ORIGINAL RESEARCH

Correlation of Serum Vitamin D with Crestal Bone Level in Dental Implant Patients Using CBCT: A Clinical Retrospective Study

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Abstract

Aim: The purpose of this study is to correlate the role of serum vitamin D levels associated with crestal bone in dental implant patients using cone-beam computed tomography (CBCT).

Materials and methods: This retrospective study enrolled patients among whom implants were placed after a detailed planning using CBCT and the delayed loading protocol was followed. After 3 months and 6 months of loading, CBCT evaluations were carried out, serum vitamin D levels were also tested at the end of 6 months of loading. A total of 30 patients were recruited with 15 patients in each group based on normal and deficient levels of vitamin D to correlate with crestal bone levels using CBCT.

Results: Clinically acceptable crestal bone loss (CBL) was visible with all the implants at different time intervals. Statistical analysis was done for intergroup and intragroup comparisons which showed significant *p*-value (< 0.05) for CBL at the time of loading, at 3 months, and at 6 months follow-up for both normal and deficient serum values. In the deficient group, the mean value at baseline was 9.69 mm ± 1.10 and the CBL at 6 months follow-up was 8.80 mm ± 1.10 whereas for the normal group at baseline, the mean was 9.08 mm ± 1.21 and at 6 months follow-up was 8.12 mm ± 1.25 which showed meaningful difference.

Conclusion: There is a positive correlation seen between CBL on CBCT and vitamin D serum levels. The success of the implant is significantly affected by vitamin D as it regulates the bone physiology and has systemic effects on accelerating bone formation around titanium implants.

Clinical significance: Vitamin D is essential in maintaining the balance of bone minerals and assists to preserve the crestal bone level making the implant treatment more predictable and successful.

Keywords: Crestal bone level, Dental implants, Vitamin D.

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Introduction

Comprehensive treatment planning preoperatively and close monitoring during the healing phase is essential for making implants successful in order to achieve osseointegration. One of the main factors affecting the success of implants postoperatively is crestal bone resorption.[1] Osseo-insufficiency suggests crestal bone loss (CBL) which affects the implant clinically and can lead to deformation of the soft tissue, compromised esthetics, bone deformation, and sometimes even removal of the implant.[2] Initial CBL leads to heightened bacterial build-up and secondary peri-implantitis, both of them can cause loss of bone support around the implant.[3] Albrektsson[4] suggested a criteria to analyze crestal bone levels, that is, mean CBL of 1.5 mm in the first functional year and 0.2 mm annually in subsequent years. Hence, the preservation of crestal bone is important to maintain the stability of the implant.

Vitamin D has been demonstrated to be essential for maintaining the balance of bone minerals by promoting intestinal absorption of phosphate and calcium. Vitamin D enhances the formation of extracellular matrix proteins and osteoblast activity in bone. Also, phosphorus and calcium combine to generate hydroxyapatite crystals, which mineralize and strengthen bones.[5] Vitamin D deficiency likewise negatively influences bone regeneration, including fracture healing and also osseointegration of implants. Hence, Vitamin D supplementation is an effective treatment for reduced peri-implant bone formation because it directly counteracts the catabolic mechanisms of Vitamin D deficiency. Inadequate dietary intake and insufficient sun exposure can both contribute to vitamin D insufficiency that further can cause poor formation of bone around dental implants leading to crestal bone loss. Supplemental cholecalciferol (Vitamin D3) is believed to improve bone density.[6]

There has been evidence in the literature comparing bone loss in vitamin D deficient patients using periapical radiographs but not with the detailed cross-sectional images by a cone-beam computed tomography (CBCT) which shows 3D volumetric changes. High sensitivity up to 80–100% in the detection of bone defects, less distortion and overlapping, dimensions are all compatible with the actual size. CBCT is significantly more accurate and reliable than two-dimensional conventional imaging techniques for assessing

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the height of the alveolar bone crest. This helps us to assess it with more precision.[7]

The purpose of this study is to correlate the serum vitamin D levels associated with crestal bone in dental implant patients by using CBCT. The null hypothesis of this study is that there is no correlation between serum levels of vitamin D with crestal bone level in dental implant patients.

Materials and Methods

Institutional ethical committee (MRDC/IEC/2020/12) approved the study as per the principles of the declaration of Helsinki regarding human subjects. This study was conducted from October 2021 to October 2022 and utilized a retrospective clinical record that helped in assessing information about the patients who were formerly treated with dental implants.

Inclusion Criteria

- The patients included in the study were adult patients with ages ranging from 25 years to 45 years.
- Patients were selected irrespective of sex, caste, religion, or socioeconomic status.
- Patients with one missing tooth in mandibular posterior region who did not require the use of bone grafts during implant placement.
- Patients who were treated with endosseous implants of variable length and diameter (Neodent Grand Morse, Straumann) followed conventional surgical protocol with delayed loading.
- Patients with bone density values of 850–1250 HU.
- Patients with detailed CBCT analysis at the time of loading, at the end of 3 months and 6 months of post-loading.

Exclusion Criteria

- Patients having a known history of bone disorders and with insufficient inter-arch space to accommodate the prosthetic component were excluded from the study.
- Patients who were not willing to participate in terms of serological and radiological evaluation were also excluded from the study.

Serological examinations pertaining to the level of vitamin D were carried out at the end of 6 months follow-up. According to the levels of vitamin D, the subjects were divided into two groups with normal and deficient levels. Adjusting the power of the study to be 80% and confidence interval of 95% was taken, a total of 30 subjects were recruited with 15 patients in each group based on normal and deficient levels of vitamin D.

Standardized protocol for measuring the CBCT (Genoray, Papaya 3D) was followed using the Genoray Dental Software Triana. The CBCT machine had a minimal radiation time of 7.7 seconds with low voltage and voxel size of 0.075 mm. The coronal plane was nearly always drawn in the same location in each subsequent CBCT when using curved slicing because it was represented by a line drawn in a path that passes through the center of the implant placed in bone in order to construct the dental arch. Each time the CBCT images were superimposed to the baseline image. A permanent reference line was drawn parallel to the apical tip of the implant and perpendicular to the horizontal tangent in order to ensure that measurements were taken precisely in the same location on every subsequent CBCT (Fig. 1). The crestal bone level around each implant was measured at the highest level of bone

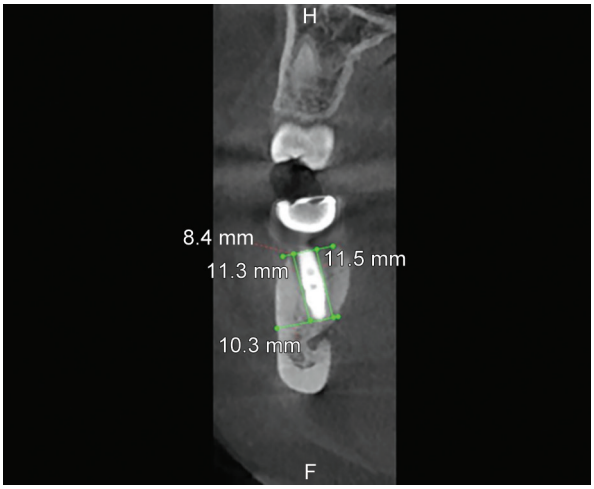
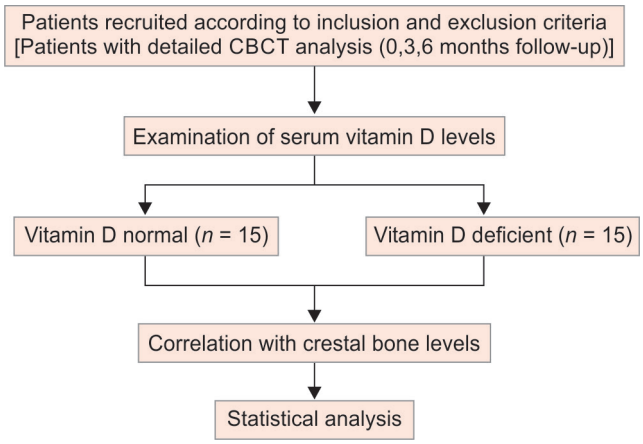


Fig. 1: Measurement of CBL using CBCT section

Flowchart 1: Outline of the study design



on the buccal and lingual sides of each implant at intervals of time which is during loading and at 3 and 6 months follow-up. After getting the measurements from the software, the difference was seen in each CBCT.

Statistical analysis was done for the result to evaluate the difference in bone loss after loading derived from CBCT and also to compare the vitamin D, Ca, and phosphorus levels in blood after the implant placement. Data analysis was performed using SPSS (statistical package for social sciences) version 25.0 and MedCalc software. The Shapiro-Wilk test was used for testing the normality of the data. The *p*-value was kept at 0.05 ($p < 0.05$) and confidence interval at 95% (Flowchart 1).

Results

The distribution of the study population and comparison of CBL according to normal and deficient serum levels are seen in Table 1.

The mean CBCT at loading time, 3 months, and 6 months was compared between deficient and normal vitamin D levels using the unpaired *t*-test.

The intragroup comparison of CBL at different time intervals for normal and deficient serum levels of mean CBCT was done using the post hoc Bonferroni test. The mean difference in CBCT score

Table 1: Distribution of study population and comparison of CBL according to normal and deficient serum levels

	Deficient Vitamin D		*Normal Vitamin D*				
CBCT	*Mean*	*Std. Deviation*	*Mean*	*Std. Deviation*	*Mean difference*	*t-test value*	*p-value*
At loading time	9.69	1.10	9.08	1.21	0.61	2.500	0.046
3 months	9.19	1.12	8.62	1.23	0.57	2.203	0.048
6 months	8.80	1.10	8.12	1.25	0.68	–0.747	0.035

Table 2: Intragroup comparison of CBL at different time intervals for normal and deficient serum levels

		Deficient vitamin D	*Normal vitamin D*	
CBCT		*Mean difference*	*Mean difference*	*p-value*
At loading time	3 months	0.50	0.21	0.001*
At loading time	6 months	0.89	0.36	0.001*
3 months	6 months	0.39	0.15	0.001*

*Significant *p*-value

decreased significantly from loading time to 3 months to 6 months as seen in Table 2.

Discussion

For longevity of implant treatment through diagnosis, systemic health, meticulous planning and implementation of the treatment plan is important to avoid certain complications such as inadequate osseointegration and periimplantitis. Only a few clinical research have examined how vitamin D deficiency affects osseointegration and bone regeneration by CBCT up to this point in the dental literature. Only a small portion of them is investigated clinically, the majority are animal-based studies.[8]

The present study helped us in understanding the levels of vitamin D that play a major role in the success of the implant as it regulates the bone physiology which leads to better osseointegration and crestal bone preservation. A significant correlation was seen between serum vitamin D3 and crestal bone levels. Hence, the null hypothesis for this study is rejected.

According to Atwood,[9] there are four main factors that are responsible for bone loss, that is, (a) anatomic factors, (b) prosthetic factors, (c) metabolic and systemic factors, like vitamin D deficiency, (d) periodontal disease, and (e) post-menopausal women. In the present study, CBL has shown a minimal gradual decrease for both serum deficient and serum normal levels after loading and the follow-ups. In comparison, there was more mean difference seen in the those with deficient levels compared with normal levels of vitamin D, calcium, and phosphorus.

Bone remodeling activities around dental implants may be reduced by a deficiency of vitamin D which may also increase the healing period until osseointegration takes place. It affects the crestal bone resorption which eventually risks the success of the implant. Therefore, based on the findings of our investigation, we can imply that early osseointegration, crestal bone preservation, and bone formation may need vitamin D-dependent regulatory systems.[10]

Intergroup comparison was done between deficient and normal vitamin D groups at different time intervals. Significant results were obtained (p-value > 0.05). The mean for the normal group at the time of loading was 9.08 ± 1.21 and at 6 months follow-up was 8.12 ± 1.25 which shows gradual bone loss. The mean for the deficient group at the time of loading was 9.69 ± 1.10 and at 6 months follow-up it was 8.80 ± 1.10 with which we can infer that there was a drastic decrease in the bone level compared with normal group. The mean difference at 3 months follow-up was 0.57 and 0.68 at the 6 months follow-up which shows the increase in bone loss in 3 months. On intragroup comparisons for normal vitamin D levels, the mean difference of bone loss at the time of loading and at 3 months was 0.21 and after 6 months was 0.36, whereas for the deficient group, the bone loss was 0.36 and 0.89, respectively. We can infer that there is more bone loss seen for deficient vitamin D levels comparatively.

Garg P et al.[11] performed a comparative study to assess the level of crestal bone in patients who had low vitamin D levels, either with or without supplements treated with dental implants. They came to the conclusion that vitamin D supplementation significantly improves the osseointegration of implants. This study is in agreement with our study as vitamin D deficient subjects show more bone loss compared with those with supplements.

The findings of our investigation were consistent with research done by Kwiatek J et al.[12] wherein they did a randomized controlled clinical trial to determine the impact of vitamin D deficiency treatment and 25-hydroxycholecalciferol levels on changes in the bone level at the implant site during the osseointegration process in the mandible. According to the study, the greater amount of 25-hydroxycholecalciferol found on the day of surgery, the greater was the level of bone found surrounding the implant 6 and 12 weeks later.

Piccolotto A[13] in his study evaluated patients with implant-supported prostheses clinically and radiographically to determine whether low vitamin D levels have an impact on their peri-implant health which includes probing depth, bleeding crest, plaque index, distance from implant to bone crest. The clinical and radiographic findings of this investigation imply that supplementing with vitamin D for individuals with insufficient serum levels has no adverse effects on the health of the surrounding tissue around the implant. This study is not in consensus with the present study as the serum levels showed differences in the distance from implant to bone crest at different times after loading.

There have been studies done in the past comparing CBL mainly by using panoramic digital radiographs. The disadvantage of using panoramic imaging is two-dimensional view which is overcome by using CBCT which provides three-dimensional view. Cone-beam computed tomography is the best modality for the ease of acquisition and relatively low radiation risk even for single implants. It is proven to supply uniform images and is accepted to be reliable for performing analytic measurements. Akdeniz BG[14] did a study to compare the computed tomography (CT) and panoramic radiography measurements of the bone height and bone density at implant recipient sites. The investigation showed that the values

of bone height obtained using the two radiography techniques differed significantly. Data showed that as compared with CT, panoramic radiography greatly underestimated bone height.

Naje AR et al.[15] did a study in animals to contrast the diagnostic capabilities and practical benefits of cone beam and panoramic computed tomography imaging systems in identifying mechanically simulated flaws around various-sized dental implants. Through their research, they came to the conclusion that CBCT performed noticeably better than a panoramic radiograph in identifying circumferential peri-implant bone defects.

Dave et al.[16] evaluated the diagnostic efficacy of conventional peri-apical radiography vs that of CBCT in detecting peri-implant bone abnormalities in in vitro research. According to the authors, CBCT offers more precise and useable information regarding bone in all dimensions surrounding implants than other imaging techniques.

The current study has made it clear that dietary intake like vitamin D is crucial to the effectiveness of implants because it affects bone physiology, promoting improved osseointegration and the maintenance of crestal bone. The limitations of this study are that long-term follow-up is required for a better understanding of the physiology and behavior of CBL around dental implants. The study was done based on two-piece implants whereas in other methods like one-piece implants, submerged and non-submerged implant, and immediate loading were not mentioned. Other metabolic factors can also be incorporated like salivary biomarkers which were not followed.

Hence, clinical studies pertaining to the above criteria can be carried out for better understanding and clinical implication of the various effects of different micronutrients such as Vitamin D on CBL.

Conclusion

The inferences which have been drawn based on the findings of this clinical study are serum vitamin D levels were found to have a significant impact on the crestal bone levels in dental implant patients. There was a significant difference in the mean bone level changes at the time of loading, 3 months follow-up and at 6 months follow-up for patients with deficient values of serum vitamin D compared with normal serum vitamin D levels. Vitamin D has a systemic effect on accelerating the formation of bone around dental implants.

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