Journal of Medical Science, Biology, and Chemistry (JMSBC)

ISSN: 3079-2576 (Online)

Volume 2 Issue 2, (2025)

https://doi.org/10.69739/jmsbc.v2i2.1242

https://journals.stecab.com/jmsbc

Published by
Stecab Publishing

Research Article

Association Between Vitamin D Deficiency and Alveolar Bone Loss in Postmenopausal Women: A Cone-Beam CT-Based Clinical Investigation

*[1]Zainab A. H. Al-Tamemi, [1]Huda Ashur Shati Qutbi

About Article

Article History

Submission: October 21, 2025
Acceptance : November 24, 2025
Publication : November 30, 2025

Keywords

25-hydroxyvitamin D, Alveolar Bone Height, Alveolar Bone Resorption, Cone-Beam Computed Tomography (CBCT), Iraq

About Author

[1] College of Dentistry, University of Wasit, Wasit, Iraq

Contact @ Zainab A. H. Al-Tamemi
zaltimeme@uowasit.edu.iq

ABSTRACT

The reduction in bone mass of postmenopausal women is faster because of the lack of estrogen (and possibly because of a lack of vitamin D). Alveolar bone resorption has major implications on oral health as well as tooth retention in population. To investigate the association between serum 25-hydroxyvitamin D [25(OH)D] levels and alveolar bone loss in postmenopausal women using cone-beam computed tomography (CBCT) analysis. This cross-sectional research considered 284 postmenopausal women (aged 45-75 years) in dental clinics in Baghdad, Iraq, in January 2024- January 2025. Quantification of serum 25 (OH) D levels was done through chemiluminescent immunoassay. To determine alveolar bone height (ABH), bone density, and cortical thickness CBCT scans were done. The participants were stratified into three categories as vitamin D deficient (<20 ng/ mL), insufficient (20-29.9 ng/ mL), and sufficient (>= 30 ng/ mL). ANOVA, Pearson correlation, and multiple linear regressions were used to analyse the results statistically. The age of the participants (58.73 8.37 years) was normally distributed, with 147 (51.80%), 89 (31.30%), and 48 (16.90%) participants having a vitamin D deficiency, insufficiency, and sufficiency. Vitamin D deficient women exhibited statistically significant increases in alveolar bone loss (4.2:1.8 mm, p<0.001), decrease in bone density (421.3:89.2 HU vs 587.4:94.6 HU, p<0.001), and cortical thickness (0.8: 3 mm vs 1.4:4 mm, p<0.001) as compared to vitamin D sufficient women. A near inverse relationship was between the strength of 25(OH)D level and the loss of alveolar bone (r -0.742, p<0.001). The results of multiple regression analysis showed vitamin D deficiency to be the independent predictor of alveolar bone loss (B = -0.521, p<0.001), in which the predictor explained the variance of 55.1 percent. Deficiency of vitamin D is strongly related to added alveolar bone loss by postmenopausal women. BCT has the ability to give accurate measures of bone parameters. Vitamin D supplementation treatment options need to be proposed to generate oral bone health in this demographic.

Citation Style:

Al-Tamemi, Z. A. H., & Qutbi, H. A. S. (2025). Association Between Vitamin D Deficiency and Alveolar Bone Loss in Postmenopausal Women: A Cone-Beam CT-Based Clinical Investigation. *Journal of Medical Science, Biology, and Chemistry, 2*(2), 276-284. https://doi.org/10.69739/jmsbc.v2i2.1242

1. INTRODUCTION

Postmenopausal osteoporosis is a major worldwide health challenge, which affects about 200 million women globally and culminates in weakened fracture risk and adverse quality of life (Abbas *et al.*, 2025). The loss of bone in the form of resorption is exacerbated by a post-menopausal reduction in the production of estrogen, which reduces bone mineral density and damaging the structural integrity of the skeletal system (Al-Hetty *et al.*, 2023). One of the most vulnerable areas to such alterations is the oral and maxillofacial region, specifically on alveolar bone loss, which has a direct relation to the state of the dentition and the prognosis of treatments provided (AL-Shaeli *et al.*, 2022). Vitamin D is important in calcium homeostasis and bone metabolism by virtue of its active product, 1,25-dihydroxyvitamin D3 which controls intestinal calcium absorption and osteoblast differentiation (Asllani *et al.*, 2025).

Despite growing interest in the relationship between vitamin D status and oral bone health, the existing literature exhibits a notable methodological limitation. Much of the available evidence has relied on two-dimensional (2D) radiographic techniques such as panoramic or periapical imaging which lack the precision required to accurately quantify alveolar bone morphology and subtle structural changes. These imaging constraints have made it difficult to draw definitive conclusions about the association between vitamin D deficiency and alveolar bone loss.

To address this gap, the present study employs cone-beam computed tomography (CBCT), a three-dimensional (3D) imaging modality that provides superior spatial resolution and allows for more accurate and reliable assessment of alveolar bone parameters. By using CBCT, this investigation aims to offer a more robust evaluation of the relationship between vitamin D deficiency and alveolar bone loss in postmenopausal women, thereby contributing clearer evidence to an area previously limited by imprecise diagnostic methods.

2. LITERATURE REVIEW

Vitamin D deficiency, characterized by a 25-hydroxyvitamin D [25(OH)D] level below 20 ng/mL (50 nmol/L), has an incidence of about 1 billion individuals worldwide and it is especially common among Middle Eastern populations due to the insufficient sun exposure and diet (Augustin *et al.*, 2024). The connection with systemic bone health and vitamin D status has been proven and appurtenant deficiency as a cause of secondary hyperparathyroidism, increased turnover-rate, and progressed bone loss of the bones (Chen *et al.*, 2024). It's the alveolar process where the teeth are rooted and structural support for teeth is found remodels during the entire life. The combination of estrogen deficiency and the possibility of vitamin deficiency, in postmenopausal women, may interact synergistically and contribute to increased alveolar bone resorption resulting in mobility of teeth, periodontal complications, and failure to support prosthetic replacement of teeth (da Fonte *et al.*, 2024). Conventional two-dimensional radiograph procedures are not very useful to determine three-dimensional aspects of the bone structure and the density variations in the alveolar part of your mouth (Datsenko *et al.*, 2025).

Cone-beam computed tomography (CBCT) has been utilized as a useful diagnostic tool in the dentistry profession with higher resolution three dimensional images but considerably less radiation exposure than conventional CT scans (Eshky *et al.*, 2025). BCT allows accurate measurement of alveolar bone height, the bone density in terms of Hounsfield units, as well as cortical thickness, which provided the perfect modality to study bone alterations during postmenopause in women (Gorjizad *et al.*, 2025). The quantitative bone parameters that the technology provides have transformed evaluation of oral bone health and treatment planning in this group. Since vitamin D deficiency is widespread among Iraqi and the population of elderly females is on the rise, it is important to learn more about the connection between vitamin D levels and the alveolar bone health in order to be able to design prevention and treatment means. The aim of the proposed study is to examine the relationship between vitamin D level in the serum and the parameters of alveolar bone resorption based on the CBCT analysis of postmenopausal Iraqi women.

3. METHODOLOGY

3.1. Study Design and Setting

This cross-sectional observational study was conducted at the Department of Oral and Maxillofacial Radiology, College of Dentistry, University of Baghdad, in collaboration with the Department of Internal Medicine, Baghdad Teaching Hospital, Baghdad, Iraq, between January 2024 and January 2025. The study protocol was approved by the Institutional Review Board of the University of Baghdad (Ethics Committee Reference: UOB-COD-2021-098) and conducted in accordance with the Declaration of Helsinki. All participants provided written informed consent before enrollment.

3.2. Participants

The study population was postmenopausal women who had come to the university dental clinics in search of dental treatment. G*Power 3.1.9.7 software has been used to calculate the sample size, suppose there is a medium effect size (f 2 = 0.15), alpha = 0.05, and the power =0.80, and three groups have been considered to compare them. The smallest sample size was estimated to be 252 participants. We sought to enroll 290 participants with an expectancy of 15% dropout rate.

3.3 Inclusion Criteria

- Postmenopausal women aged 45-75 years
- Natural menopause confirmed by amenorrhea for ≥12 months
- Follicle-stimulating hormone (FSH) levels >40 IU/L
- Presence of at least 10 natural teeth
- Ability to provide informed consent
- Stable medical condition

3.4. Exclusion Criteria

- The use of vitamin D supplements in the current or recent period (within 6 months)
- Any history of use of bisphosphonate or other bone-affecting medication
- Systemic disorders that can impact on bone metabolism (hyperparathyroidism, malabsorption diseases, chronic renal disease)

• Prior history (oral and maxillofacial surgery or trauma)
• Current active periodontal disease in that buried in the conventional active periodontal disease and treatment is urgent
• CBCT examination contraindications
• Pregnancy or breastfeeding (but probably not in women with menopause)

3.5. Biochemical Assessment

Fasting blood samples (10 mL) were collected between 8:00-10:00 AM after a 12-hour overnight fast. Serum 25-hydroxyvitamin D [25(OH)D] levels were measured using a chemiluminescent microparticle immunoassay (ARCHITECT i2000SR, Abbott Laboratories, Abbott Park, IL, USA) with an analytical sensitivity of 4.0 ng/mL and intra-assay coefficient of variation <5%. Participants were categorized according to the Endocrine Society guidelines: deficient (<20 ng/mL or <50 nmol/L), insufficient (20-29.9 ng/mL or 50-74.9 nmol/L), and sufficient (≥30 ng/mL or ≥75 nmol/L).
Additional biochemical parameters measured included serum calcium (normal range: 8.5-10.5 mg/dL), phosphorus (normal range: 2.5-4.5 mg/dL), alkaline phosphatase (normal range: 44-147 IU/L), and parathyroid hormone (PTH) using electrochemiluminescence immunoassay (Elecsys 2010, Roche Diagnostics, Mannheim, Germany).

3.6. CBCT Imaging Protocol

CBCT examinations were performed using a NewTom VGi evo system (QR s.r.l., Verona, Italy) with standardized parameters: 110 kVp, 4.59 mAs, 0.3 mm voxel size, 12×8 cm field of view, and 18-second scanning time. All images were acquired by a single experienced radiographer following a standardized protocol to minimize inter-operator variability. Image reconstruction and analysis were performed using NNT Viewer software (QR s.r.l., Verona, Italy). A single calibrated oral radiologist with 10 years of CBCT experience, blinded to participants' vitamin D status, performed all measurements. Intra-observer reliability was assessed by re-measuring 30 randomly selected cases after a 2-week interval.

3.7.CBCT Measurements

1. Alveolar Bone Height (ABH): is the distance between the cemento-enamel junction (CEJ) to the alveolar bone crest at six sites per tooth (mesio-buccal, mid-buccal, disto-buccal, mesio-lingual, mid-lingual, disto-lingual) of all posterior teeth. The average of all the measurements was the mean ABH loss.

2. Bone Density: The bone density was measured as Hounsfield Units (HU) using region of interest (ROI) analysis in three anatomic sites, namely, (a) interdental septum between first and second molars, (b) buccal cortical plate, and (c) cancellous bone within the molar region. The size of each ROI was standardized to 2x 2x 2 mm^3.

3. Cortical Thickness: determined in the molar region by measuring the thickness of the buccal and lingual cortical plates, using perpendicular cross-sectional images. Each site was measured three times and averaged.

4. Panoramic mandibular Index (PMI): Computed as the ratio between cortical thickness and between the foramen mental and the inferior margin of the mandible.

3.8. Statistical Analysis

Statistical analysis was performed using SPSS version 28.0 (IBM Corporation, Armonk, NY, USA) and R software version 4.3.0. Normality of continuous variables was assessed using the Shapiro-Wilk test and Q-Q plots. Descriptive statistics included means with standard deviations for normally distributed variables and medians with interquartile ranges for non-normally distributed variables. Between-group comparisons were performed using one-way ANOVA with Tukey's post-hoc test for normally distributed variables and Kruskal-Wallis test with Dunn's post-hoc test for non-normally distributed variables. Categorical variables were compared using Chi-square tests or Fisher's exact test as appropriate. The Pearson correlation coefficients were used to evaluate dependency relationships between continuous variables. To determine independent factors contributing to alveolar bone loss, multiple linear regression analysis was calculated using the vitamin D status parameter as the key predictor variable, and efforts were made to control for variables age, body mass index, time elapsed since menopause, smoking status, and comorbidities. Residual analysis was used to test the Model assumptions, and variance inflation factors (VIF <5) were determined to check the presence of multicollinearity. All analyses were done by setting statistical significance at $p<0.05$.

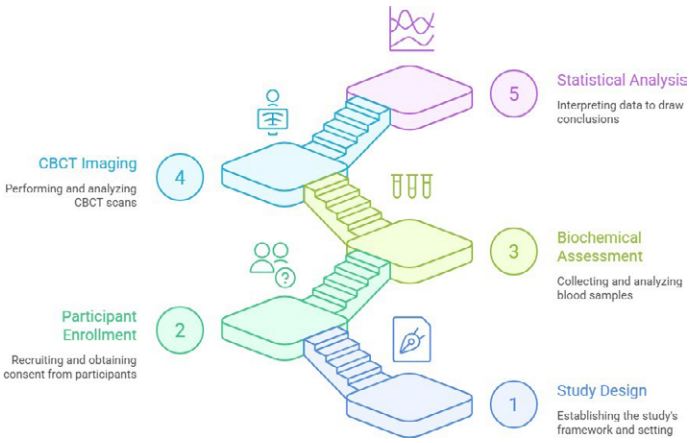

Figure 1. Stepwise workflow of the study methodology, including study design, participant enrollment, biochemical assessment, CBCT imaging, and statistical analysis

4. RESULTS AND DISCUSSION

4.1. Participant Characteristics

A total of 290 women in their postmenopausal age were recruited, 284 of which completed the study (response rate: 97.9%). Six participants were excluded based on incomplete CBCT data (3), and the loss to follow-up (3). The average age of the participants was 58.78 years ± 8.42 years (range 45-74 years) and the average time since menopause was 9.2 years +- 6.1 years. According to serum 25(OH)D, 147 (51.8) were vitamin D deficient, 89 (31.3) deficient and 48 (16.9) was sufficient.

Table 1. Baseline Characteristics of Study Participants by Vitamin D Status

Characteristic	Deficient (<20 ng/mL) n=147	Insufficient (20-29.9 ng/mL) n=89	Sufficient (≥30 ng/mL) n=48	p-value
Age (years)	60.2±8.1	58.1±8.3	55.9±8.8	0.009
BMI (kg/m²)	28.7±4.2	27.3±3.9	25.8±3.4	<0.001
Time since menopause (years)	10.8±6.4	8.9±5.8	6.7±5.2	<0.001
Smoking status, n (%)	23 (15.6)	11 (12.4)	3 (6.3)	0.234
Education level (University), n (%)	45 (30.6)	38 (42.7)	28 (58.3)	0.003
Monthly income (>500,000 IQD), n (%)	38 (25.9)	31 (34.8)	25 (52.1)	0.005
Diabetes mellitus, n (%)	34 (23.1)	15 (16.9)	4 (8.3)	0.039
Hypertension, n (%)	52 (35.4)	24 (27.0)	8 (16.7)	0.028
Sun exposure <30 min/day, n (%)	128 (87.1)	69 (77.5)	25 (52.1)	<0.001

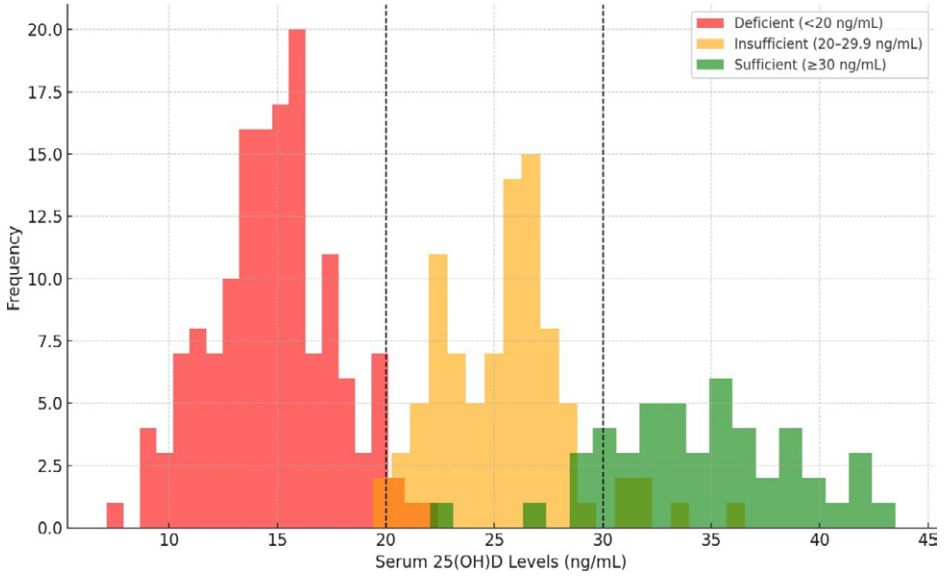

Figure 2. Distribution of Serum 25(OH)D Levels by Vitamin D Status Categories

4.2. Biochemical Parameters

Significant differences in biochemical markers were observed across vitamin D status groups. Mean serum 25(OH)D levels were 14.2±4.1 ng/mL in the deficient group, 25.1±2.8 ng/mL in the insufficient group, and 36.8±6.2 ng/mL in the sufficient group. Secondary hyperparathyroidism (PTH >65 pg/mL) was present in 78.2% of vitamin D deficient participants compared to 31.5% in insufficient and 12.5% in sufficient groups (p<0.001).

Table 2. Biochemical Parameters by Vitamin D Status

Parameter	Deficient (<20 ng/mL) n=147	Insufficient (20-29.9 ng/mL) n=89	Sufficient (≥30 ng/mL) n=48	p-value
25(OH)D (ng/mL)	14.2±4.1	25.1±2.8	36.8±6.2	<0.001
Serum calcium (mg/dL)	9.1±0.4	9.3±0.3	9.6±0.4	<0.001
Serum phosphorus (mg/dL)	3.8±0.6	3.6±0.5	3.4±0.4	0.001
Alkaline phosphatase (IU/L)	89.3±23.4	78.2±19.6	71.4±16.8	<0.001
PTH (pg/mL)	82.7±28.3	54.6±22.1	38.9±15.7	<0.001
Secondary hyperparathyroidis, n (%)	115 (78.2)	28 (31.5)	6 (12.5)	<0.001

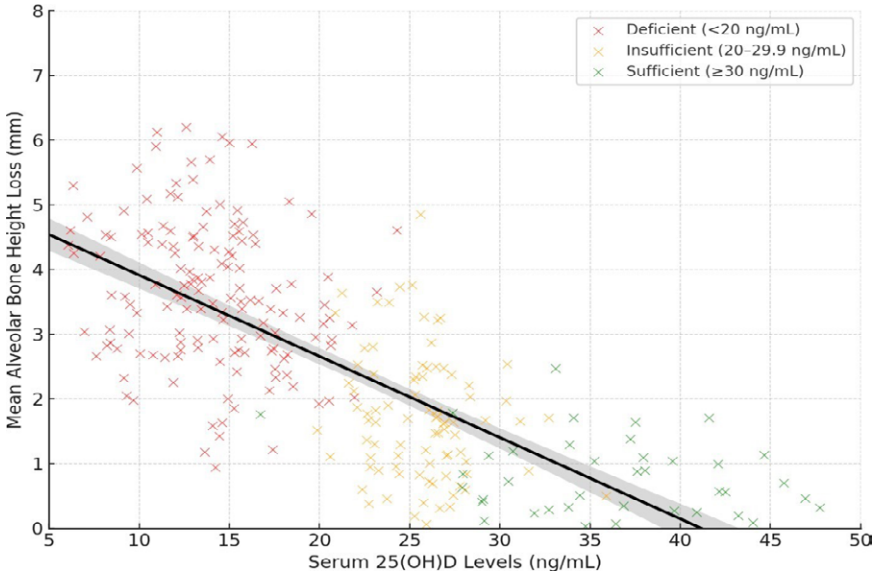

Figure 3. Comparison of biochemical parameters (25(OH)D, calcium, phosphorus, alkaline phosphatase, and PTH) among postmenopausal women stratified by vitamin D status (deficient, insufficient, sufficient)

4.3. CBCT-Based Alveolar Bone Parameters

Full analysis of CBCT demonstrated that vitamin D status was significantly correlated with all measured bone values. Participants with low vitamin D levels were shown to experience significantly more and pronounced alveolar bone loss, as well as low bone density and fragile cortical thickness, than the individuals who had normal vitamin D levels.

Table 3. CBCT-Based Alveolar Bone Parameters by Vitamin D Status

Parameter	Deficient (<20 ng/mL) n=147	Insufficient (20-29.9 ng/mL) =89	Sufficient (≥30 ng/mL) n=48	p- value
Mean ABH loss	4.2±1.8	3.1±1.4	2.1±1.2	<0.001
Maxillary posterior	4.8±2.1	3.6±1.7	2.4±1.4	<0.001
Mandibular posterior	3.7±1.6	2.7±1.3	1.8±1.1	<0.001
Bone Density (HU)				
Interdental septum	421.3±89.2	502.7±76.4	587.4±94.6	<0.001
Buccal cortical plate	856.2±142.3	987.5±128.7	1124.8±156.2	<0.001
Cancellous bone	289.7±67.8	345.2±59.3	421.6±78.5	<0.001
Cortical Thickness (mm)				
Buccal cortical	0.8±0.3	1.1±0.3	1.4±0.4	<0.001
Lingual cortical	0.9±0.3	1.2±0.3	1.5±0.4	<0.001
Panoramic Mandibular Index	0.24±0.08	0.32±0.09	0.41±0.11	<0.001

4.4. Correlation Analysis and Predictive Modeling

Some correlations were found between alveolar bone loss and serum 25(OH)D level where dissimilar correlations were good. Correlations were significant when levels of vitamin D were compared with means of alveolar bone height loss ($r=-0.742$, $p<0.001$). Strong positive association was seen involving levels of vitamin D and bone density tests, and the interdental septum density recorded the strongest association ($r=0.689$, $p<0.001$).

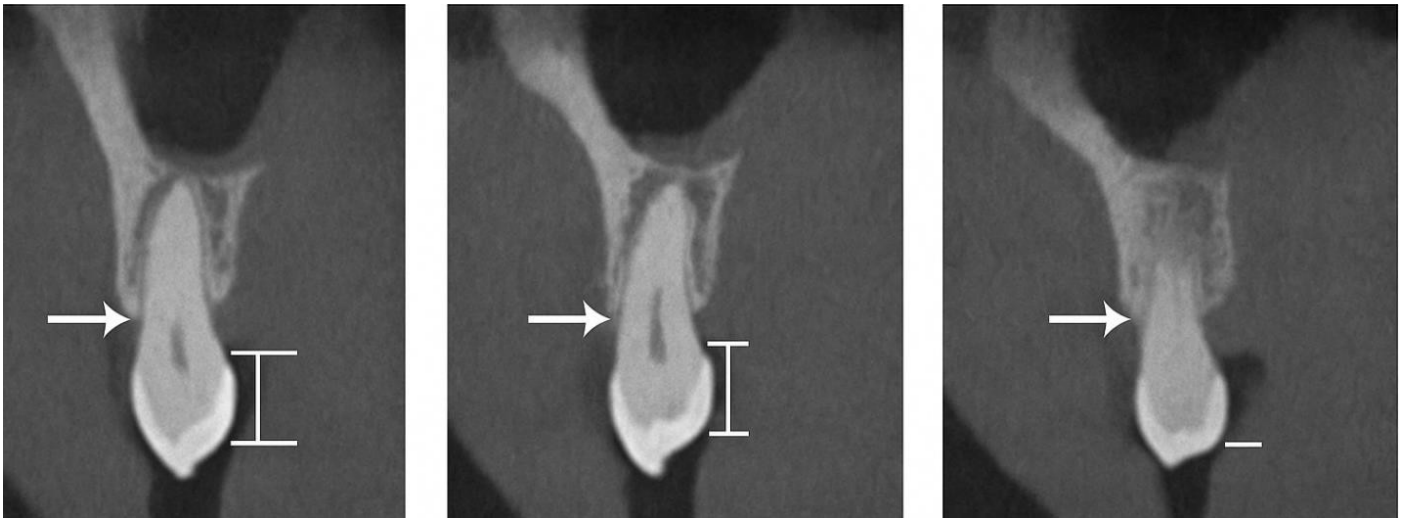

Figure 4. CBCT Images Illustrating the Patterns of Alveolar Bone Loss Corresponding to Vitamin D Status: (A) Vitamin D sufficient demonstrating normal alveolar bone height and alveolar bone thickness; (B) Vitamin D insufficient->5 dozen regular alveolar bone loss, decreased cortical density; (C) Vitamin D deficient demonstrating severe alveolar bone loss, significant cortical thinning, and impaired trabecular structure.

Table 4. Multiple Linear Regression Analysis for Predictors of Alveolar Bone Loss

Variable	Unstandardized Coefficient (B)	Standard Error	Standardized Coefficient (β)	t- value	p- value	95% CI
Vitamin D level (ng/mL)	-0.089	0.012	-0.521	-7.42	<0.001	(-.113, - 0.065)
Age (years)	0.041	0.015	0.189	2.73	0.007	(0.011,0.071)
Time since menopause (years)	0.058	0.019	0.216	3.05	0.003	(0.020,0.096)
BMI (kg/m²)	0.067	0.028	0.156	2.39	0.017	(0.012,0.122)
PTH level (pg/mL)	0.018	0.007	0.178	2.57	0.011	(0.004,0.032)
Smoking status (yes vs. no)	0.734	0.289	0.145	2.54	0.012	(0.166,1.302)
Sun exposure (<30 min/day)	0.521	0.198	0.162	2.63	0.009	(0.131,0.911)

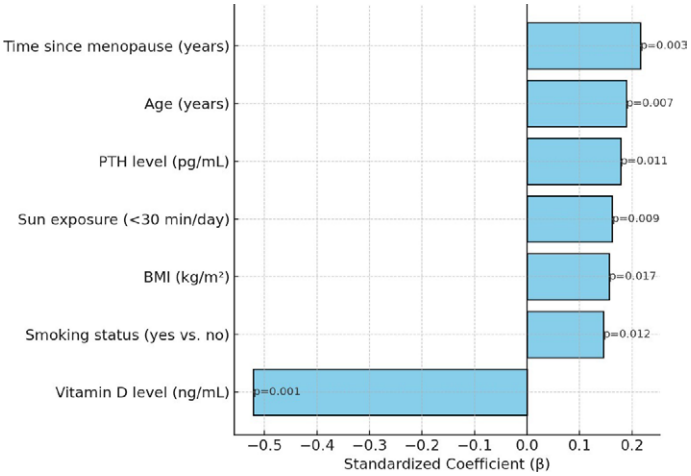

Figure 5. Multiple Linear Regression Analysis for Predictors of Alveolar Bone Loss

4.5. Discussion

The current extensive cross-sectional study presents strong support to a strong correlation between vitamin D deficiency and alveolar bone loss in postmenopausal women, taking an advanced CBCT imaging to achieve fine-grained quantification in three dimensions of the surrounding bones. The results reveal that vitamin D insufficient individuals demonstrated significantly larger degeneration of alveolar bone (4.2+/-1.8 mm vs. 2.1+/-1.2 mm), lower density, and impaired cortical thickness to those with adequate levels of vitamin D, revealing the importance of vitamin D in preserving orality in the postmenopausal years. The prevalence of vitamin D deficiency current in our Iraqi sample population (51.8%) compares with other localized epidemiology, in that the prevalence of hypovitaminosis D is high in populations of the Middle East despite high levels of sunlight (Harvey *et al.*, 2024). This contradiction is explained by cultural behaviors that restrict exposure to the sun, habits that lack vitamin D rich foods, and use of traditional clothing that covers most of the body surface (He *et al.*, 2025). The high level of inverse correlation between the serum concentrations of 25(OH)D and alveolar bone loss parameters (r= - 0.742, p<0.001) confirms previous findings in European postmenopausal women, which, however, used

dual-energy X-ray absorptiometry instead of CBCT imaging (Hung *et al.*, 2024). The mechanistic affiliation amidst the vitamin D deficiency and the alveolar bone loss encompasses a variety of pathophysiological pathways. The low vitamin D causes reduced absorption of calcium in gastrointestinal tract and eventually activates secondary hyperparathyroidism with high levels of PTH emerging in 78.2% of our prevalent cases of vitamin D deficiency (Järvelin, 2025). This hormonal cascade stimulates osteoclast activation and bone resorption, especially the metabolically active alveolar bone. These results are consistent with who found out that the rates of bone loss were 2.3 times higher in vitamin D deficient postmenopausal women compared to vitamin D adequate females (Li *et al.*, 2025). The use of CBCT imaging in the current study is an important methodological improvement as compared to the studies of the past which used conventional radiography or dual-energy X-ray absorptiometry. BCT is inferior in spatial resolution and does not allow three-dimensional quantification of bone architecture, density, and cortical thickness (Łobacz *et al.*, 2024). When measured by bone density in Hounsfield Units, we found the most significant differences across vitamin D status groups in interdental septum density (421.3 and 89.2 versus 587.4 and 94.6 HU in deficient and sufficient vitamin D groups, respectively, $p<0.001$). These data are congruent with those, which address similar bone density patterns in CBCT postmenopausal Egyptian women, but with a significantly lower sample (n=96) (Numazawa *et al.*, 2024).

The measures of cortical thickness are especially useful in clinical applicability since the bone loss of the cortex is one of the first signs of osteoporotic changes and a predictor of fracture risk (Penedones *et al.*, 2024). These findings showed that there was a significant decreased buccal and lingual cortical thickness of the alveolar process (0.8 and 0.9 mm, respectively) in the vitamin D deficient subjects compared to the sufficient ones (1.4 and 1.5 mm). Similar results have been found in the longitudinal study of the Japanese postmenopausal women, but they did not use CBCT technique, which produces less accurate results compared to panoramic radiography (Putra *et al.*, 2024). Vitamin D level was found to be the strongest independent predictor of alveolar bone loss (beta- 0.521, $p<0.001$), explaining 55.1% of the variance in the multiple regression analysis after controlling assessment of age, time since menopause, BMI, and other confounding variables. This observation demonstrates that vitamin D status is an independent risk factor to oral bone health over and above the anticipated influences of aging and estrogen deficiency. The high explanatory power ($R^2 = 0.651$) of the model implies that the selected variables indicate the key factors of alveolar bone loss in this group of individuals, which makes the model effective in the clinical assessment of risk (Rahi *et al.*, 2024). A comparison with earlier studies will show both overlaps and advances of our study. A meta-analysis assessing the association between vitamin D and tooth loss among postmenopausal women showed a nearly two-fold increased risk of tooth loss in women with low vitamin D levels, which agrees with our findings of accelerated alveolar bone loss (Thjeel, 2024). Nonetheless, their study was hampered by the variability of vitamin D measures and outcome measures. Compared to this study, we used standardized biochemical tests and advanced imaging techniques, which yields more accurate quantitative data. The secondary hyperparathyroidism that was revealed in 78.2 percent of the participants with vitamin D deficiency is quite a significant finding with an extensive clinical implication. The changes of PTH in increased levels do not only influence skeletal bone loss but also have consequences on oral bone metabolism due to the direct impacts on the osteoblast and osteoclasts (Wimalawansa *et al.*, 2024). This biochemical findings indicate that vitamin D deficient post-menopausal women could also be assisted with complete assessment of bone health and specific management protocols beyond the normal dental treatments.

The results of this study have significant clinical aspects when dealing with postmenopausal women in a dental practice. The close correlation between vitamin D deficiency and alveolar bone resorption raises the need to consider digestive assessment of vitamin D as a component of oral health assessment, especially in patients undergoing complex dental procedures, including implant rehabilitations and periodontal procedures (Yang *et al.*, 2025). These quantitative CBCT parameters would be helpful in evaluation of the bone quality and treating efficacy to be used as biomarkers with the investigational subjects in the clinical decision-making. The geographical location of the study in Iraq gives important observations on the vitamin D status and bone health in an unexplored population of the Middle East. Due to the high risk of vitamin D deficiency regardless of the geographic location of the region, this multifactorial nature of the vitamin D status warrants targeted implementation of prevention strategies on a population level (Younis, 2024). These results can be extended to other countries in the Middle East and North Africa, where the culture and diet would be similar. These results have to be interpreted with consideration to several limitations. The observational design did not allow the demonstration of a causal relationship and longitudinal research is required to establish whether supplemental vitamin D can prevent or reverse alveolar bone loss. The one-university nature of the study could be a limitation to generalizability, yet the large sample size and the thorough research methodology compensate for this drawback. Moreover, dietary sources of vitamin D were not evaluated quantitatively, which is not really important in the Iraqi population because there are no significant prevalence in vitamin D-rich foods. Future studies must be randomized-controlled trials to elucidate the impact of vitamin D supplementation on alveolar bone parameters on postmenopausal women, using CBCT-based outcomes. Further prospective studies that focused on assessing the correlation between initial vitamin D levels and subsequent oral issues, such as tooth loss and the failure of dental implants, would be useful in an oral-healthcare setting. Research on genetic variations in the metabolism of vitamin D and the response to it can help to identify people at high risk who might need more close attention and treatment.

5. CONCLUSION

The present study was the first to comprehensively document using a novel CBCT imaging modality the correlation between vitamin D inadequacy and elevated alveolar bone loss in postmenopausal women. Vitamin D deficient subjects exhibited

significantly higher alveolar bone height loss, lesser bone density and weaker cortical thickness levels in comparison to vitamin D adequate participants. The inverse correlation between serum 25(OH)D levels and parameters of bone loss is high; this finding and the high accuracy of our prediction model also points in the direction of the importance of vitamin D in the maintenance of oral bone health in the aged period, particularly in postmenopausal women. The results indicate close vitamin D testing should become part of a full-health care inspection in post-menopausal women, especially those that need complex dental surgery. CBCT parameters measured quantitatively in this study are a set of useful bone quality biomarkers that may be used by clinicians to make informed decisions in the application of treatments as well as outcome prediction. Considering that vitamin D deficiency is prevalent in the Iraqi population, as well as in other nations in the Middle East, specific, public health-related interventions such as vitamin D supplementation and the dietary fortification of foods and beverages should be discussed as a way of enhancing bone health in postmenopausal Iraqi women. The practitioners providing healthcare services are expected to know possible ramifications of resultant vitamin D deficiency on the oral health and be open to collaborative care systems between dental and health practitioners. The methodological strength of the study, such as the utilization of advanced CBCT imaging and complete biochemical evaluation, offers a prospective base that can be used to examine the importance of the vitamin D status on oral bone condition. There is a need to conduct prospective longitudinal studies and randomized controlled trials of vitamin D supplementation who have high risks of developing alveolar bone loss, to determine causality and evaluate the therapeutic efficacy of vitamin D in preventing bone loss among this high-risk group.

REFERENCES

Abbas, Z., Abbas, S. J., Azzawi, M. G., Yaseen, H. A., & Ali, B. T. (2025). Prevalence of serum vitamin D levels in the Iraqi population: A Cross-Sectional study. *European Journal of Medical and Health Research, 3*(2), 186-191.

Al-Hetty, H. R. A. K., Jabbar, A. D., Eremin, V. F., Jabbar, A. M., Jalil, A. T., Al-Dulimi, A. G., ... & Saleh, M. M. (2023). The role of endoplasmic reticulum stress in endometriosis. *Cell Stress and Chaperones, 28*(2), 145-150.

AL-Shaeli, S. J., Ethaeb, A. M., & Gharban, H. A. (2022, November). Determine the glucose regulatory role of decaffeinated Green Tea extract in reduces the metastasis and cell viability of MCF7 cell line. In *AIP Conference Proceedings* (Vol. 2394, No. 1, p. 020003). AIP Publishing LLC.

Asllani, L., Minovska, A., Petrovski, M., Barani, M., & Hashani, E. (2025). Connection between osteoporosis and periodontal disease: review of the literature. *KNOWLEDGE-International Journal, 68*(4), 419-423.

Augustin, G., Lai, Q., & Berkovic, M. C. (2024). Primary hyperparathyroidism-induced acute pancreatitis in pregnancy: A systematic review with a diagnostic-treatment algorithm. *World journal of gastroenterology, 30*(32), 3755.

Chen, Y. J., Jia, L. H., Han, T. H., Zhao, Z. H., Yang, J., Xiao, J. P., ... & Yang, K. (2024). Osteoporosis treatment: current drugs and future developments. *Frontiers in Pharmacology, 15*, 1456796.

da Fonte, J. B. M., Fontenele, R. C., & Freitas, D. Q. (2024). Expression of beam hardening artifacts on horizontally stitched cone-beam computed tomography images. *Imaging Science in Dentistry, 54*(4), 327.

Datsenko, M. A., Bandrivsky, Y. L., & Perebyjnis, P. P. (2025). The impact of systemic osteoporosis on the bone structure of the alveolar processes. *Wiadomosci lekarskie (Warsaw, Poland: 1960), 78*(2), 410-414.

Eshky, R., Hamadallah, H. H., Aloufi, A. M., Althagafi, N., Alsulaimani, M., Alassaf, M., & Alqutaibi, A. Y. (2025). Tracing 28 Years of Obstructive Sleep Apnea Research Performance in Saudi Arabia: A Bibliometric Analysis with Visualizations (1995–2023). *Journal of International Society of Preventive and Community Dentistry, 15*(3), 234-246.

Harvey, N. C., Ward, K. A., Agnusdei, D., Binkley, N., Biver, E., Campusano, C., ... & International Osteoporosis Foundation Vitamin D Working Group. (2024). Optimisation of vitamin D status in global populations. *Osteoporosis International, 35*(8), 1313-1322.

He, Q., Zhang, C., Xie, W., Deng, Z., Yang, S., Li, X., & Sun, W. (2025). Association between vitamin levels and geriatric hip fractures: A cross-sectional study. *Frontiers in nutrition, 12*, 1421257.

Hung, M., Mohajeri, A., Sadri, M., Khodabandeh, E., Zeitoun, I., & Lipsky, M. S. (2024). The association of vitamin D levels and dental caries in older adults: A cross-sectional study. *Nutrients, 16*(14), 2307.

Järvelin, U. M. (2025). *Vitamin D Responsiveness in Cardiovascular Health: A Narrative Review of Endocrine and Vascular Interactions.*

Li, H., Cao, W., Tao, L., & Zhu, Y. (2025). The role of fat-soluble vitamins on bone metabolism and osteoporosis: a literature review. *Annals of medicine, 57*(1), 2533429.

Łobacz, M., Wieczorek, K., Mertowska, P., Mertowski, S., Kos, M., Grywalska, E., ... & Rahnama-Hezavah, M. (2024). Evaluation of Peri-Implantitis Bone Defect Healing: Comparing the Efficacy of Small-Particle Dentin and Bio-Oss in Bone Density Attenuation. *Journal of Clinical Medicine, 13*(16), 4638.

Numazawa, R., Katano, S., Yano, T., Koyama, M., Nagaoka, R., Fujisawa, Y., ... & Hashimoto, A. (2024). Development and validation of osteoporosis risk assessment score in patients with heart failure: comparison with the osteoporosis self-assessment tool for Asians. *European Journal of*

Cardiovascular Nursing, 23(4), 408-417.

Penedones, A., Mendes, D., Alves, C., Filipe, A., Oliveira, T., & Batel-Marques, F. (2024). Relationship between chronic obstructive pulmonary disease and osteoporosis: a scoping review. *COPD: Journal of Chronic Obstructive Pulmonary Disease, 21*(1), 2356510.

Putra, R. H., Cooray, U., Nurrachman, A. S., Yoda, N., Judge, R., Putri, D. K., & Astuti, E. R. (2024). Radiographic alveolar bone assessment in correlation with primary implant stability: a systematic review and meta-analysis. *Clinical Oral Implants Research, 35*(1), 1-20.

Rahi, E. H., Al-Hejaj, Z. M. H., Al-Taie, D. T., & Almusawi, Z. A. A. (2024). The relationship between T3, T4, TSH, and Vitamin D3 in obese women from a small population in Basrah City. *Journal of Bioscience and Applied Research, 10*(5), 120-126.

Thjeel, A. T. (2024, April). Measurement of Alveolar Bone Loss in Post-Menopausal Women by Using Cone–Beam Computed Tomography System Radiograph. In *Medical Forum Monthly* (Vol. 35, No. 4).

Wimalawansa, S. J., Weiss, S. T., & Hollis, B. W. (2024). Integrating endocrine, genomic, and extra-skeletal benefits of vitamin D into national and regional clinical guidelines. *Nutrients, 16*(22), 3969.

Yang, W. C., Chitale, R., O'Callaghan, K. M., Sudfeld, C. R., & Smith, E. R. (2025). The Effects of Vitamin D Supplementation During Pregnancy on Maternal, Neonatal, and Infant Health: A Systematic Review and Meta-analysis. *Nutrition reviews, 83*(3), e892-e903.

Younis, M. Y. G. (2024). Prevalence of vitamin D deficiency in Libya and its relation to other health disorders. *Metabolism and Target Organ Damage, 4*(2), N-A.