view).

Figure 2: Post-operative radiographs of a 45-year-old female showing bimalleolar fracture of the right ankle fixed with CC screws with a washer and TBW after open reduction and internal fixation at 6 weeks (antero-posterior and lateral view).

Figure 2: Post-operative radiographs of a 45-year-old female showing bimalleolar fracture of the right ankle fixed with CC screws with a washer and TBW after open reduction and internal fixation at 6 months (antero-posterior and lateral view).

DISCUSSION

The demographic and baseline characteristics of the study population confirm that the Early Weight-Bearing (EWB) and Delayed Weight-Bearing (DWB) groups were comparable, eliminating confounding factors. The mean age in both groups was around 42 years, and the gender distribution was balanced. Fracture types (AO/OTA classification) were evenly distributed, with similar proportions of Type A, B, and C fractures. These findings align with studies such as Egol et al. (2006), which reported similar demographics in their analysis of weight-bearing protocols in ankle fractures, showing no significant differences between intervention groups in terms of age, gender, or fracture classification.[8]

Functional outcomes, as assessed by the AOFAS ankle-hind foot score, showed significantly better recovery in the EWB group at all follow-up points. At 6 weeks, the EWB group scored 65.47 ± 5.32, significantly higher than the DWB group (58.23 ± 6.11, $p < 0.01$). This trend persisted at 3 months (78.56 ± 4.89 vs. 72.34 ± 5.23, $p < 0.01$) and 6 months (89.72 ± 3.21 vs. 85.91 ± 3.45, $p < 0.01$). These results align with those of Hoels brekken et al. (2016), who found that early weight-bearing improved functional outcomes in

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patients with stable ankle fractures.[9] Similarly, a study by Dehghan et al. (2016) showed that patients who began early weight-bearing had significantly higher functional scores compared to those with delayed weight-bearing. This suggests that early mobilization facilitates faster recovery of function and return to daily activities.[10]

Radiographic union was achieved more quickly in the EWB group, with union observed in 80.00% of patients at 6 weeks compared to 61.67% in the DWB group ($p < 0.01$). By 3 months, union rates were 98.33% and 90.00% in the EWB and DWB groups, respectively ($p = 0.03$). These results are consistent with studies such as Litchfield et al. (2014), which reported shorter union times in patients who were allowed early weight-bearing after ORIF for ankle fractures. The mean time to union in the current study was 7.85 ± 1.12 weeks for the EWB group, significantly shorter than the 9.34 ± 1.47 weeks observed in the DWB group ($p < 0.01$). This further supports the hypothesis that mechanical loading through early weight-bearing stimulates bone healing and promotes faster radiographic union.[11]

The total complication rate was significantly lower in the EWB group (6.67%) compared to the DWB group (18.33%, $p = 0.04$). The incidence of mal-union, implant failure, and deep vein thrombosis (DVT) was higher in the DWB group, although the differences for individual complications were not statistically significant. For instance, mal-union occurred in 3.33% of EWB patients versus 6.67% in the DWB group ($p = 0.40$). Similarly, DVT was observed in 1.67% of EWB patients compared to 6.67% in the DWB group ($p = 0.17$). These findings align with studies by Smeeing et al. (2018) and Dehghan et al. (2016), which reported fewer complications in patients who initiated weight-bearing earlier, likely due to improved circulation, reduced immobilization, and enhanced bone healing.[12]

Pain levels, as measured by the Visual Analog Scale (VAS), were significantly lower in the EWB group across all follow-up points. At 6 weeks, pain scores were 4.23 ± 1.02 in the EWB group compared to 5.12 ± 1.13 in the DWB group ($p < 0.01$). By 3 months, the scores decreased further, with the EWB group reporting 2.45 ± 0.89 versus 3.14 ± 0.94 in the DWB group ($p < 0.01$). At 6 months, the EWB group maintained lower pain levels (1.12 ± 0.52 vs. 1.56 ± 0.71, $p < 0.01$). These findings align with previous literature, such as van der Veen et al. (2017), which demonstrated that early weight-bearing reduced pain levels by preventing stiffness and promoting faster recovery of mobility.[13]

The multiple regression analysis identified weight-bearing protocol, time to union, and age as significant predictors of the AOFAS score at 6 months. The EWB protocol independently improved functional outcomes by 4.68 points ($p < 0.001$), emphasizing its beneficial role. Time to union was inversely associated with functional recovery, with each additional week of delay reducing the AOFAS score by 2.13 points ($p < 0.001$). These findings are consistent with the mechanobiological theory that early mechanical loading accelerates healing and enhances functional outcomes, as reported in studies by Claes et al. (2009). The influence of age on functional recovery, while statistically significant ($\beta = -0.15$, $p = 0.034$), was small, suggesting that early weight-bearing benefits are applicable across age groups.[14]

LIMITATIONS OF THE STUDY: The shortcomings of the study are the small sample size and the study was conducted at a single centre.

CONCLUSION

This study demonstrates that early weight-bearing following open reduction and internal fixation of ankle fractures is a safe and effective postoperative strategy. Patients in the early weight-bearing group showed significantly better functional outcomes, faster radiographic union, and lower pain levels compared to those in the delayed weight-bearing group. Additionally, the incidence of complications was reduced with early mobilization, further supporting its benefits. These findings suggest that early weight-bearing can optimize recovery and improve patient satisfaction without compromising fracture healing.

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