

Prospective Evaluation of Serum Vitamin D and Its Impact on Radiological Union in Diaphyseal Long Bone Fractures**Umesh Prasad¹, Intekhab Akram², Marut Nandan Kumar³, Rakesh Chaudhary⁴**^{1,2}Senior Resident, Department of Orthopaedic, PMCH, Patna, Bihar, India³Professor, Department of Orthopaedic, Patna Medical College and Hospital, Patna, Bihar, India⁴Professor & H.O.D., Department of Orthopaedic, Patna Medical College and Hospital, Patna. Bihar, India

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Abstract

Background: Vitamin D plays a key role in bone metabolism, bone mineralization and fracture healing. The role of Vitamin D deficiency in delayed fracture union and bone repair is a possibility that has been suggested, but studies on the effect on radiological healing are conflicting, especially among Indians. This study was designed to assess the correlation of serum Vitamin D with radiological union in patients with long bone fractures occurring in the diaphyseal area.

Materials and Methods: A prospective observational study, conducted at the Department of Orthopaedics, Patna Medical College and Hospital (PMCH), Patna, Bihar, from March 2025 to November 2025. A total of 60 adult patients with fresh diaphyseal fractures of the femur, tibia, humerus or radius-ulna were enrolled. 25-hydroxy Vitamin D blood level was taken at the time of admission and classified as deficient, insufficient and sufficient. Radiological union was determined at 6, 12 and 24 weeks by conventional radiographic criteria. Data were analyzed statistically in SPSS software, and $p < 0.05$ was regarded as statistically significant.

Results: A diagnosis of vitamin D deficiency was made in 46.7% of patients, deficiencies in 33.3%, and sufficiency in 20.0%. Radiological union rates were 64.3%, 85.0% and 100% for the deficient, insufficient and sufficient groups, respectively ($p = 0.020$). The mean time to healing was significantly increased in deficient patients. There was a significant negative correlation between serum Vitamin D and time to union ($r = -0.52$, $p = 0.001$).

Conclusion: A decrease in Vitamin D levels was found to be correlated with delayed radiological union and longer fracture healing. Regular screening and correction of Vitamin D deficiency can have a positive impact on fracture healing.

Keywords: Vitamin D, Fracture Healing, Radiological Union, Diaphyseal Fracture, Long Bone Fracture, Delayed Union.

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Introduction

Fracture healing is a complex biological process that restores the structure and function of the injured bone. Successful fracture union is critical to restoration of mobility, reduction of disability and enhanced quality of life in the affected person [1]. Long bone fractures of the femur, tibia, humerus and radius-ulna are very common orthopedic injuries observed in road traffic accidents, falls, sports and occupational trauma.

Long bone fractures continue to be a significant problem in developing countries, like India, because of the rise in urbanization, motorization, and population growth [2]. The evolution of orthopedic surgical techniques and fixation

methods has significantly enhanced outcomes, but delayed union and non-union remain important clinical concerns [3]. The process of fracture healing is a carefully orchestrated series of inflammatory, reparative and remodeling stages, which all require sufficient cellular activity, vascularization and nutritional status [4].

Vitamin D has been the subject of much attention due to its role in calcium and phosphate metabolism, and is one of the various nutritional factors that impact bone health [5]. Vitamin D helps the body absorb calcium, regulate calcium levels and bone mineralization. In addition, it affects the activity of osteoblasts and osteoclasts,

regulates bone remodeling and participates in the formation and maturation of fracture callus [6]. A Vitamin D deficiency can interfere with these physiological mechanisms, which can contribute to slow healing, reduced bone strength and complications of fractures [7].

Several studies have documented high rates of Vitamin D deficiency in people who come to hospitals with fractures. Studies in various populations have implicated insufficient Vitamin D levels with delayed fracture union, longer fracture healing times and non-union [8]. But the findings of the evidence are not consistent. Some researchers have shown a strong association between vitamin D deficiency and impaired fracture healing, while others have found less or no association with vitamin D deficiency after adjusting for other confounding variables like age, comorbidities, fracture type and treatment modality [9]. The opposing results suggest the need for additional prospective studies to ascertain the role of Vitamin D in fracture repair.

Clinical information regarding the relationship of serum Vitamin D level with fracture healing is limited in India, especially in the eastern parts of the country [10]. Vitamin D deficiency is extremely common despite an abundance of sunlight in the world, because of lifestyle, dietary and social factors [11]. Thus, the effect of Vitamin D on radiological union may offer evidence for optimizing management of long bone fractures. The present study was conducted to evaluate, in a prospective manner, serum Vitamin D levels and their effect on radiological union in patients attending the PMCH with a diagnosis of diaphyseal long bone fracture in the state.

Objective

- To assess the effect of serum vitamin D level on the radiological union in patients with long bone fractures of the diaphyseal.
- To assess the prevalence of Vitamin D deficiency in patients with diaphyseal long bone fractures.
- To evaluate the effect of serum Vitamin D level on the rate of radiological union in patients.
- To compare fracture healing outcomes between Vitamin D-deficient, insufficient and sufficient patients.

Materials and Methods

Study Design and Setting: The present study was a prospective observational study carried out in the Orthopaedics Department of PMCH, Patna, in Bihar.

The study aimed to determine the association between the serum Vitamin D levels and

radiological union in patients admitted to the hospital with diaphyseal long bone fractures. The data in this study were collected from March to November 2025, a period of nine months. A total of 60 eligible patients were selected by a consecutive sampling technique that ensured all patients who met the selection criteria in the study period were included until the required sample size was reached.

Study Population: The adult patients who came to the hospital with fresh diaphyseal fractures of long bones were screened for eligibility. All study participants gave written informed consent prior to involvement.

Inclusion Criteria

- Age ≥ 18 years
- Fresh fractures of the long bones of the limbs (fractures of the tibia, femur, or humerus, for example).
- The presentation within two weeks of injury.
- Willingness to give informed consent.

Exclusion Criteria

- Pathological fractures
- Known metabolic bone diseases
- Chronic kidney disease
- Chronic liver disease
- Current Vitamin D supplementation
- Malignancy
- Grade III open fractures

Data Collection: Demographic and clinical data were collected in a structured form to obtain baseline data. Demographic variables were age, sex, and Body Mass Index (BMI). The clinical variables were the mechanism of injury, type of fracture, fracture site, and type of treatment used. As part of routine orthopedic workup, all patients had routine clinical and radiological assessment.

Laboratory Assessment: The serum 25-hydroxy Vitamin D [25(OH)D] level was taken at admission time before initiation of any Vitamin D supplements. Samples of blood were taken in an aseptic manner and examined in the laboratory of the institution. Patients were divided into three groups based on serum Vitamin D level. Patients were considered Vitamin D deficient if their serum Vitamin D level was less than 20ng/mL, insufficient if 20-29ng/mL, and sufficient if greater than 30ng/mL.

Radiological Assessment: Standard projections (anteroposterior and lateral) at baseline and at 6, 12 and 24 weeks post-treatment were used for radiological assessment. Fracture healing was evaluated by experienced orthopedic surgeons. Radiological union was considered when there was a bridging callus across at least three cortices on orthogonal radiographs. Radiological union was

defined as abnormal if it did not occur by 24 weeks. Delayed union was defined as radiological union not occurring until after 24 weeks.

Outcome Measures and Statistical Analysis:

Radiological union of the fracture was the main outcome variable of this study. Secondary outcomes included time to fracture union, delayed union and the relationship between serum Vitamin D level and fracture healing. The Software used for the statistical analysis is SPSS. Data were presented as mean $\pm$ standard deviation for continuous variables and frequencies and percentages for categorical variables. Chi-square test and independent t-test were used to compare categorical and continuous variables, respectively. Pearson correlation analysis was used to determine the association between serum Vitamin D levels and time to fracture union. The p-value of < 0.05 was regarded as statistically significant.

Ethical Considerations: The study was carried out in accordance with the ethical principles stated in the Declaration of Helsinki. The study was approved by the Institutional Ethics Committee at PMCH before the study was started. Informed written consent was ensured and confidentiality of patient information was preserved throughout the study.

Results

A total of 60 patients with fractures of the diaphyseal of long bones were studied. Data on the demographic profile, fracture characteristics, serum Vitamin D levels and clinical outcomes of fracture healing were used to identify if there was any relationship between Vitamin D levels and radiological healing.

Table 1: Age and Gender Distribution of Study Participants (n = 60)

Variable	Frequency (%)
Age Group (Years)	
18–30	18 (30.0)
31–45	22 (36.7)
46–60	14 (23.3)
>60	6 (10.0)
Gender	
Male	38 (63.3)
Female	22 (36.7)

Most of the patients were in the age group of 31-45 years (36.7%). The gender distribution of the study population was 63.3% males, suggesting that males were more likely to have long bone fractures.

Table 2: Distribution of Fracture Sites

Bone Involved	Frequency (%)
Tibia	24 (40.0)
Femur	18 (30.0)
Humerus	10 (16.7)
Radius-Ulna	8 (13.3)

The most frequent was tibial fractures (40.0%) followed by femoral fractures (30.0%). The fractures of the humerus and the radius-ulna were smaller proportions of the study population.

Table 3: Distribution of Serum Vitamin D Levels

Vitamin D Category	Frequency (%)
Deficient (<20 ng/mL)	28 (46.7)
Insufficient (20–29 ng/mL)	20 (33.3)
Sufficient (≥ 30 ng/mL)	12 (20.0)

Almost half of the participants (46.7%) were found to have a deficiency of Vitamin D, with only 20.0% showing adequate levels of Vitamin D.

Table 4: Association between Vitamin D Status and Radiological Union

Vitamin D Status	Union n (%)	Delayed Union n (%)
Deficient	18 (64.3)	10 (35.7)
Insufficient	17 (85.0)	3 (15.0)
Sufficient	12 (100.0)	0 (0.0)

Chi-square = 7.84, p = 0.020

Patients who had adequate vitamin D levels showed 100% union rate while delayed union was more common in patient who had vitamin D deficiency. This association was statistically significant.

Table 5: Mean Time to Radiological Union According to Vitamin D Status

Vitamin D Category	Mean Time to Union (Weeks) $\pm$ SD
Deficient	20.8 $\pm$ 3.4
Insufficient	17.2 $\pm$ 2.8
Sufficient	14.6 $\pm$ 2.1

ANOVA $p = 0.001$

Logarithmic regression analysis showed that the mean time to fracture union was significantly shorter with higher levels of Vitamin D. The radiological union occurred much earlier in patients with adequate Vitamin D level than in those with deficient levels.

Table 6: Correlation between Serum Vitamin D Level and Healing Time

Variable	r-value	p-value
Serum Vitamin D vs Time to Union	-0.52	0.001

A moderate negative correlation between serum Vitamin D and healing time was found ($r = -0.52$), suggesting that the higher the level of Vitamin D the quicker the fracture healed. Overall, the results indicate that sufficient levels of Vitamin D are associated with good radiological fusion and shorter time to fracture healing in patients with long bone fractures of the diaphyseal.

Discussion

The association between serum Vitamin D level and radiological union was investigated in the present prospective observational study in patients with long bone diaphyseal fractures. The study revealed that almost half of the study population (46.7%) was vitamin D-deficient. Those who had adequate levels of vitamin D had better rates of radiological union and a significantly shorter healing time than individuals with low levels of vitamin D. In addition, a moderate negative correlation was found between the healing time and serum Vitamin D levels, indicating that the higher the Vitamin D levels, the faster the fracture would heal.

The high vitamin D deficiency found in this study is similar to that in the previous literature. [12] Reported that a high prevalence of Vitamin D deficiency was present in patients with delayed and non-union fractures. Likewise, [13] reported that Vitamin D insufficiency and deficiency were prevalent among orthopedic trauma patients. [14]

Pointed out that Vitamin D deficiency is common in fracture patients and that Vitamin D may play a role in the healing of fractures. The study also showed that low levels of Vitamin D can have a negative impact on bone metabolism and fracture repair, says [15]. Such a high prevalence as seen in the current study is indicative of the increasing awareness that Vitamin D deficiency is still relatively common even in areas with abundant sunlight exposure. There was a distinguished relationship between the vitamin D status and the outcome of fracture healing. Earlier and more frequently, patients with adequate vitamin D levels progressed to radiological union than did those who

were deficient in vitamin D. Delayed union was observed mainly in people who had low levels of Vitamin D. The study results indicate that Vitamin D has an important role in the fracture healing process, and that it may affect the healing rate and quality of the bone.

The relationship between them can be explained biologically based on the effect of Vitamin D on calcium and phosphate metabolism, which is important for bone mineralization. In fracture healing, sufficient Vitamin D can aid the maturation of the callus and mineral deposition. Also, Vitamin D regulates osteoblast differentiation and activity, promotes bone matrix formation and influences osteoclast-mediated remodelling. Deficiency can affect these processes and lead to slow fracture union and delayed callus formation.

The findings of this study have important clinical implications. Periodic measurement of vitamin D in patients with long bone fractures may aid in identifying those who are at risk of delayed fracture healing. Dietary interventions or Vitamin D supplementation can help reduce the risk of delayed healing of fractures and be used as early treatment to correct Vitamin D deficiency.

Some restrictions should be acknowledged. The findings of the study may not be generalizable, as the study took place at a single tertiary care center. The sample size was relatively small and the follow-up period was limited to 24 weeks. More extensive multicentre studies with longer follow-up should confirm these findings.

The study has several strengths, despite these limitations. Its prospective design minimized recall bias and allowed systematic follow-up of patients. The radiologic union was evaluated with the standardized criteria at predetermined time intervals. In addition, the study provides useful information in a population of Indians, especially the eastern Indian population, where the prospective evidence on Vitamin D and fracture healing is limited.

Conclusion

In this study, vitamin D deficiency was a significant problem in patients suffering from fractures of the diaphyseal long bones. A significant association between a decrease in serum Vitamin D and delayed radiological union and prolonged healing time was found. The results showed that the patients with adequate Vitamin D levels had better outcomes for fracture healing. These findings imply that regular screening and correction of Vitamin D deficiency may prove to be a useful ancillary therapy in managing fracture patients, and contribute to optimal bone healing.

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