




The Effect of Vitamins and Minerals on Dental Implants: A Review

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ABSTRACT

Introduction: The focus of this review study was to examine and analyze the impact of vitamins and minerals on dental implants.

Materials and Methods: In order to obtain information on the effects of vitamins and minerals on dental implants, a group of existing articles was thoroughly examined for their findings. This examination process involved the selection of specific articles that met the necessary criteria to be included in the analysis, which were then subjected to an extensive review process. The duration of this review process was over a time span of 11 years, starting from the year 2011 and concluding in the year 2022.

Results: A total of 23 articles were included in the study, consisting of 9 clinical studies, 6 animal studies, 1 laboratory study, and 7 reviews. Clinical studies were limited due to uncertain results regarding the impact of vitamins and minerals on DIT, with most focusing on vitamin D levels rather than other nutrients.

Conclusion: It has been concluded that vitamins and minerals play an important role in forming bone tissue. The lack of these essential elements may result in several diseases, such as diabetes mellitus and osteoporosis. It is therefore recommended to increase the levels of vitamins and minerals in patients before undergoing dental implant treatment (DIT), even though the quality of the patient's bone can also impact the success of the implant. Consequently, the patient's diet should be modified, and essential supplements and vitamins should be administered to ensure optimal implant success.

Keywords: Vitamins; Minerals; Vitamin D; Calcium; Dental implants; Osseointegration.

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Introduction

Nowadays, dental implant therapy (DIT) has been documented as a successful treatment option for replacing missing teeth [1]. As the key to the success of a dental implant, osseointegration is the direct structural and functional connection between the vital bone and the surface of the load-bearing implant [2]. Besides, a common etiology of implant failure is lack of osseointegration. The osseointegration of dental implants depends on various factors, including surgical, prosthetic, and patient-related factors (host response). Also, host factors, such as vitamin D and calcium deficiency can certainly contribute to implant failure. Dental caries and periodontitis, as two common oral diseases, are further associated with low vitamin D levels [3]. Besides, numerous factors can shape the ossification process around the dental implant, including nutrition, supplements, and hormones. Among the supplements and nutritional elements, calcium and vitamin C play the leading roles in collagen and callus formation [4,5]. Magnesium, as the fourth most abundant cation, is also present in the bone structure, as an effective osteogenesis factor [6,7]. Additionally, more magnesium intake with higher bone density multiplies osteogenesis [8]. Dental implant therapy (DIT) has become a widely accepted treatment for replacing missing teeth [1]. Successful DIT relies heavily on osseointegration, the direct structural and functional connection between the bone and the implant's surface [2]. Failure of osseointegration is considered a primary cause of dental implant failure. Various factors contribute to the success of osseointegration, including surgical, prosthetic, and patient-related factors. Host-related factors such as vitamin D and calcium deficiency have been shown to contribute to implant failure, while dental caries and periodontitis are associated with low vitamin D levels [3]. Numerous factors influence the ossification process around the dental implant, including nutrition, supplements, and hormones. Calcium and vitamin C are vital in collagen and callus formation and play a leading role in promoting osseointegration [4,5]. Magnesium is the fourth most abundant cation in bone structure, which acts as an influential osteogenesis factor [6,7]. Higher magnesium intake has been associated with increased bone density and greater osteogenesis [8]. Vitamin D, also known as vitamin D3 or cholecalciferol, is a steroid hormone that can promote bone formation around the implant [9,10]. Low vitamin D levels can negatively impact the healing process and new bone formation at the implant surface since tooth protein remodeling

is determined by bone metabolism [11]. Osteoporosis, a multifactorial disease, occurs due to a sedentary lifestyle, improper nutrition, lack of calcium and vitamin D intake, and high consumption of alcohol and smoking [12,13,14]. This study aimed to review the effects of vitamins and minerals on dental implants, specifically focusing on their impact on osseointegration.

Materials and Methods

This study aimed to investigate the effect of vitamins and minerals on dental implants through a comprehensive literature search from January 2011 until November 2022. Relevant articles were identified by searching the databases of PubMed, Scopus, and Google Scholar. Inclusion criteria were articles written in English, published between 2011 and 2022, and with available full text. Exclusion criteria included non-English studies, articles not indexed in the databases mentioned above, and articles with no full text. Data extraction was performed by two authors, with the following information extracted for each selected article: first author name, year of publication, study type, sample size, and results. The information from each article was then compiled into a checklist, and essential results were extracted and summarized in Table 1.

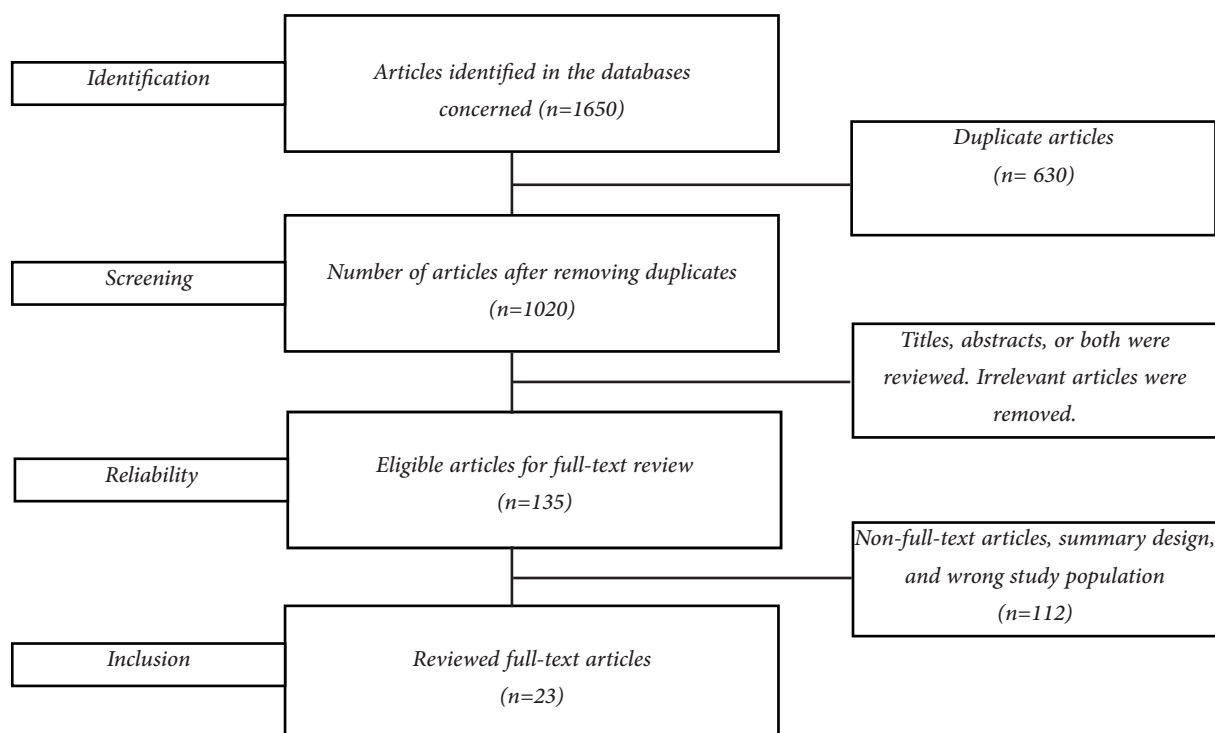
Results

This study aimed to review the impact of vitamins and minerals on dental implant therapy (DIT). A total of 1650 studies were initially found through a search of PubMed, Scopus, and Google Scholar databases using specific keywords. After a thorough review, 23 articles were selected for further analysis, and data extracted from these studies were imported into Table 1. Among the selected articles, 7 were review studies, 9 were clinical studies, 6 were animal studies, and 1 was a laboratory study (see Figure 1). The review found that fewer clinical studies have examined the effect of vitamins and minerals on DIT, with most clinical studies focusing on the impact of vitamin D levels on DIT. In contrast, other minerals and vitamins should have been considered. A total of 1342 patients and 125 animal models were evaluated in the selected studies. Vitamin C was evaluated in 128 patients (9.5%), while the effect of vitamin D was evaluated in 90.5% of human studies. Regarding animal studies, 5% of the models were dogs, 8% were rabbits, and 87% were rats.

Table 1. The characteristics of articles included in the review.

#	Authors	Year	Type of study	Number of samples
1	Kwiatek et al [15]	2021	RCT	122 patients
2	Tabrizi et al [16]	2021	Retrospective	90 patients
3	Diachkova et al [17]	2020	Case report	1 patient
4	Garg et al [18]	2020	RCT	32 patients
5	Li et al [19]	2018	RCT	128 patients
6	Mangano et al [3]	2018	Retrospective	885 patients
7	Acipinar et al [9]	2016	RCT	53 patients
8	Bryce et al [20]	2014	Case report	1 patient
9	Salomó-Coll et al [21]	2016	Animal	6 dogs
10	Liu et al [22]	2014	Animal	30 rats
11	Wu et al [23]	2013	Animal	10 rats
12	Akhavan et al [24]	2012	Animal	48 rats
13	Zhou et al [25]	2012	Animal	20 rats
14	Abosaooda et al [26]	2021	Laboratory	-
15	Martelli et al [27]	2014	Review	9 studies
16	Hakim et al [28]	2021	Review	8 studies
17	Nastri et al [29]	2020	Review	19 studies
18	Vesala et al [30]	2020	Review	14 studies
19	Trybek et al [31]	2018	Review	8 studies
20	Yu et al [32]	2017	Animal	10 Rabbits
21	Javed et al [33]	2016	Review	6 studies
22	Pouran Famili et al [34]	2015	Case-control	30 Patients
23	Gaetti et al [35]	2011	Review	6 studies

Figure 1. A schematic view of selected articles.



Discussion

Dental implants are highly effective in replacing missing teeth with a high survival rate [36]. The purpose of this study is to review the impact of minerals and vitamins on the success of implant treatment. A total of 23 papers were examined in this literature review, including nine human studies, six animal studies, one laboratory study, and seven reviews. Clinical studies analyzed 1342 patients, focusing on examining vitamin D levels. One study, which included 128 patients, evaluated the role of Vitamin C in the healing process after implant placement. Li et al. [19] concluded that vitamin C improved postoperative symptoms in patients with chronic periodontitis and those treated with guided bone regeneration or Bio-Oss Collagen grafts but did not reduce pain after DIT. The average level of Vitamin D in blood serum is recommended to be $\geq 30\mu\text{g/ml}$ [15], with a blood test requested 1-2 weeks prior to implant placement. In cases of Vitamin D deficiency, clinicians should supplement patients with vitamin D a week before surgery [16,17,18]. Blood samples were taken from patients in the follow-up period after DIT to measure vitamin D levels. The recommended dose of vitamin D supplements for patients with a Vitamin D deficiency is 7000–10,000 IU daily [15].

Implants were primarily evaluated using an intra-oral radiograph with a parallel technique to assess the bone level. Bone densitometry was used to evaluate bone density before and after implant placement. Clinical studies suggest that Vitamin D deficiency can contribute to implant failure. The animal studies in this review involved 124 models, with 87% being rats. Most of these studies evaluated the impact of vitamin D on animals, while one study examined Zinc and Magnesium. Results showed that vitamin D improved osseointegration of dental implants and reduced bone loss. Kwiatek et al. [15] suggested that having the proper level of vitamin D on the day of implant placement and treating vitamin D inadequacy can increase the bone level at the implant site during osseointegration as evaluated radiologically. Marginal bone loss is a critical factor in determining the success of implant placement, with an average marginal bone loss of 0.5 mm or less during the healing period and a vertical bone loss of 0.2mm per year being considered successful [37]. In the past, osteoporosis was a risk factor for marginal bone loss, with patients exhibiting more marginal bone loss than normal individuals [38]. Vitamin D supplements are beneficial in reducing marginal bone loss. However, more research is needed to determine the impact of bisphosphonates on the osteointegration of

dental implants [39]. In contrast to osteoporosis, periodontal diseases and implant location in the regenerated bone can strongly affect marginal bone loss [40]. Tabrizi et al. [16] found that low vitamin D levels were related to an increase in marginal bone loss around dental implants, but none of the implants were lost due to low serum vitamin D levels. According to Diachkova et al. [17], patients with bone mineral disorders should consult with an endocrinologist before DIT, as treating these disorders increases the five-year success rate of DIT by 100%. Garg et al. [18] also found that patients supplementing with vitamin D had better osseointegration results, as vitamin D has systemic effects on increasing bone formation around dental implants. However, Mangano et al. [3] did not find a significant relationship between low vitamin D serum levels and early dental implant failure, although a decrease in blood vitamin D levels was associated with considerable growth in early dental implant failure in 11.1% of patients. Additionally, Acipinar et al. [9] suggested that vitamin D levels might be an essential indicator of peri-implant disease and that delivering vitamin D supplements could lead to successful implant placement. Bryce et al. [20] found that vitamin D deficiency could significantly contribute to the failure of implant osseointegration. Thus, measuring vitamin D levels in patients who had undergone long-term hospital care or rehabilitation before dental implant placement was recommended. However, due to the small sample sizes in the studies and the need for simultaneous investigations of control and experimental groups receiving vitamin D, it was impossible to reject or confirm the effect of vitamins on the failure of DIT.

Liu et al. [22] found that vitamin D injection successfully modified serum 1,25D (OH) levels and cured hyperparathyroidism in rats with chronic kidney disease. The results also showed successful osseointegration, elevated bone-implant contact ratio, and bone volume around the implant. Wu et al. [23] concluded that combined vitamin D3 and insulin treatment normalized hyperglycemia levels in diabetic rats and reversed bone vulnerability of implants. Akhavan et al. [24] reported that vitamin D supplementation at 130 mg/dL in blood glucose ≤ 200 mg/dL did not significantly affect the bone-implant contact ratio and was not time-dependent. Zhou et al. [25] found that 1,25D (OH) improved implant osseointegration in rats with osteoporosis. Hakim et al. [15] noted that while there is little evidence to confirm the association between vitamin D and early implant failure, vitamin D seems to play a central role in implant success, con-

sidering its immunomodulatory effects. Vitamins, especially vitamin D, are essential for bone formation, and their deficiency can be related to osteoporosis [41,42]. Martelli et al. [27] suggested that vitamin D might impact periodontal disease risk by regulating the immune system or influencing bone mineral density. There is an association between some vitamin D varieties, periodontitis, and bone metabolism. Pouran Famili et al. [34] argued that diminished skeletal bone density confirmed by oral bisphosphonate treatment did not affect the success of dental implants. Alqutaibi et al. [44] found a significant difference between patients with osteoporosis and healthy individuals regarding implant bone loss. However, clinical studies have reported inconsistent results regarding the effectiveness of vitamin D levels in dental implant success.

The effectiveness of vitamin D3 supplementation on implant osseointegration is still unclear. It requires more studies, according to Javed et al. [33]. Conversely, Abosooda et al. [26] found that vitamin C at different concentrations can have varying effects on gums and dental implants while protecting them. In contrast, Nastri et al. [29] stated that minerals have no impact on implant osseointegration, and a deficiency in certain nutrients does not lead to implant failure. However, some studies have shown that a deficiency in vitamin D can lead to early implant failure. Vesala et al. [30] reported that systemic vitamin D administration had beneficial outcomes for patients with severe deficiency, indicating the importance of maintaining vitamin D levels for bone regeneration around the implant.

In addition, Mikhail et al. [45] found that low-intensity laser radiation can significantly improve bone healing and accelerate bone osseointegration and that vitamin C and calcium, along with laser therapy, can positively impact improving osseointegration. Trybek et al. [31] concluded in their review study that the prevalence rate of vitamin D deficiency in the European population was not the direct cause of osseointegration failure. Yu et al. [33] found that zinc and magnesium functional implants significantly increased osteogenesis, angiogenesis, and bacterial inhibition, which positively affected implant stability and supporting tissue. Gaetti et al. [35] investigated the status of dental implants in patients with osteoporosis and concluded that impaired bone metabolism could result in decreased bone healing around implants in these patients. However, other factors may contribute to implant failure, and osteoporosis is not considered a contraindication for DIT. In these cases, dental professionals should plan appropriate treatments, modify the implant's

geometric shape, use a larger implant diameter with surface treatment, and perform a detailed analysis of bone quality using tomography. The review examined recent literature on how vitamins and minerals affect dental implants, only including English full-text articles. However, the study has limitations, such as the absence of data extraction, typical in literature reviews, and the exclusion of publications in other languages, which could have added more insights. Additionally, financial support needed to be increased, leading to a restricted scope of the study. Nevertheless, the review still provides valuable information, presenting a comprehensive overview of the latest findings. Further research is necessary to expand the study's conclusions, especially concerning the effects of vitamins and minerals on dental implant outcomes, and to investigate the influence of various factors on implant success.

Given the limited number of human studies, including randomized clinical trials and prospective studies, the authors suggest that further research should investigate the impact of vitamins and minerals at the clinical level. Since most of the studies only evaluated the effect of vitamin D, further studies should assess the possible impact of other vitamins and minerals. Additionally, it is recommended to take a blood sample before the procedure to achieve better results in DIT and supplement the necessary vitamins and minerals.

Conclusion

The impact of minerals and vitamins on dental implant treatment has been analyzed, with clinical studies primarily focusing on Vitamin D levels. Vitamin D deficiency has been linked to implant failure, while supplementation has been shown to improve osseointegration and reduce bone loss. They are measuring Vitamin D levels before implant placement may be beneficial for patients who have undergone long-term hospital care or rehabilitation. Animal studies have also demonstrated the positive effects of Vitamin D supplementation on osseointegration. However, due to conflicting results, more detailed investigations are necessary to understand the impact of vitamins on dental implant treatment fully. The authors suggest conducting additional clinical studies with refined care protocols. Minerals and vitamins are crucial for bone formation, and deficiencies can lead to various diseases, including diabetes mellitus and osteoporosis. Therefore, it is advisable to treat individuals with vitamin and mineral deficiencies before starting DIT, with dietary changes and supplement prescriptions being some options.

Conflict of Interest

There is no conflict of interest to declare.

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