

## Original Article

# INFLUENCE OF VITAMIN D STATUS ON OSSEOINTEGRATION AND IMPLANT OUTCOMES

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## ABSTRACT

**Objectives:** Lack of vitamin D can reduce the bone density around the implant which will increase the rate of early implant failure by 300%. Acceptable level of vit. D is very important for proper healing of the patient especially after placing the implant.

**Materials and Methods:** This clinical study was carried out in the department of Oral and Maxillofacial Surgery, Altamash Institute of Dental Medicine, Karachi on thirty healthy individuals with age between 25 to 45 years, who needed only one dental implant. The patients were classified into group I (>30ng/ml) and group II (<20 ng/ml) on the basis of serum vitamin D level. The implant stability (ISQ) was determined at the start than 3 months and 6 months intervals by resonance frequency analysis. Crestal bone level and peri-implant bone density was estimated by CBCT scanning.

**Results:** Both groups showed improvements in terms of implant stability during the course of the study period, but vitamin D-sufficient subjects showed higher ISQ values and better crestal bone support and bone density round implants compared to vitamin D-deficient subjects. The observed differences were statistically significant ( $p < 0.05$ ).

**Conclusion:** Sufficient levels of vit. D affect osseointegration & success rates of implants in a positive way.

**Key words:** Bone Loss, Dental Implants, Implant Stability, Osseointegration, Vit. D

**Cite as:** Shah SU, Shabbir M, Khan T, Haroon AM, Daniyal RM, Memon MI. Influence of Vitamin D Status on Osseointegration and Implant Outcomes. Journal of Khyber College of Dentistry Sep 2026, Vol. 16, No. 3. <http://doi.org/10.33279/jkcd.v16i03.1021>

## INTRODUCTION

Dental implants constitute a very viable method in restorative dentistry, offering secure and aesthetically pleasing tooth replacements with high rates of success at around 95 percent. However, failure owing to inadequate osseointegration remains a source of

worry. Osseointegration refers to the process of formation of a biological bond among live bone tissue and the implant, being essential for the sustainability of dental implants. Recent research suggests that the health of the body plays a considerable role in osseointegration, and especially the significance of Vitamin D as a vital mineral<sup>1</sup>.

The process of osseointegration involves a working ankylosis in which BIC occurs through the fusion of newly formed bone with the foreign substance. Vitamin D is known to affect bone growth and lack of it is associated with diseases such as periodontitis, loss of teeth and poor wound healing. It stimulates absorption of calcium and phosphate from

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Date Submitted: March 2026

Date Revised: June 2026

Date Accepted: July 2026

the intestines<sup>2</sup>. Vit. D plays a crucial part in dental implant osseointegration by influencing immune modulation and bone metabolism. While historically, the focus has been on implant materials, design, and surgical techniques to enhance success rates, the direct bone-to-implant interface is vital for implant stability and longevity. This method is affected by both local factors, including surgical methods and implant characteristics, as well as systemic factors like the hosts bone quality immunological response, and overall health<sup>3</sup>. A higher incidence of delayed union is linked to vitamin D insufficiency during trauma, according to human research. Furthermore, even though the significance of VDRs in inter-organ interaction involving skeletal, neurological, & bone marrow organs has been extensively explored, more research is needed<sup>4</sup>.

Studies indicate that vitamin D3 deficiency prevalence ranges from 20% to 90% in the Middle East, Europe, and the USA, affecting both developed and developing nations. A substantial body of research links vitamin D3 insufficiency to autoimmune diseases, diabetes, cardiovascular, and renal disorders. Recent evidence suggests that this deficiency may also negatively impact mineral metabolism in young and middle-aged individuals previously not considered at risk for osteoporosis<sup>5</sup>.

Society recognition of vitamin D has significantly raised due to the global frequency of vitamin D deficiency (VDD), which is concerning for general health, particularly regarding children, pregnancy, cancer risk, and infection prevention<sup>6-9</sup>.

The presence of Vit. D is crucial for maintaining not only for keeping the bone healthy but also for the restoration of the tissue after the dental implant procedure. Although further studies need to be conducted to establish how effective this vitamin can be, the use of Vit. D in patients deficient in this nutrient can help implants work better. Also, some patient-related factors, such as smoking and poorly controlled diabetes, have already been identified as contributing to the implant failure and recently the lack of Vit. D has been added to the list.

## MATERIALS AND METHODS

**Study Design and Setting:** Randomized controlled clinical trial carried out by the researcher at the Department of Oral and Maxillofacial Surgery,

Altamash Institute of Dental Medicine, Karachi. Ethical approval and informed consent were obtained.

**Participants and Sample Selection:** 30 systemically healthy patients aged 25-45 years requiring single dental implants were enrolled. Serum 25(OH) D was measured using chemiluminescence immunoassay; >30 ng/mL classified as normal (Group 1) and <20 ng/mL as deficient (Group 2).

### Sample Size Calculation

The sample size was calculated using G\*Power software. The calculation was based on the primary outcome, implant stability quotient (ISQ), comparing two independent groups. A two-tailed test with a significance level ( $\alpha$ ) of 0.05, statistical power of 80%, and an allocation ratio of 1:1 was used. Based on the assumed effect size, the required sample size was 30 participants, with 15 participants allocated to each group.

### Inclusion Criteria:

- Age 25- 45 years
- Adequate bone volume for implant placement
- Good oral hygiene
- Non-smokers;
- Consented to participate.

### Exclusion Criteria:

- Uncontrolled systemic disease (e.g., diabetes, osteoporosis)
- Current corticosteroid or bisphosphonate therapy
- Pregnancy or lactation
- Recent bone graft at implant site
- Chronic local infection.

**Implant Procedure:** Standard two-stage protocol with implants placed under local anesthesia following manufacturer torque guidelines. Postoperative antibiotics and chlorhexidine were prescribed. Prosthetic loading after uncovering at 3 months.

**Outcome Measures:** Primary outcome: Implant stability (ISQ) via resonance frequency analysis at baseline, 3 and 6 months. Crestal bone level and bone density measured on CBCT

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Statistical Analysis: Data were processed by the means of SPSS v. 25.0. Continuous variables such as ISQ, crestal bone level, and peri-implant bone density were presented in the form of mean  $\pm$  standard deviation (SD). The normality of distribution of data was tested prior to analysis.

To evaluate changes over time and differences between the two groups, repeated measures ANOVA was applied. When statistically significant differences were detected, post-hoc Tukey tests were performed to identify specific cluster changes. A p-value  $< 0.05$  was considered statistically significant.

### RESULT

Results from ANOVA indicated significant improvement in implant stability over time in both groups ( $p < 0.001$ ). Intergroup comparison revealed significantly higher ISQ scores in the vitamin D sufficient group after both three and six months ( $p = 0.018$ ).

Repeated measures ANOVA indicated significant crestal bone loss over time for both groups ( $p < 0.05$ ). Notably, the vitamin D deficient group experienced greater bone loss at three and six months, with a significant difference involving clusters ( $p = 0.032$ ).

The statistical analysis indicated that vitamin D status significantly influences peri-implant healing and osseointegration. Patients with adequate vit. D levels demonstrated:

Higher implant stability values

Greater increase in peri-implant bone density

Less crestal bone loss

These differences were statistically significant ( $p < 0.05$ ).

### DISCUSSION

The study describes an important association

**Table 1: Implant stability was considered utilizing resonance frequency analysis (ISQ) at baseline, three and six months.**

| Time Interval | Group I ( $>30$ ng/mL) | Group II ( $<20$ ng/mL) |
|---------------|------------------------|-------------------------|
| Baseline      | $65.2 \pm 3.8$         | $63.4 \pm 4.1$          |
| 3 Months      | $71.6 \pm 3.2$         | $67.8 \pm 3.9$          |
| 6 Months      | $75.9 \pm 2.7$         | $71.3 \pm 3.4$          |

between the levels of vit. D levels and peri-implant bone healing outcomes. Patients having adequate level of vit. D demonstrated an increase rate of implant stability (high ISQ value) during a period of 6 months when compared to patients with low levels of Vit. D, indicating the importance of Vit. D in promoting the bone remodeling. There was a decrease in crestal bone in both the groups, however, the group with low level of Vit. D lost more bone level, showing the protective effect of Vit. D on bone level maintenance. In this regard, it is important to highlight the possible effects of proper pre-implant vitamin D status to improve healing processes and results. Regarding vitamin D supplementation, one may refer to such research works as by Flanagan et al<sup>10</sup> and Fretwurst<sup>11</sup> where positive results are obtained, showing the worth of regulating the level of Vit. D to achieve good implant results. It should be noted that different techniques of Vit. D supplementation were used in the mentioned articles. According to Kwiatek et al<sup>12</sup>, the level of Vit. D increased to 33.1 ng/mL from 23.9 ng/mL in 12 weeks after surgery. Additionally, Flanagan et al<sup>10</sup> employed Vit. D3 supplements together with other treatments. Thus, one patient in the study by Fretwurst et al<sup>11</sup> had a considerable improvement in his Vit. D levels which reached to 46  $\mu$ g/L.

The studies<sup>13,14</sup> on vitamin D supplementation's effect on osseointegration in diabetic rats found no significant differences in bone-implant contact (BIC) and new bone production involving supplemented and non-supplemented groups. However, when vitamin D and insulin were co-administered, the treated diabetic rats showed significantly higher BIC and bone area (BA) compared to untreated rats, similar

**Table 2: Crestal bone level was evaluated using CBCT scans at baseline, six months, and three months.**

| Time Interval | Group I            | Group II           |
|---------------|--------------------|--------------------|
| Baseline      | 0 mm               | 0 mm               |
| 3 Months      | $0.36 \pm 0.18$ mm | $0.58 \pm 0.22$ mm |
| 6 Months      | $0.71 \pm 0.24$ mm | $1.08 \pm 0.31$ mm |

**Table 3: Peri-implant bone density was assessed using CBCT grey scale values (HU equivalent).**

| Time Interval | Group I      | Group II     |
|---------------|--------------|--------------|
| Baseline      | $712 \pm 85$ | $684 \pm 92$ |
| 3 Months      | $768 \pm 88$ | $715 \pm 90$ |
| 6 Months      | $826 \pm 90$ | $741 \pm 87$ |

to healthy controls according to Natri L et al<sup>15,16</sup>. Vitamin D improves resistance to bacterial infections and aids healing around dental implants, promoting secondary stability. However, some studies, including those by Alsulaimani L. et al<sup>17</sup>, found no clear link to vitamin D levels, suggesting other factors like smoking and poor bone restoration contribute to early implant loss.

Implant failures in two clinical cases have been found to occur due to the presence of vit. D deficiency in three patients. Paz et al<sup>1</sup> reported an increased risk of early implant rejection in patients with low serum vitamin D3 levels. Studies conducted on human subjects have shown that sufficient concentration of vit. D is correlated with improved rate of osseointegration of dental implants<sup>18</sup>. The presence of sufficient amounts of vit. D is required for proper osseointegration because of case studies by Sundar et al<sup>18</sup> and Flanagan et al<sup>19</sup> on the primary catastrophe of implants in vit. D deficient individuals that resolved after treatment. According to Burt et al<sup>20</sup> individuals with low serum levels of vit. D are at threat of primary failure of dental implants but vitamin D supplementation promotes bone development.

## LIMITATION

Our study's limitation was that it was limited to a specific geographic area and only included patients who reported to a certain hospital.

## CONCLUSION

Within the limitations of this study, it is clear that the status of Vit. D affects the healing of implant and the peri-implant bone response. Patients with sufficient Vit. D levels showed more stable implants, increased bone density, and less crestal bone loss than those with inadequate vitamin D. Based on these results, the assessment of Vit. D levels before the insertion of implant may contribute to improved clinical outcomes.

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### CONFLICT OF INTEREST

Authors declare no conflict of interest.

### GRANT SUPPORT AND FINANCIAL DISCLOSURE

None declared.

### AUTHORS' CONTRIBUTION

The following authors have made substantial contributions to the manuscript as under:

Conception or Design: SUS, MS, TK, AMH, RMD, MIM

Acquisition, Analysis or Interpretation of Data: SUS, MS, TK, AMH, RMD, MIM

Manuscript Writing & Approval: SUS, MS, TK, AMH, RMD, MIM

All the authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.



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