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Original Research Article

Correlation between Serum Vitamin D Levels and Bone Mineral Density among Patients with Fragility Fractures

Shubhanshu Srivastava[1], Mohd Abubakar[2], Kiran Kumari[3]

[1]Assistant Professor, Department of Orthopedics, ASMC, Kanpur Dehat, Uttar Pradesh, India
[2]Assistant Professor, Department of Radiodiagnosis, ASMC, Firozabad, Uttar Pradesh, India
[3]Associate Professor & Head, Department of Dentistry, ASMC, Firozabad, Uttar Pradesh, India

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Corresponding author: Dr. Shubhanshu Srivastava
Conflict of interest: Nil

Abstract

Background: Deficiency of vitamin D is a common problem worldwide and is associated with decreased bone mineral density (BMD), leading to an increased risk of fragility fractures, particularly among the elderly population.

Objectives: To evaluate the correlation between serum vitamin D levels and bone mineral density among patients presenting with fragility fractures.

Materials and Methods: A hospital-based cross-sectional study was conducted among 60 patients presenting with fragility fractures at a tertiary care center. Serum vitamin D levels were measured using standard laboratory methods, and bone mineral density was assessed using dual-energy X-ray absorptiometry (DEXA). Statistical analysis was performed to determine the correlation between serum vitamin D levels and bone mineral density.

Results: Vitamin D deficiency was observed in a significant proportion of participants. 56.7% had osteoporosis on BMD assessment. A significant positive correlation was observed between serum vitamin D levels and bone mineral density.

Conclusion: Routine evaluation of vitamin D levels and BMD may aid in early detection and management of osteoporosis, thereby reducing the risk of future fractures.

Keywords: Vitamin D Levels, Bone Mineral Density, Fragility Fractures.

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Introduction

Fragility fractures represent a major public health concern worldwide and are commonly associated with osteoporosis and reduced bone mineral density (BMD). These fractures occur following minimal trauma, such as a fall from standing height, and frequently involve the hip, vertebrae, and wrist. The incidence of fragility fractures increases with advancing age and is particularly common among postmenopausal women due to accelerated bone loss related to hormonal changes. It has been estimated that nearly 50% of women and 20% of men will experience a fragility fracture during their lifetime, highlighting the growing burden of osteoporosis and bone fragility in aging populations. [1]

Bone mineral density is widely recognized as the most important determinant of bone strength and fracture risk. Measurement of BMD using dual-energy X-ray absorptiometry (DXA) is considered the gold standard for diagnosing osteoporosis and predicting fracture risk. However, bone health is influenced not only by bone density but also by metabolic factors such as calcium homeostasis, hormonal regulation, and nutritional status. Among these factors, vitamin D plays a crucial role in maintaining bone metabolism and skeletal integrity. [2]

Vitamin D is essential for intestinal absorption of calcium and phosphorus, regulation of bone remodeling, and maintenance of neuromuscular function. Deficiency of vitamin D leads to decreased calcium absorption, secondary hyperparathyroidism, increased bone resorption, and progressive reduction in bone mineral density. Over time, these changes predispose individuals to osteopenia, osteoporosis, and fragility fractures. [3]

Several investigations have also explored the relationship between serum vitamin D levels and bone mineral density. Evidence suggests that reduced vitamin D levels are associated with lower BMD and increased risk of osteoporosis. [4] Furthermore, emerging research indicates that

biologically active or free vitamin D may correlate positively with lumbar BMD and could potentially serve as a predictor of osteoporotic vertebral fractures. [5] Despite increasing awareness regarding the importance of vitamin D in bone health, the exact relationship between vitamin D levels and bone mineral density in patients with fragility fractures remains incompletely understood. In view of the growing burden of osteoporosis and fragility fractures, understanding the relationship between vitamin D status and bone mineral density is essential for early diagnosis, prevention, and management of bone fragility. Hence, the present study was undertaken to assess the correlation between serum vitamin D levels and bone mineral density among patients presenting with fragility fractures.

Materials & Methods

Study Design & Setting: A hospital-based observational cross-sectional study was conducted in the Department of Orthopaedics at a tertiary care teaching hospital over a period of six months to evaluate the correlation between serum vitamin D levels and bone mineral density among patients presenting with fragility fractures. The study included patients presenting to the Orthopaedics department with fragility fractures, defined as fractures occurring after minimal trauma such as a fall from standing height or less. A total of 60 patients with fragility fractures who fulfilled the inclusion criteria were included in the study.

Inclusion Criteria

- Patients aged ≥40 years presenting with fractures occurring due to low-energy trauma or fall from standing height.
- Patients willing to participate and undergoing bone mineral density (BMD) assessment.

Exclusion Criteria

- Patients with high-energy trauma fractures (e.g., road traffic accidents).
- Patients with known metabolic bone diseases other than osteoporosis.
- Patients receiving vitamin D or calcium supplementation in the previous three months.
- Patients with chronic kidney disease, liver disease, malignancy, or endocrine disorders affecting bone metabolism.

Data Collection: Detailed clinical history and demographic information including age, sex, mechanism of injury, and relevant medical history were recorded using a structured proforma. Clinical examination was performed for all patients.

Estimation of Serum Vitamin D Levels: Blood samples were collected under aseptic conditions. Serum was separated and analyzed for 25-hydroxyvitamin D [25(OH)D] levels, which is considered the best indicator of vitamin D status. Vitamin D levels were measured using chemiluminescent immunoassay (CLIA)/ELISA method in the clinical biochemistry laboratory. Vitamin D levels were categorized as follows:

Table 1:

Vitamin D Level	Interpretation
< 20 ng/mL	Deficient
20–30 ng/mL	Insufficient
> 30 ng/mL	Sufficient

Assessment of Bone Mineral Density: Bone mineral density was measured using Dual-Energy X-ray Absorptiometry (DXA) at the lumbar spine and femoral neck, which is considered the gold standard method for assessing BMD. BMD results were interpreted according to World Health Organization (WHO) criteria using T-scores:

Table 2:

T-score	Interpretation
≥ −1.0	Normal
−1.0 to −2.5	Osteopenia
≤ −2.5	Osteoporosis

Statistical Analysis

Data obtained was entered into Microsoft Excel and analyzed using SPSS software version 21. The Pearson or Spearman correlation coefficient was used to determine the relationship between serum vitamin D levels and bone mineral density. A p-value < 0.05 was considered statistically significant.

Results

The majority of patients belonged to the age group of 61–70 years, followed by 51–60 years. Fragility fractures were more common in elderly individuals.

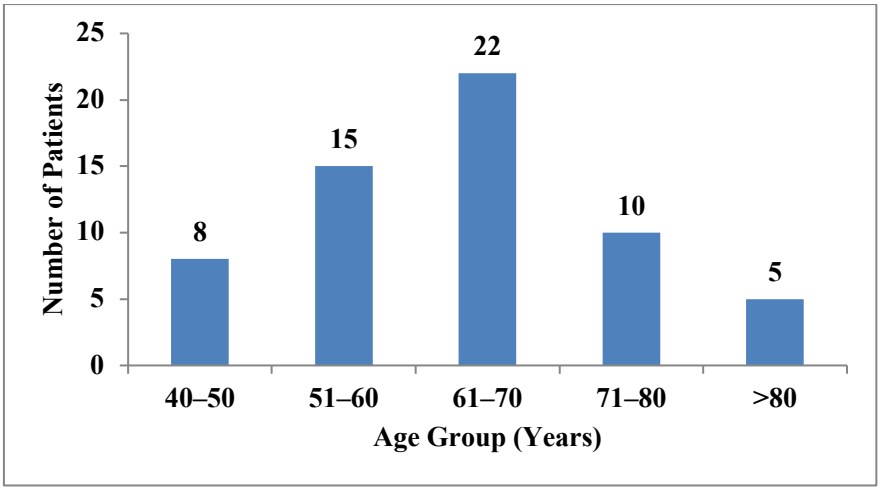

Figure 1: Bar diagram showing age distribution of patients with fragility fractures. (n = 60)

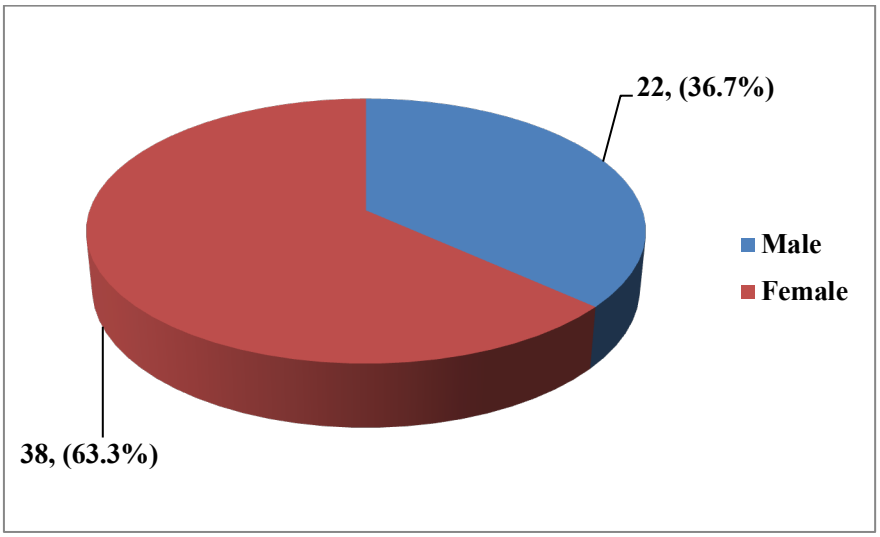

Figure 2: Pie chart showing gender distribution among study participants.

Among the 60 patients, females constituted the majority, reflecting the higher prevalence of osteoporosis in postmenopausal women.

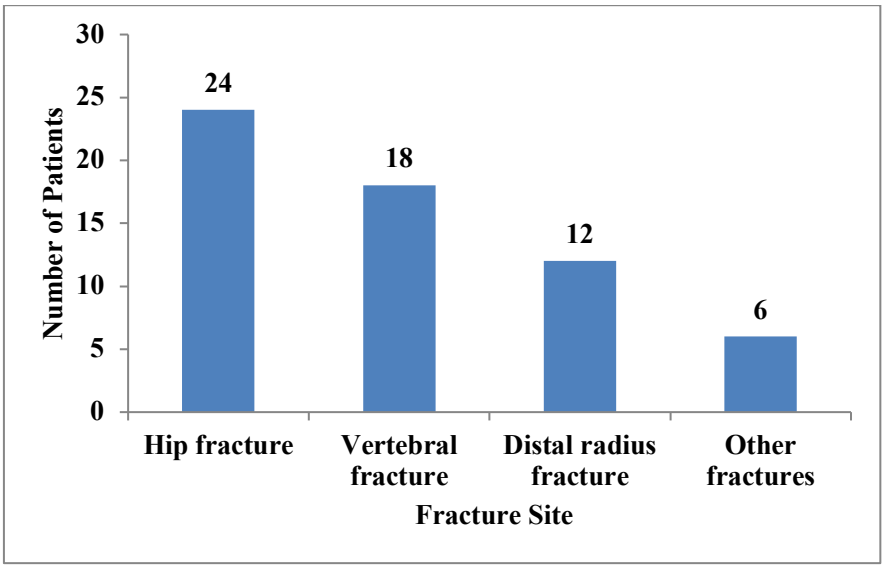

Figure 3: Bar diagram showing distribution of Fragility Fractures by sites.

The most common fragility fracture observed was hip fracture, followed by vertebral fractures.

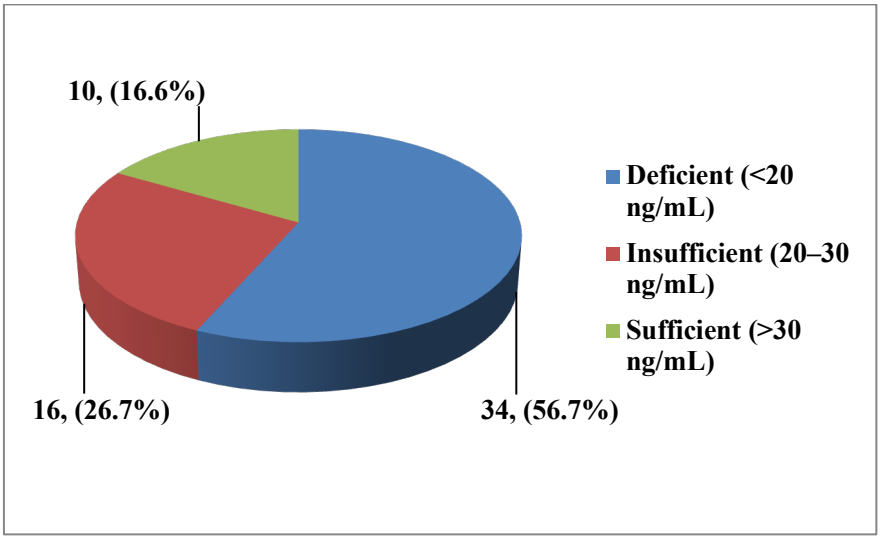

Figure 4: Pie chart showing Distribution of Serum Vitamin D Levels of study participants.

Vitamin D deficiency was observed in the majority of patients presenting with fragility fractures.

Table 3: Distribution of study subjects based on Bone Mineral Density (BMD)

BMD Category	Number of Patients	Percentage (%)
Normal	6	10.0
Osteopenia	20	33.3
Osteoporosis	34	56.7
Total	**60**	**100**

Based on WHO criteria, a significant proportion of patients were found to have osteoporosis.

Table 4: Correlation between Vitamin D Status and BMD

Vitamin D Status	Normal BMD	Osteopenia	Osteoporosis	Total
Deficient	1	9	24	34
Insufficient	2	7	7	16
Sufficient	3	4	3	10
Total	**6**	**20**	**34**	**60**

Statistical analysis using Pearson correlation demonstrated a significant positive correlation between serum vitamin D levels and bone mineral density ($r = 0.48$, $p < 0.01$).

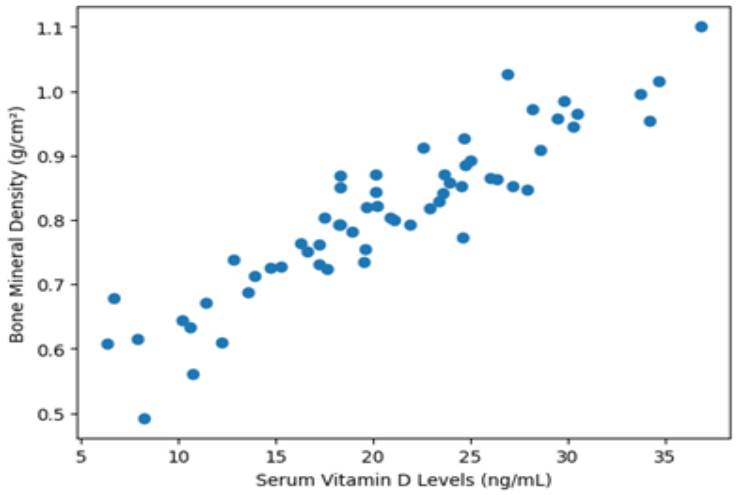

Figure 5: Scatter plot showing correlation between serum vitamin D levels and BMD

A significant association was observed between vitamin D deficiency and low bone mineral density.

Discussion

In this study, the majority of patients belonged to the 61–70 years age group, which reflects the increasing prevalence of osteoporosis and fragility fractures with advancing age. Aging is associated with reduced osteoblastic activity, decreased calcium absorption, and diminished cutaneous synthesis of vitamin D. These factors collectively contribute to progressive loss of bone mass and increased fracture susceptibility. Previous epidemiological studies like done by Sözen T et al [6] in 2017 have also demonstrated that the incidence of osteoporotic fractures increases significantly after the age of 60 years due to age-related decline in bone quality and mineral density.

The present study also showed a female predominance, accounting for nearly two-thirds of the participants. The findings are consistent with earlier studies done by Khosla S et al [7] in 2017 and Dadra A, et al [8] in 2019 that fragility fractures are more common among postmenopausal women. Estrogen deficiency after menopause accelerates bone resorption and reduces bone formation, thereby leading to rapid bone loss. Vitamin D deficiency further aggravates this process by impairing calcium metabolism and increasing bone turnover.

Another important observation in this study was the high prevalence of vitamin D deficiency, which was identified in more than half of the patients. Study conducted in asian population by Mithal A et al 9 in 2009 have reported widespread vitamin D deficiency despite adequate sunlight exposure, largely due to limited outdoor activity, cultural clothing practices, and inadequate dietary intake.

The analysis of bone mineral density in the present study revealed that more than half of the participants had osteoporosis, while a considerable proportion had osteopenia. These findings highlight the substantial burden of low bone mass among individuals presenting with fragility fractures. According to previous research done by Kanis J A et al [10] in 1994 and Bouillon R et al [11] in 2019 each standard deviation decrease in BMD is associated with a two-fold increase in the risk of osteoporotic fractures.

A key finding of this study was the moderate positive correlation between serum vitamin D levels and bone mineral density. Patients with lower vitamin D levels were more likely to exhibit osteoporotic BMD values, whereas individuals with sufficient vitamin D levels tended to have relatively higher BMD. Similar findings have been reported in recent studies evaluating the relationship between vitamin D status and bone health. Reid et al. [12] demonstrated that adequate vitamin D levels are associated with improved bone density and reduced fracture risk in elderly individuals. Likewise, a systematic review by Lips and van Schoor [13] highlighted the importance of maintaining sufficient vitamin D levels for optimal musculoskeletal health and prevention of osteoporotic fractures. Bischoff-Ferrari et al. [14] reported that vitamin D supplementation significantly reduces the incidence of falls and fractures in elderly populations. Recent clinical guidelines also recommend screening for vitamin D deficiency in individuals at risk of osteoporosis and fragility fractures. [15]

Recommendations

1. Routine screening of vitamin D levels should be considered in patients presenting with fragility fractures, especially in elderly individuals and postmenopausal women, to enable early identification and management of vitamin D deficiency.
2. Lifestyle modifications, including adequate sunlight exposure, balanced diet rich in calcium and vitamin D, and regular weight-bearing exercises, should be encouraged to maintain optimal bone health.
3. Early screening in high-risk groups, such as elderly individuals, postmenopausal women, and patients with previous fractures, may help in the prevention of osteoporosis-related complications.

Limitations

1. Small sample size & Single-center study: The study included only 60 participants and was conducted in a single tertiary care hospital which may limit the generalizability of the findings to the wider population
2. Lack of follow-up: The study did not include follow-up to assess the effect of vitamin D supplementation or treatment on bone mineral density.
3. Confounding factors not evaluated: Other factors influencing bone health such as dietary calcium intake, physical activity, sun exposure, and comorbid conditions were not extensively analyzed.

Conclusion

This study demonstrated a significant association between serum vitamin D levels and bone mineral density among patients with fragility fractures. A high prevalence of vitamin D deficiency and reduced BMD was observed, particularly among elderly and female patients. Routine assessment of vitamin D status along with bone mineral density evaluation may help in early diagnosis, timely intervention, and prevention of osteoporosis-related fragility fractures.

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