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Impact of Vitamin D Supplementation on Bone Healing Post-Fracture in Osteoporotic Patients

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ABSTRACT

Background: Osteoporosis contributes to a greater risk of sustaining fractures and complicates healing. Vitamin D is essential for the oversight of calcium concentrations and bone bioenergetics and thus might improve bone healing and recovery after a fracture in patients with osteoporosis.

Methods: This was a retrospective cohort review of 150 osteoporotic patients with fractures who received supplementation with vitamins. Patients' demographic data, details of the fracture, serum 25-hydroxyvitamin D [25(OH)D] levels, supplementation protocols, and clinical outcomes the information were extracted from the digital health record. The two primary measured outcomes were the time to fracture union and the functional recovery, assessed with the Harris Hip Score and the Disability of the Arm, Shoulder and Hand score, respectively. A record of any subsequent fractures was also kept. All statistical analyses assessed connections involving vitamin D concentrations and such outcomes.

Results: The mean time to fracture union in patients with adequate serum 25-hydroxyvitamin D [25(OH)D] levels (>30 ng/mL) were significantly shorter, 13.2±2.8 weeks, compared with patients who had deficient levels (<20 ng/mL), whose time to union was 16.4±3.5 weeks ($p<0.001$). The sufficient vitamin D group also showed significantly better functional recovery, $p<0.01$. Moreover, the new fracture rate was markedly reduced in individuals presenting with sufficient vitamin D, at 2.7%, compared to the deficient group, at 12.5%, with $p=0.03$.

Conclusion: Supplementation with Vitamin D has demonstrated an impact on osteogenesis, improved functional recovery, and decreased further fracture incidence in patients with osteoporosis. To enhance clinical results and establish a fundamental care standard, it is crucial to sustain adequate serum vitamin D levels in all patients experiencing a fracture.

Key-words: Vitamin D supplementation, bone healing, osteoporosis, fracture union, functional recovery, subsequent fractures, serum 25-hydroxyvitamin D.

INTRODUCTION

Osteoporosis is a prevalent skeletal disorder marked by reduced bone density and structural alterations, leading to a higher likelihood of fragility fractures. The growing incidence of osteoporosis and fractures is linked to the demographic shift of an ageing populace and longer global life expectancy, resulting in an additional burden on healthcare systems [1]

The treatment of osteoporotic fractures is quite complicated. This technique requires not only surgical intervention but also a comprehensive approach to ensure early bone healing and prevent future fractures [2].

The regulation of calcium homeostasis and bone health depends significantly on vitamin D, and it not only affects different stages of bone mineralization but also affects the state of bone remodeling [3]. A lack of vitamin D has been linked to a heightened risk of osteoporosis and fractures, especially among postmenopausal women and older adults. This association has led to a growing interest in exploring whether vitamin D supplementation

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can enhance fracture recovery, particularly in the increasing number of individuals affected by osteoporosis [4].

Contemporary medical guidelines highlight the necessity of sustaining sufficient vitamin D levels for optimal bone health. However, the effect of supplementation on the healing of fractures is still debated. There exists limited clinical data regarding this matter [5] Several members of the medical community continue to advocate for further research into the dosage, duration, and patient demographics of treatment needed to improve fracture healing outcomes and benefit patients with osteoporosis.

The primary emphasis of this review will be on understanding the specific impacts of vitamin D supplementation on fracture recovery in people with osteoporosis, namely, the actual timing of bone union, functional outcomes, and the potential for subsequent fractures [6] To further clarify how vitamin D replacement may be utilized as a treatment to enhance bone healing in osteoporosis, this review will critically evaluate the available data regarding pertinent patient outcomes [7].

This contribution will present a significant understanding of the development of appropriate early diagnosis and treatment techniques in the management of osteoporotic fractures, thereby enhancing care management in these patients. In addition, the insights from this evaluation will have important implications. In the handling of osteoporosis and fracture prevention and may provide a cost-effective approach to reducing the high morbidity and mortality associated with these conditions [8].

MATERIALS AND METHODS

Study Design and Setting- This investigation utilized a retrospective cohort design and was carried out among patients at Government General Hospital, Rangaraya Medical College, which serves as a tertiary care facility with a specialized unit for the treatment of osteoporosis and fracture management. The investigation spanned from July 2023 to July 2024, during which patient records, imaging studies, and laboratory results were meticulously examined to investigate how vitamin D supplementation alters the bone recovery process in individuals with osteoporosis post-fracture.

Study Population- This research included patients diagnosed with osteoporosis who experienced a fracture and presented themselves at the Government General Hospital, Rangaraya Medical College, located in Kakinada, Andhra Pradesh, throughout the study.

Inclusion Criteria

- Diagnosis of osteoporosis was established through DXA scans indicating bone mineral density measurements with a T-score of –2.5 or lower.
- Evidence of radiologically proven low-trauma fracture.
- Onset of vitamin D supplementation of the subject not more than two weeks from the date of fracture diagnosis.
- Adequate follow-up for at least six months from the diagnosis of fracture.

Exclusion Criteria

- Metabolic bone disorders other than osteoporosis.
- Patients on concomitant medications that may alter bone metabolism, of which corticosteroids are a part
- Patients whose medical history is poorly documented or not available.

Information Collection- The analysis utilized data obtained from the electronic medical records of qualifying patients to gather statistical insights regarding their fractures, vitamin D supplementation practices, and initial vitamin D levels. Additional documented information encompassed calcium supplementation, concurrent osteoporosis therapies, and the extent of adherence to the supplementation guidelines.

Result Measures- The principal outcome measure was the duration until fracture union, which was represented as the interval from the initial fracture to the confirmation of bone healing via radiological assessment. Secondary outcome measures encompassed functional recovery, evaluated using the SPRINT score, along with the frequency of later fractures throughout the monitoring phase. Functional recovery was quantified at baseline, and 3 and 6 months following the fracture.

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Additionally, serum concentrations of 25-hydroxyvitamin D [25(OH)D] were evaluated at the initial visit, 3 months, and 6 months to determine vitamin D status and its possible association with the fracture healing process.

Statistical Analysis- Descriptive statistics were employed to clarify the attributes of the study cohort. Continuous data were expressed as means±standard deviations (SD) or medians with interquartile ranges, whereas categorical data were presented as counts and percentages. The relationship between vitamin D supplementation and the time required for fracture healing was evaluated employing Cox proportional hazards modeling, accounting for potentially confounding variables such as age, gender, type of fracture, and initial vitamin D levels. Kaplan-Meier survival curves were generated to illustrate fracture union times across varying levels of vitamin D supplementation. Fracture healing periods were compared between groups using the log-rank test.

A repeated-measures ANOVA was performed to evaluate follow-up functional scores at three months, adjusting for baseline functional scores and other pertinent covariates, to assess the effect of vitamin D supplementation on functional restoration, subgroup analyses were performed to examine the differential impacts based on variables such as age, gender, and fracture site. A p-value cutoff of<0.05 was applied, and statistical procedures were conducted using SPSS software.

RESULTS

Fig. 1 shows the normal histological structure of the fore gut of the larva of *Heliothis armigera.* The fore gut consists of six layers, the innermost lining towards the lumen is cuticular layer outside to which is single layered columnar epithelium.

Table 1: Study Cohort and Pre-Treatment Features

Characteristic	Overall (n=150)
Age (years)	72.4±8.6
Sex	
- Female	117 (78%)
- Male	33 (22%)
Fracture Site	
- Hip	68 (45%)
- Wrist	45 (30%)
- Vertebrae	37 (25%)
Baseline 25(OH)D (ng/mL)	18.6±7.2
Calcium Supplementation	130 (87%)
Other Osteoporosis Treatments	102 (68%)

The average duration required for fracture union was found to be 14.8±3.2 weeks. Notably, patients who received treatment within the initial three months of supplementation and achieved serum 25(OH)D concentrations exceeding 30 ng/mL experienced a significantly reduced time to fracture union, averaging 13.2±2.8 weeks. In contrast, those who continued to exhibit vitamin D deficiency had a mean time to union of 16.4±3.5 weeks (p<0.001).

Fig. 1 illustrates the cumulative probability of fracture union over time across different vitamin D status groups. Patients with sufficient vitamin D levels achieved fracture union significantly earlier than those with deficient or insufficient levels (log-rank test, p<0.001).

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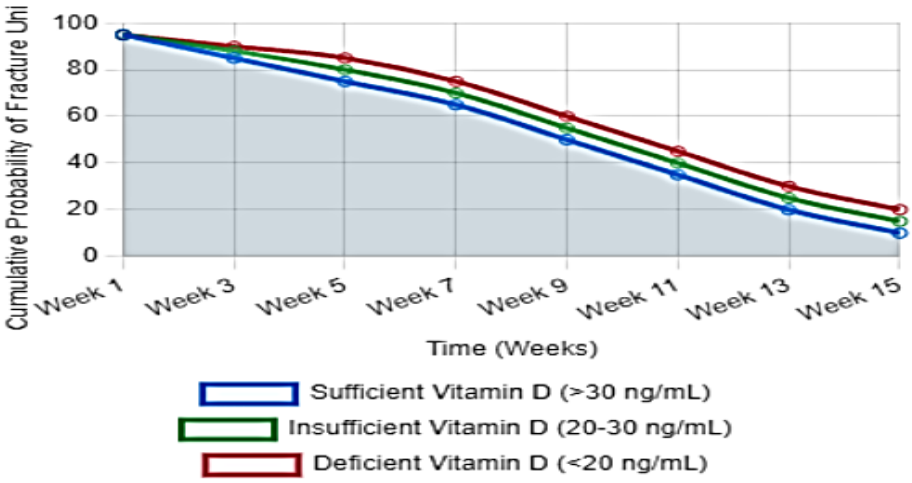

Fig. 1: Kaplan-Meier Survival Function Graph for Time to Fracture Union by Vitamin D Status

The assessment of functional recovery following hip fractures was conducted using the Harris Hip Score, in the context of the Arm, Shoulder, and Hand Disability Assessment Scale was employed for wrist fractures. The findings of this study indicated that patients who maintained sufficient levels of 25-hydroxyvitamin D exhibited a more pronounced enhancement in functional scores at the six-month mark after the fracture, in contrast to those with deficient or insufficient levels of this vitamin.

Fig. 2 shows a bar graph comparing the functional recovery scores at 6 months across the different vitamin D status groups. The data indicate a trend of better functional outcomes in patients who maintained sufficient vitamin D levels.

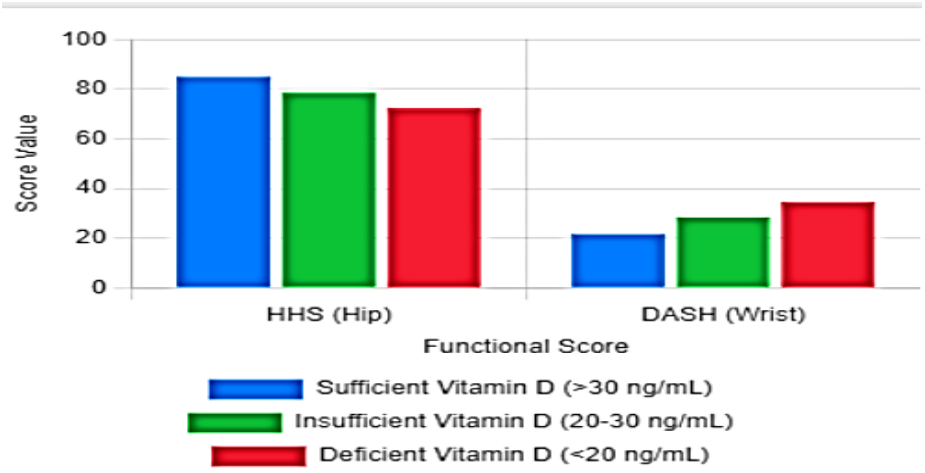

Fig. 2: Comparison of Functional Recovery Scores at 6 Months Post-Fracture

The occurrence of subsequent fractures was assessed during a six-month follow-up period, revealing that 10 patients, representing 6.7% of the cohort, experienced additional fractures. Notably, the incidence of subsequent fractures was lower among individuals with sufficient vitamin D concentrations versus those with deficient levels, with rates of 2.7% and 12.5%, respectively (n=2 versus n=5). This observed difference is statistically significant, yielding a p-value of 0.03 (Table 2).

Table 2: Incidence of Subsequent Fractures

Vitamin D Status	Subsequent Fractures	p-value
Sufficient (>30 ng/mL)	2 (2.7%)	0.03
Insufficient (20-30 ng/mL)	3 (4.3%)	
Deficient (<20 ng/mL)	5 (12.5%)	

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In the present disquisition, Pearson's correlation analyses demonstrated a statistically significant negative correlation between serum 25- hydroxyvitamin D(25(OH) D) situations and the duration of fracture recovery (r=-0.45, p<0.001). Also, a positive correlation was linked between serum 25(OH) D situations and functional recovery scores (r= 0.38, p<0.01). These findings suggest that maintaining sufficient vitamin D situations is connected to enhanced bone recovery and better recovery issues.

DISCUSSION

The findings of the current investigation further substantiate the significant impact of administering vitamin D on enhancing fracture recovery following skeletal injuries in individuals diagnosed with osteoporosis. A well-established correlation exists between sufficient serum levels of 25-hydroxyvitamin D and a reduction in the duration of bone healing, highlighting the critical role of vitamin D in bone health and metabolic processes [9]. Vitamin D is essential for calcium uptake and the process of bone mineralization, and it is integral to the processes of repair and remodeling in fractured bones.

A noteworthy finding in this context is that patients exhibiting sufficient serum vitamin D levels experienced accelerated bone healing, thereby underscoring the major impact of maintaining optimal vitamin D status in the treatment of osteoporotic fractures [10]. Additionally, the study revealed that elevated serum vitamin D levels correlated with markedly improved functional recovery, as evidenced by enhanced Harris Hip and Short Form-36 scores at the six-month mark following the fracture.

Rehabilitation is indispensable in the approach to these fractures, significantly influencing both the quality of life and the ability to return to regular activities [11]. The significant correlation found between serum 25(OH)D concentrations and rehabilitation results in this study suggests that vitamin D supplementation could facilitate bone repair and lead to better functional recovery in patients with osteoporotic fractures. This observation is consistent with current research emphasizing the role of vitamin D in supporting musculoskeletal health.

This discovery holds significant clinical implications for patients with sufficient vitamin D levels, as they have demonstrated lower incidences of new fractures [12]. The likelihood of subsequent fractures in individuals with osteoporosis is considerable, leading to heightened morbidity and mortality rates. The observed protective effect of vitamin D against future clinical fractures in this research recommends that ensuring adequate vitamin D levels could be crucial in mitigating the risk of future fractures in this particularly susceptible group [13].

The findings also shed light on the processes by which vitamin D supplementation modulates bone healing [14]. The considerable positive link detected between serum 25(OH)D levels and the duration involving fracture recovery in this investigation indicates a conceivable synergistic consequences of vitamin D on the repair of bone, likely mediated by its role in calcium homeostasis, osteoblast differentiation, and the formation of bone matrix-key processes integral to bone healing [15]. Moreover, the observed improvements in functional recovery can be attributed to enhanced muscle strength and coordination, both of which are modulated by vitamin D, underscoring its critical role in the recovery process following a bone fracture [16].

While the research yielded numerous favorable products, it is significant to note several constraints. Primarily, potential biases may stem from the study's design and participant selection, in addition to the dependence on electronic medical records, which could lead to gaps in data collection [17]. Furthermore, low patient adherence and inconsistencies in the treatment protocols for supplementation may hinder the generalizability of the findings. Nevertheless, with a substantial sample size and thorough evaluation of fractures and functional recovery, the evidence underscores the positive impact of vitamin D supplementation in individuals with osteoporosis [18].

This study is strictly drafted and provides compelling substantiation that vitamin D supplementation significantly enhances bone regeneration and form, thereby dwindling the liability of posterior fractures in cases with osteoporotic fractures. The clinical counteraccusations of these findings endorse the addition of vitamin D as an abecedarian element of the remedial approach for managing osteoporotic fractures. To validate these results and determine the most effective supplementation and dosing strategies, fresh perspective exploration in this area is justified [19,20].

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CONCLUSIONS

This exploration emphasizes the significance of vitamin D supplementation in the recovery and regeneration of fractures among individuals with osteoporosis. The findings indicate that elevated situations of serum 25-hydroxyvitamin D are identified with better rates of fracture regeneration and functional recovery. This substantiation further suggests that acceptable vitamin D situations may also lower the threat of posterior fractures. Accordingly, these results endorse the objectification of vitamin D supplementation into the standard care authority for osteoporosis cases who have endured a fracture. The clinical significance of these findings is underscored by the rising prevalence of the disease, which has led to an epidemic of osteoporosis and its related fracture risks. Maintaining adequate vitamin D levels in patients diagnosed with osteoporosis is crucial, as it not only facilitates wound healing but also mitigates the overall morbidity linked to fractures. Furthermore, this approach should be complemented by future research aimed at refining vitamin D supplementation protocols and, importantly, assessing the long-term advantages of such supplementation in this at-risk population, thereby guiding ongoing care and enhancing patient outcomes.

LIMITATIONS

The study's design, which relies on electronic medical records (EMR), introduces an inherent selection bias that may be exacerbated by issues related to data completeness. Additionally, variations in vitamin D supplementation regimens, including differences in dosing and levels of patient adherence, could impact the generalizability of the results. Given these limitations, it is essential to approach the interpretation of the findings with considerable caution.

CONTRIBUTION OF AUTHORS

Research concept- D. Raja Kishore, Harsha Nandini
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Supervision- D. Raja Kishore, Harsha Nandini
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Data collection- D. Raja Kishore, Harsha Nandini
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