

ROLE OF VITAMIN D3 IN ORAL IMPLANTOLOGY: A LITERATURE REVIEW

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<https://doi.org/10.55231/jpid.2024.v07.i03.03>

Abstract

Dental implants integrated in the bone for a long period of time is the main goal of implantology, which in turn depends on many factors such as implant-related and others to the patient. Patient-related risk factors affects the success or failures of implants; this has initiated researchers into finding various mechanisms which control the remodelling of bone in the body of which Vit D3 plays an important role. The present review focuses on the importance of vitamin D3 in oral implantology.

Keywords: Vitamin D3, Dental implants, Osseointegration, Bone.

Introduction:

The primary goal in the field of oral implantology is long-term stable dental implants which are now considered a permanent solution for patients having few or completely missing natural dentitions to meet their functional and esthetic requirements; this statement has been repeatedly proved in the scientific literature through long term clinical studies demonstrating success rate of more than 95%¹⁻³. For achieving long-

term success with dental implants, the primary factor which is involved is the direct connection between the surface of implant and bone in the host site, without intervening fibrous tissues⁴. Once osseointegration is established, it should be maintained over a period to resist the functional load in the oral cavity leading to clinically asymptomatic fixation of the implant⁵. The formation of this direct bony connection is a complicated procedure and depends on numerous entities such as implant biomaterial related like (type of alloy, implant design, and surface characteristics), protocol related (drilling method, time to load), & last but not the least patient-related (quantity and type of bone at the implant position & the body's immunity)^{4,5}.

Although the reliability of dental implants in long term has been proven clinically reliable still few failures of implants at an very initial stage right after placement have been reported in the literature^{6,7}. The search for the factors to avoid such failures in initial stage and ensure a hundred percent success is ongoing to date and includes the following such as smoking, blood sugar levels, localized bone degeneration due to heat generation during drilling, or torque lev-

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els during implant placement⁸⁻¹². A deficient level of Vit D3 has led to higher rate of infection in periprosthetic joints in the field of orthopedics¹². Some implants fail at a very early stage despite using the best biomaterials, following ideal surgical protocol, and even if the bone quality and quantity are sufficient at the host recipient site^{13,14}. All the above findings lead us to believe that there are certain patient-related risk factors influencing bone metabolism, remodeling, and turnover, and further investigation are needed on this aspect.^{15,16} Presently, no study in the literature has established a clear correlation between bone metabolism, vitamin D, and implant success in humans which is a major lacuna.

Vitamin D is a fat-soluble vitamin that plays an important role in bone and hard tissue metabolism in the human body¹⁷. Ca & P in the human body are regulated by Vitamin D, helps in calcium absorption in the intestines, and also is the building block in the mineralization of bones and teeth¹⁸. Active Vitamin D (cholecalciferol) is naturally produced on exposure to sun after which it undergoes double hydroxylation in the kidneys and liver, converting it into 1,25-dihydroxy vitamin D3 or calcitriol which is its active form^{17,18}. This active form i.e., vitamin D3 binds to various receptors in the body and exerts its action by regulating the transcription of specific target genes¹². Past studies in the literature suggest that vitamin D helps in success of dental implants by forming bone them in rodents^{19,20}. Vit. D is also a regulator of the immunity in the body since vitamin d receptors are present in all the cells involved with immunity and it targets both the adaptive and innate immune response, which has been established through research in the past decade²¹⁻²³.

Vit. D status in the human body is most accurately assessed by measuring serum vitamin D3 levels. The present recommendation suggests that a subject with a serum level ranging between 21ng/l - 29 ng/l is considered to have vi-

tamin D insufficiency, subjects with serum levels less than 21 ng/l are called vitamin D deficient whereas serum levels below 10 ng/l are considered severely deficient²²⁻²⁵. The optimal range of vitamin D in a healthy adult is a serum value greater than 30 ng/mL. Deficiency of Vit. D is very common nowadays & is widely prevalent in the world. When we talk about our country the rate of vit. D deficiency is 40-99% with maximum studies reporting it to be between 80-90%. Vit. D deficiency is prevalent in whole population in all age groups i.e. old, young, children etc.

An increased indoor lifestyle, pollution hampering the synthesis of Vit D by UV rays, low dietary intake, pigmented skin, unspaced and unplanned pregnancies, & increased age are common reasons for deficiency. Despite playing such an essential part in the human body in hard tissue metabolism^{11,12}, very limited literature is present on the role of its deficiency of vit. D supplements on the success rate of dental implants²⁶⁻³⁴: also underlying the fact that almost all of the studies on this topic have been performed on animal models and very few human clinical trials have been done^{33,34}

Presently, due to a lack of evidence in the literature, vitamin D test before placing implants cannot be made mandatory due to scarce research in this area. Also, in the recent past authors of a few case reports, review articles, and retrospective studies reported the essentiality of vit. D3 in dental implants & suggested further research in the concerned field. To address this demand, the present literature review aims to find out the influence of Vit D3 on the success of dental implants.

Animal studies:

Animal studies can provide valuable insights into the effects of vitamin D on oral implantology. While clinical trials involving human subjects are essential for confirming the safety and efficacy of treatments, animal studies offer an op-

portunity to conduct controlled experiments and explore the underlying mechanisms of vitamin D in implantology. Here are some key aspects of animal studies in this field:

1. **Bone Health and Implant Integration:**

Animal studies often investigate the impact of vitamin D on bone health and its role in promoting osseointegration (the integration of the implant with the surrounding bone). Researchers can use various animal models, such as rats, rabbits, or dogs, to assess how vitamin D supplementation affects bone density, bone turnover, and the success of dental implants. Calciolari, E. et al.³⁵ studied the effect of vitamin D on bone formation and osseointegration in an implant placed in the vitamin D-deficient rat. In this study, the authors investigated the influence of vitamin D deficiency on bone formation and the success of dental implant osseointegration in a rat model. Their research focused on how vitamin D status affected bone density, bone turnover, and the integration of implants with the surrounding bone. Dvorak et al (2012)³⁶ did an animal study showing the Impact of dietary vit. D3 & success of implants. Fifty rats who were ovariectomized were divided into 3 separate groups. The diet was different in all three groups, one group consumed food which was deficient in the vitamin D, whereas the second group was initially given a diet which was deficient followed by a standard diet, whereas the last group was given a standard diet. Tibial bone was used to place two titanium mini-implants. The investigations which were done were blood sample testing and histomorphometry analysis. The study concluded that vitamin D deficiency hampers bone formation in the cortical area which was compensated by vitamin D supplementation

2. **Inflammatory Response:** Animal studies can help researchers explore the anti-inflammatory properties of vitamin D and its potential to reduce peri-implantitis, an inflammatory condition that can affect dental implants. These studies may involve inducing inflammation and infection around dental implants in animal subjects and examining how vitamin D supplementation influences the inflammatory response. Salari, A., et al.³⁷ did a study on the impact of vitamin D supplementation on peri-implantitis in a rat model. In this study, the authors explored the potential effects of vitamin D supplementation on peri-implantitis, an inflammatory condition that can negatively impact dental implants. They induced inflammation and infection around dental implants in a rat model and examined how vitamin D supplementation influenced the inflammatory response and the progression of peri-implantitis.

3. **Healing and Soft Tissue Management:**

Oral implantology also involves the management of soft tissues around implants. Animal studies can investigate the effects of vitamin D on wound healing, gingival health, and the prevention of complications related to soft tissue. Lee, J. H.³⁸ studied the effect of vitamin D supplementation on wound healing and gingival health around dental implants in a canine model. In this study, the authors investigated the impact of vitamin D supplementation on wound healing, gingival health, and the prevention of complications related to soft tissues around dental implants. They used a canine model to assess the effects of vitamin D on these aspects in the context of implant dentistry.

4. **Biomechanical Assessments:** Animal

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models allow for biomechanical assessments, such as testing the stability and load-bearing capacity of implants in animals treated with vitamin D supplements compared to control groups. These studies help assess the mechanical performance of implants under various conditions. Guler, N.³⁹ researched the effect of vitamin D on implant stability and peri-implant bone in an osteoporotic rat model. In this study, the authors examined how vitamin D supplementation influenced the stability and peri-implant bone health of dental implants in an osteoporotic rat model. Their research focused on biomechanical assessments to understand the mechanical performance of implants under conditions of osteoporosis and vitamin D supplementation.

5. **Histological and Microscopic Analysis:**

Researchers can use animal models to perform histological and microscopic analyses of the bone-implant interface and surrounding tissues. This enables them to examine tissue responses, bone remodelling, and any histological changes influenced by vitamin D. De Aza, P. N.⁴⁰ researched on the Histological and histomorphometric evaluation of the bone-implant interface and surrounding tissues in vitamin D-deficient rats." In this study, the authors examined the bone-implant interface and surrounding tissues in vitamin D-deficient rats using histological and histomorphometric techniques. Their research aimed to understand the impact of vitamin D deficiency on tissue responses, bone remodelling, and histological changes at the implant site.

6. **Bone Grafting and Augmentation:**

In cases where bone grafting or augmentation is required before implant placement, animal studies can investigate the

effects of vitamin D supplementation on bone graft integration and subsequent implant placement.

It's important to note that while animal studies provide valuable preliminary data and mechanistic insights, their findings should be further validated in human clinical trials before making specific recommendations for patient care. Additionally, ethical considerations and relevant regulations must be followed in conducting animal research in implantology or any other field.

Human studies:

Human studies on the role of vitamin D in oral implantology have investigated its impact on bone health, osseointegration, implant success, and related aspects. These studies often explore the correlation between vitamin D status and dental implant outcomes in human subjects. Here are some key findings from human studies in this field:

1. **Improved Implant Osseointegration:**

Some human studies suggest that maintaining adequate vitamin D levels may lead to improved osseointegration of dental implants. Patients with sufficient vitamin D levels may experience better implant stability and a higher success rate. Fretwurst et al. (2016)⁴¹ published an article that mentioned about two case reports of implant failure right after placement due to deficiency of Vit. D. Autologous bone grafting was done in one of the cases before implant placement. The implants showed signs of failure within the first 15 days only and had to be removed in both cases. For determining the cause of implant failure, various investigations were carried out including serum vitamin D levels and coincidentally there was a deficiency of vitamin D in both the patients i.e levels were below 20ng/l, following which they have prescribed chole-

calciferol supplements and implants were placed. The implants were successful in both cases following vitamin D supplementation.

2. **Reduced Risk of Peri-Implantitis:** Research has indicated that individuals with optimal vitamin D status may have a reduced risk of developing peri-implantitis, a condition characterized by inflammation around dental implants. Lu et al⁴² suggested the involvement of vitamin D in the pathogenesis of periodontitis and said that the evidence suggests that adequate levels of vitamin D support periodontal health.
3. **Enhanced Bone Density:** Vitamin D is known to play a role in bone metabolism. Human studies have shown that individuals with higher vitamin D levels tend to have better bone density, which can positively influence the long-term stability of dental implants. Mishra et al (2019)⁴³ conducted a randomized controlled trial to chalk out the association b/w cholecalciferol and the severity of osteoporosis, he also evaluated the significance of supplements in osteoporosis treatment. A total of 80 patients in 2 groups were recruited. One group received vitamin D supplements whereas the second group was the placebo group. This study concluded that appropriate supplementation of vitamin D helps in the speedy improvement of BMD in osteoporosis patients. It is also shown that vitamin D oral supplementation also helped to improvise as well as normalize the vitamin D status among the elderly. They concluded that vitamin D supplementation is highly recommended for the elderly to treat osteoporosis.
4. **Faster Healing:** Vitamin D has been linked to improved wound healing and tissue repair. Patients with sufficient vitamin D levels may experience faster healing and less postoperative complications following implant placement. Garg P et al (2020)⁴⁴ conducted a study on the association between crestal bone loss and low serum Vitamin D levels. 32 individuals were included in the clinical trial and divided into two groups on the basis of vitamin D levels. One group received vitamin D supplements whereas the second group didn't receive any supplements. No implants failed and the crestal bone levels were within acceptable levels clinically at follow-ups.
5. **Potential for Reduced Complications:** Some studies have suggested that maintaining proper vitamin D levels could reduce the risk of complications during implant surgery and the early stages of healing. Bryce and Macbeth (2014)³⁴ in their article illustrated the deficiency of Vit. D and failure of an immediate implant. A 29-year-old male patient reported a broken lower teeth fractured following an accident. The concerned tooth was not in a condition to be saved & was removed followed by insertion of the implant. The pt. was asymptomatic during the initial phase of treatment but after five months of surgery, there was no formation of bone around the fixture. Following the failure of the implant various investigations were conducted which revealed that implant failure was caused due to extremely low levels of cholecalciferol in the body.
6. **Optimal Levels and Supplementation:** Human studies emphasize the importance of assessing a patient's vitamin D status and considering supplementation when necessary, particularly for individuals with deficiencies. Mangano et al

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(2016)⁴⁵ conducted a retrospective study on failure in initial stage of implants & low serum vitamin D levels. Previous data was retrieved from implant patients done in the past few years along with the blood investigations done, on analyzing the data they found out that 27 implants failed out of 1625 implants placed in 822 patients. They couldn't find any association between the sex of the patient, age, smoking history, periodontal status, and early failure of implants.

7. Individual Variability: It's worth noting that the effect of vitamin D on oral implantology may vary among individuals, and the optimal vitamin D level for implant success may differ from person to person.

It's important to consult with a healthcare professional, such as a dentist or oral surgeon, to determine an individual's specific vitamin D needs in the context of oral implantology. Additionally, the findings and recommendations from human studies may evolve over time as further research is conducted in this area.

Discussion:

Vitamin D is a multifunctional micro nutrient primarily produced naturally in the human body. It is formed in the largest organ of the body i.e., skin when it exposed to the UV spectrum of the sunlight. Some of the quantity is made available to the human body in the form of food products and supplement we consume on daily basis⁴⁴.

The deficiency of this micronutrient is very pronounced in the Indian population and is potentially a risk factor affecting the jaw bones⁴¹. Uwitonze et al. (2018)⁴⁶ in his research stated that hard tissue healing is affected in human body especially mouth due to deficient serum vitamin D levels. Adequate formation of bone around the dental implants is an important parameter of

implant success. Current research in the scientific literature describes the key factor in implant failure including smoking or use of tobacco, increased blood sugar & poor osteotomy^{37,38}.

As success of implants is closely related to bone metabolism, this might suggest that low vitamin D levels may lead to impaired healing and adversely affect the new bone formation on the implant surface³⁸. Few recent case reports in the scientific literature have raised this important fact of the association of vitamin D deficiency with the early success of dental implants³⁷. Osteoimmunology supports the fact that cholecalciferol is essential nutrient affecting the formation of bone and it helps in the initial phase of fixture healing^{22,45,46}.

Dvorak et al. in their research on fifty ovariectomized rats provided the first point of view on the possible effects of vitamin D supplementation on dental implants and hold a special place in the scientific literature. the research suggested that vitamin D deficiency had a negative influence on bone formation around dental implants which can be compensated by vitamin D supplementation³⁹.

Researchers in the past created animal models to find out the association between cholecalciferol and success of implants in which dental implants were placed in animals carrying various abnormalities related to metabolism of cholecalciferol like osteoporosis, CKD, increased blood sugar levels etc. & the results were observed for the rate of BIC & implant stability with supplements of cholecalciferol. Animal studies have also been done where implants have been coated with vitamin D and placed in the bone. The results reported that the bone formation was stimulated where implants were coated with vitamin D and there was less CBL. Implant success in animal models have led us to the conclusion that further prospective research are required to see the correlation between Vit. D and implant success in humans which is the main objective

of the present research proposal.

Conclusion:

As the field of oral implantology has been expanding dental health care is becoming more and more aware of the importance of vitamin D in maintaining disease-free oral health⁴⁴. As proved in the literature vitamin D has been closely associated with bone metabolism and thus it is expected to be closely related to the success of dental implants as they are directly related to the bony tissues. However contradictory results have been reported in the literature through experimental and clinical studies^{33,34,37,38} and thus more broader studies should be conducted for filling the lacunae existing in the present scientific literature.

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