

Effect of Vitamin D in Dental Implants Osseointegration – A Randomized Controlled Trial

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Abstract

Objective: To assess the impact of vitamin D supplementation on osseointegration success rates in dental implant patients at a tertiary care hospital.

Methods: The randomized control trial included patients aged 18 to 45 years, either gender with Vitamin D insufficiency undergoing dental implant procedures and had vitamin D insufficiency. Exclusion criteria was prior bone regenerative therapy, arthritis, periodontal disease, bleeding disorders, poor oral hygiene, uncontrolled hypertension and diabetes mellitus, severe vitamin D deficiency, chronic renal disease, use of proton pump inhibitors, pregnant women. This was a and patients were enrolled via non probability consecutive sampling. Participants were equally divided into two groups: Group A received a daily oral intake of 5000 IU Vitamin D3 for 12 weeks, while Group B received a placebo (vitamin E 400mg). Osseo-integration was evaluated at three months using radiographic and clinical assessments with Ostell (ISQ). Additionally, serum Vitamin D levels were measured pre-operatively and post-operatively at 3 months interval post implant placement. Data analysis was performed using SPSS version 23.00.

Results: The median ISQ at three months was notably higher in Group A (Vitamin D supplement) compared to Group B (placebo), with values of 71 vs 65 ISQ ($p=0.001$). Moreover, the median Vitamin D levels at three months were significantly elevated in Group A compared to Group B ($p=0.001$). The mean age of the study sample was 33.71 ± 7.84 years. The study found that vitamin D levels were significantly higher in Group A compared with Group B at three months ($p=0.001$) that suggesting that the supplementation was effective in elevating Vitamin D levels.

Conclusion: The study concludes that Vitamin D supplementation significantly improves osseointegration of dental implants. It emphasizes the importance of targeted vitamin D supplementation in optimizing implant success.

Keywords: Dental implants, implantation, ISQ value, Osseo-integration, Vitamin D deficiency, Vitamin D supplementation.

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Introduction

Dental implants have evolved into a crucial and secure therapeutic option for restoring the function and aesthetics of fully or partially edentulous patients^{1,2}.

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Demonstrating predictability with long-term success rates reaching up to 95%, dental implants serve as an effective solution for rehabilitating damaged teeth through various fixed and removable dental prostheses³⁻⁶.

The success of dental implants hinges on the intricate process of osseo-integration, establishing a direct and functional connection between the implant surface and vital bone tissue under functional loads⁷. The masticatory system, responsible for essential functions such as swallowing, chewing, and speaking, is a focal point in modern dentistry⁸. Titanium, owing to its biocompatible surface, is the material of choice for intra-osseous implants, fostering attachment of surrounding bone tissue.

Osseo-integration unfolds in three distinct phases: wound healing, implant integration in bone, and stabilization of implants under functional loads with prosthetic reconstruction (Figure 1). Traditionally, assessing implant stability relied on methods such as the Lekholm & Zarb jaw quality scale and Periotest, with limited precision. The Osstell method, utilizing resonance frequency analysis (RFA), emerged as a non-invasive and reliable approach to measuring implant stability, contributing to the understanding of Osseo-integration dynamics⁹.

While dental implant survival rates are generally high, the inevitability of implant failures, categorized as early and late, poses challenges. Late failures often stem from implant overload and periimplantitis, while early failures are linked to insufficient surgical techniques, poor bone quality, or quantity at the recipient site. However, the literature overlooks certain factors crucial in early dental implant failures, such as vitamin D deficiency¹⁰.

This study aims to fill this gap by examining the role of vitamin D supplementation in dental implant Osseo-integration, generating local data relevant to the Pakistani population's unique environmental and dietary factors.

The corresponding research hypotheses was formulated as follows: H0 posts no difference in implant Osseo-integration between patients receiving vitamin D supplements and those without, while Ha suggests a significant difference in implant Osseo-integration between the two groups. Patients with severe vitamin D deficiency had the highest implant loss rate (11.1%), especially when risk factors like smoking and periodontal disease were added. Dental implantation is a new technique for the single or more missing tooth replacement. Dental professionals might utilize the findings of this investigation to generate local data and learn more about how vitamin D affects bone metabolism and implant osseo-integration. The long-term success of dental implants would also be enhanced and preserved with the right medical use of vitamin D.

The study's significance lies in its potential to provide valuable insights for dental professionals, offering local data on how vitamin D influences bone metabolism and implant Osseo-integration. The outcomes could contribute to optimizing the medical application of vitamin D, thereby enhancing the long-term success and preservation of dental implants. The objective of the study was to assess the impact of vitamin D supplementation on osseointegration success rates in dental implant patients at a tertiary care hospital.

Methodology

The study was conducted at the Oral and Maxillofacial Surgery Department, providing a tertiary care setting for dental implant procedures. The study was approved by the Ethical Review Committee, Reference No:4381021ABOS. The target population included subject's aged 18 to 45 undergoing dental implants. Inclusion criteria was patients aged 18 to 45 years, either gender, undergoing dental implantation, and had vitamin D insufficiency. Exclusion criteria was prior bone regenerative therapy, arthritis, periodontal disease, bleeding disorders, poor oral hygiene, uncontrolled hypertension and diabetes mellitus, severe vitamin D deficiency, chronic renal disease, use of proton pump inhibitors, pregnant women. A sample size of 50 patients in each group was determined using OpenEpi sample size calculator, considering early implant failure statistics and applying a 25% inflation to enhance statistical robustness. In this randomized controlled trial (RCT no: NCT06274216) the participants were selected through a simple random sampling method. Patient were randomized on the basis of even and odd numbers. Group A (even numbered) received Vitamin D supplementation and Group B (odd- numbered) were given placebo. The study duration is 1 year after synopsis approval. The both groups were compared for the difference of osseointegration at 3 months, as well as difference of osseo-integration were compared with respect to implant site (maxilla and mandible). Additionally, change in vitamin D levels were also assessed pre-operatively and post-operatively at 3 months

Written informed consent was obtained from eligible participants after explaining the study's objectives, risks, and benefits. Baseline information, including age, gender, weight, height, BMI, smoking status, sun exposure, and employment, was collected through a predesigned questionnaire.

Blood tests were conducted pre-operatively to assess vitamin D levels. Implant details, including anatomical position and implant site, were documented. After implant placement, patients were assigned to Group A (received 5000 IU of vitamin D3 daily for 12 weeks, Orally) or Group B (received placebo). Osseo-integration was evaluated radiographically and clinically using Osstell at three months' interval.

Local anesthesia was administered, and implant placement followed a two-staged surgery protocol. Antibiotics and analgesics were prescribed post-operatively, and patients received thorough instructions for oral hygiene maintenance. Patients will be followed at 3 months.

SPSS version 23 was used for data analysis. Mean and SD were computed for quantitative variables, while frequency and percentage were calculated for categorical variables. Statistical tests such as Mann-Whitney and Wilcoxon Signed Rank tests were employed to assess differences in ISQ values and vitamin D level changes, respectively over a period of 3 months. The significance level was set at $p \geq 0.05$

Results

The mean age and BMI of study sample was 33.71 ± 7.84 years and 24.95 ± 3.99 Kg/m². Of 100 patients, 59 were males and 41 were females. In group A, 66% were males, while in group B 52% were males. In group A, 97.9% were indoor and in group B 93.8% were indoor workers, respectively. In group A, 84% had inadequate sun-exposure and in group 92% had inadequate sun-exposure, respectively. Overall, majority of the patients were non-smokers. In group A, 26% were smokers and in group B, 28% were smokers, respectively. Out of 100 patients, most of the patients had posterior site of implant (76%). Group-wise statistics are display-

ed in (Table 1)

Table 1. Group-wise descriptive statistics of baseline characteristics

| | Group A with supplement) | Group B without supplement | Overall |
|--------------------------|--------------------------|----------------------------|--------------|
| Age in years | 34.44 ± 8.10 | 32.98 ± 7.58 | 33.71 ± 7.84 |
| BMI in kg/m ² | 24.96 ± 3.39 | 24.94 ± 4.54 | 24.95 ± 3.99 |
| Gender | | | |
| Male | 33 (66%) | 26 (52%) | 59 (59%) |
| Female | 17 (34%) | 24 (48%) | 41 (41%) |
| Occupation | | | |
| Indoor | 47 (97.9%) | 45 (93.8%) | 92 (95.8%) |
| Outdoor | 3 (6%) | 3 (6.3%) | 6 (6%) |
| Sun exposure | | | |
| Adequate | 8 (16%) | 4 (8%) | 12 (12%) |
| Inadequate | 42 (84%) | 46 (92%) | 88 (88%) |
| Smoking | | | |
| Yes | 13 (26%) | 14 (28%) | 27 (27%) |
| No | 37 (74%) | 36 (72%) | 73 (73%) |
| Site of teeth | | | |
| Anterior | 12 (24%) | 12 (24%) | 24 (24%) |
| Posterior | 38 (76%) | 38 (76%) | 76 (76%) |

Since there was non-parametric distribution of the ISQ scores across the groups, the Mann-Whitney U test was used to compare the results. With a p-value of 0.001, group A's median ISQ at three months was considerably higher (median=71, IQR=69-73) than group B's (median=65, IQR=61-67). (Table 2)

Table 2. Comparison of ISQ values at three months between groups

| | Group A with Vitamin D supplement | Group B without Vitamin D supplement | p-value |
|--------------------------------|-----------------------------------|--------------------------------------|---------|
| ISQ | 71 (69-73) | 65 (61-67) | 0.001 |
| Data presented as Median (IQR) | | | |

The distribution of pre and post treatment vitamin D level within group A was non-parametric, therefore, Wilcoxon Signed Rank test was applied for the comparison. Post-treatment vitamin D level (Median=34, IQR=31-38) significantly increase as compared to pre-treatment vitamin d level (Median=24, IQR=23-27) in group A with p=value=0.001. (Table 3)

Table 3. Comparison of Pre and Post treatment vitamin D

| GROUP A | Pre-treatment | Post-treatment | P-value |
|---|---------------|----------------|---------|
| Vitamin D level Data presented as Median (IQR) | 24 (23-27) | 34 (31-38) | 0.001 |
| GROUP B | Pre-treatment | Post-treatment | p-value |
| Vitamin D level Data presented as Median (IQR) | 27 (22-28) | 26 (22-28) | 0.892 |

Since the distribution of vitamin D levels before and after treatment in group B was non-parametric, the Wilcoxon Signed Rank test was used to make the comparison. With a p-value of 0.892, the post-treatment vitamin D level in group B was not significantly lower than the pre-treatment vitamin D level (Median=27, IQR=22-28).

The Mann-Whitney U test was used for comparison since there was non-parametric distribution of vitamin D levels across groups at three months. With a p-value of 0.001, group A had a substantially higher median vitamin D level at three months (median=34, IQR=31-38) than group B (median=26, IQR=22-28).

There was strong positive correlation between vitamin D level and ISQ value at 3 months with p value=0.001 (Table 4).

Table 4. Correlation between vitamin D level and ISQ value at 3 months

| | | Vitamin D at 3 months | ISQ at 3 months |
|----------------|------------------------------|--------------------------|--------------------|
| Spearman's rho | Vitamin D at 3 months | r | 1 |
| | | p-value | 0.725** |
| | | n | 100 |
| | ISQ at 3 months | r | 0.725** |
| | p-value | | 1 |
| | n | 100 | 100 |

** . Correlation is significant at the 0.01 level (2-tailed)

The effects of vitamin D on osseointegration—the process by which dental implants fuse with the bone—are being investigated more and more because it is important for bone health. The mechanisms include how vitamin D affects immunological modulation, osteoblast function, and bone metabolism. According to studies, a lack of vitamin D may

level in group A and hinder osseointegration by decreasing the amount of bone surrounding the implant and possibly delaying healing.

For stability in the early stages and long-term success, adequate vitamin D levels encourage greater bone-to-implant contact. Serum levels above 30 ng/mL are generally regarded as adequate for bone health, though the optimal level is still up for debate. Some research suggests levels closer to 40–50 ng/mL for optimal osseointegration.

It is frequently advised that patients getting implants maintain adequate vitamin D levels to promote successful osseointegration. Increased calcium and phosphate absorption in the gut is supported by higher vitamin D levels (40–60 ng/mL), which are essential for bone mineralization and strengthening around the implant site. The growth and differentiation of osteoblasts, the cells that create new bone, depend on vitamin D. The body may better support bone remodeling activities surrounding the implant if higher levels are maintained.

Discussion

Dental implants have become a routine practice in restoring missing teeth, emphasizing the importance of successful Osseo-integration. Vitamin D, an integral component for bone metabolism and homeostasis, plays a vital role in the mineralization of teeth and bones. Despite global vitamin D deficiencies, studies on its impact on dental implant Osseo-integration remain limited, particularly in human subjects. Our study delves into the overlooked role of vitamin D supplementation in this process, shedding light on its impact on implant stability and bone metabolism.

The multifaceted nature of Osseo-integration involves implant-related, prosthetic, surgical, and patient-related variables. Despite high implant survival rates, significant losses occur within weeks post-implantation, emphasizing the need for a comprehensive understanding of contributing factors¹¹.

Vitamin D, a key player in bone metabolism, has been largely ignored in dental practice¹² Our findings indicate a substantial improvement in ISQ

values at three months in patients receiving vitamin D supplements, aligning with studies by Heeba et al., Bhandagae et al., and Bryce and MacBeth. This reinforces the notion that vitamin D levels correlate with implant stability¹³.

Moreover, the significant increase in the mean change in ISQ values in the vitamin D supplemented group resonates with Graeme et al.'s randomized controlled trial, illustrating the positive impact of vitamin D on implant stability¹⁴. This study emphasizes the importance of monitoring and treating Vitamin D levels in patients, particularly those with deficiencies, in order to improve dental implant outcomes.

Subgroup analyses reveal gender, implant location, smoking status, occupation, and sun exposure as potential influencers of implant stability, consistent with varying literature reports¹⁵.

However, the discussion on vitamin D supplementation isn't without controversy. Studies, such as those by Schulze-Späte et al. and Liu et al., portray conflicting outcomes, emphasizing the need for further exploration¹⁶. Notably, careful thought must be given to the possible dual effects of vitamin D on osteoclast activity. In addition to encouraging osteoblast activity and bone formation, vitamin D also affects osteoclasts, which are in charge of bone resorption, making it a complex player in bone remodeling. This dual function is important because, although vitamin D promotes calcium absorption and osteoblastic activity, it can also, in some circumstances, increase osteoclastic activity. Depending on how well bone formation and resorption are balanced, this dynamic may result in increased bone turnover, which could either improve or worsen bone stability. Particularly in implantology, where proper bone remodeling modulation is essential to guaranteeing implant integration and long-term stability, it is imperative to comprehend these complex effects of vitamin D⁷⁻¹⁸.

Our study underscores the significant incidence of osseointegration in the vitamin D supplemented group, aligning with studies by Akhavan et

al., and Naito et al. This suggests a potential positive role of vitamin D in enhancing bone-to-implant contact and bone area density¹⁹⁻²⁰.

Patients may benefit from systemic vitamin D administration weeks prior to dental implant surgery, particularly those who have a severe deficiency in this. Patients, particularly those with severe vitamin D deficiency, may benefit from systemic vitamin D administration weeks prior to dental implant surgery. Low failure rates were reported by patients with adequate vitamin D levels (>30 ng/mL) (12/410 patients, 2.9%). In patients with low vitamin D levels (10–30 ng/mL), the incidence of early failures nearly doubled (20/448 patients, 4.4%), and in patients with severe vitamin D deficiency (<10 ng/mL), the early failure rate was nearly four times higher (3/27 patients)²¹. Yet, conflicting evidence emerges from studies like Bawa et al., underscoring the complex relationship between vitamin D levels and implant outcomes²².

However, more research is necessary to fully understand the complex interactions among variables that determine vitamin D's role in implant success. Important variables that affect results include bone density, healing time, patient age, and lifestyle choices. These factors interact in intricate ways. Furthermore, we are unable to make firm conclusions about the long-term effects of vitamin D supplementation on implant survival and overall longevity due to the limitations of our study, particularly the small sample size and the short follow-up period. These limitations highlight the need for more thorough research to properly evaluate the advantages and possible mechanisms of vitamin D in implant dentistry, ideally with larger cohorts and longer follow-up periods. However, our study fills a significant void in the scant literature on vitamin D's role in implant success in the Pakistani population by offering locally pertinent data.

Vitamin D enhances the osseointegration of dental implants significantly. The study emphasizes the importance of monitoring and treating Vitamin D levels in patients, especially those with deficiencies, in order to improve dental implant outcomes.

It emphasizes the value of targeted vitamin D supplementation in improving implant success. In conclusion, our study supports the positive impact of vitamin D supplementation on dental implant osseointegration. Vitamin D supplementation significantly enhances dental implant osseointegration, as evidenced by higher ISQ values and increased incidence of osseointegration. This study underscores the importance of assessing vitamin D levels pre-implantation for improved implant stability and longevity, emphasizing the potential impact on clinical practices.

Conclusion

The study concludes that Vitamin D supplementation significantly improves osseointegration of dental implants. It emphasizes the importance of targeted vitamin D supplementation in optimizing implant success.

Conflict Of Interest: None

Disclaimer: None

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