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The significance of Vitamin D in dentistry - rewiew

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ABSTRACT

INTRODUCTION: Vitamin D plays a crucial role in maintaining overall health, with increasing clinical interest in its impact on oral health. This review explores the significance

of Vitamin D in dentistry, focusing on its effects on dental caries, periodontal disease, malocclusion, and temporomandibular disorders (TMD). Additionally, it identifies risk groups for Vitamin D deficiency and outlines current supplementation guidelines.
BRIEF DESCRIPTION OF THE STATE OF KNOWLEDGE: Vitamin D3, synthesized in the skin or obtained through diet, regulates calcium and phosphate metabolism essential for bone, enamel, and dentin mineralization. Maintaining serum 25(OH)D concentrations of at least 30 ng/ml is recommended for optimal health benefits. Vitamin D's immunomodulatory properties impact oral health by reducing inflammation and enhancing antimicrobial defenses. It plays a role in preventing dental caries, managing periodontal disease, influencing craniofacial development, and potentially affecting TMD. Risk groups for Vitamin D deficiency include the elderly, individuals with darker skin, those living in northern latitudes, and people with certain medical conditions or on specific medications.
SUMMARY: Adequate Vitamin D levels, achieved through diet, supplementation, and sun exposure, can significantly contribute to oral health and overall well-being. Increasing awareness of Vitamin D's importance, especially among at-risk groups, is crucial for maintaining optimal oral health.

Keywords: vitamins, oral health, vitamin D deficiency, dental caries, periodontal disease, TMD, malocclusion, vitamin D supplementation

INTRODUCTION

Sufficient vitamin D level has a vital role in maintaining the general health of the entire organism. There has been increasing clinical interest regarding the role of Vitamin D in oral health maintenance. Research suggests that sufficient Vitamin D levels can have a significant impact on the prophylaxis and treatment of periodontal disease, caries, and gingivitis. The aim of this study was to present the impact of Vitamin D on oral health as well as proper development and functioning of the stomatognathic system, presents risk groups of Vitamin D deficiency and current supplementation guidelines.

BRIEF DESCRIPTION OF THE STATE OF KNOWLEDGE:

Vitamin D3 is synthesized in the skin after exposure to ultraviolet B (UVB) radiation from 7-dehydrocholesterol or can be provided from the diet. It is recommended to maintain serum 25(OH)D concentrations of at least 30 ng / ml (75 nmol / L), and preferably 40-60 ng / ml (100-150 nmol / L) to obtain optimal general health benefits of Vitamin D. The primary

function of Vitamin D is the regulation of calcium and phosphate metabolism, which are essential for proper bone, enamel and dentin mineralization. Calcitriol impacts the expression of genes related to the immune system, decreases the expression of pro-inflammatory and also simultaneously increases the expression of anti-inflammatory cytokines. Vitamin D, due to its effects on the skeletal and muscular systems and its anti-inflammatory properties impacts temporomandibular joints.

SUMMARY

Ensuring adequate levels of vitamin D through diet, supplements and reasonable sun exposure can contribute significantly to oral health and overall well-being.

KEY WORDS: vitamins, oral health, vitamin D deficiency, dental caries, periodontal disease, TMD, malocclusion, vitamin D supplementation

INTRODUCTION AND OBJECTIVE

There have been an increasing number of preclinical and clinical observations in recent years that have associated Vitamin D with a multiple medical conditions.[1] The researches found that sufficient vitamin D level has a vital role in maintaining the general health of the entire organism.[2] Along with Vitamin's D important role in maintaining a healthy, mineralized skeleton, it is also an immunemodulatory hormone.[3] Therefore, a deficiency of Vitamin D is associated with a wide range of non-skeletal effects such as increased risk of obesity and diabetes, autoimmune, infectious, cardiovascular and respiratory diseases, pregnancy pathologies, as well as increased cancer incidence and mortality.[1], [4] Recently, there has been increasing clinical interest regarding the role of Vitamin D in oral health maintenance.[5] Research suggests that sufficient Vitamin D levels can have a significant impact on the prophylaxis and treatment of periodontal disease [6], caries [7], and gingivitis [8]. Deficiency of Vitamin D, as a global health concern, can lead to increased vulnerability to infection, impair the structure of the teeth and jaw bones, and consequently manifest as a deterioration in overall oral health.[5], [9] The synthesis and metabolism of vitamin D are intricate processes, involving the skin, liver and kidneys. Vitamin D, mainly in the forms D2 (ergocalciferol) and D3 (cholecalciferol), can be provided from the diet. Vitamin D2 comes mainly from plants such as mushrooms, while vitamin D3 is found in animal products such as fatty fish, liver and egg yolks.[1], [2], [10] The acceptable biomarker for determining vitamin D status is total serum 25(OH)D

levels.[1], [4] The level of 25(OH)D in the general population varies depending on several factors, such as the season, latitude, exposure to UVB light, skin pigmentation, body mass index (BMI), gender, age, physical activity level and dietary enrichment or use of Vitamin D supplements. [1] Supplements can ontain vitamin D2 or D3, although vitamin D3 is more effective in raising serum 25(OH)D levels.[4] It is recommended to maintain serum 25(OH)D concentrations of at least 30 ng / ml (75 nmol / L), and preferably 40-60 ng / ml (100-150 nmol / L) to obtain optimal general health benefits of Vitamin D.[3] The screening of serum 25(OH)D in the general population is not recommended, but examination of vitamin D status is highly recommended among risk groups.[11] [12]

This review focuses on the impact of Vitamin D on oral health as well as proper development and functioning of the stomatognathic system, presents risk groups of Vitamin D deficiency and current supplementation guidelines.

DESCRIPTION OF THE STATE OF KNOWLEDGE

Synthesis and metabolism of Vitamin D

Vitamin D3 is synthesized in the skin after exposure to ultraviolet B (UVB) radiation from 7-dehydrocholesterol, a precursor to cholesterol. As the skin is exposed to UVB, 7-dehydrocholesterol is transformed into pre-vitamin D3, which is isomerized to vitamin D3 (cholecalciferol). Subsequently, Vitamin D (D2 and D3) is transported to the liver, where it undergoes its first hydroxylation to 25-hydroxyvitamin D [25(OH)D], also known as calcidiol. This process is catalyzed by the enzyme 25-hydroxylase (CYP2R1). 25(OH)D is the major circulating form of vitamin D and a marker of vitamin D status in the body. 25(OH)D is being transported to the kidneys, where it undergoes a second hydroxylation to 1,25-dihydroxyvitamin D [1,25(OH)2D], calcitriol. This reaction is catalyzed by the enzyme 1α-hydroxylase (CYP27B1). 1,25(OH)2D is the active form of vitamin D and the ligand for the vitamin D receptor (VDR), a transcription factor that binds to sites in DNA known as vitamin D response elements (VDREs). [1], [2], [13]

Vitamin D and dental caries

Vitamin D has an important role in the prevention and reduction of dental caries. The study by Wójcik D. et al. shown that there is statistically significant relationship between the mean decayed, missing and filled teeth (DMFT) index and Vitamin D concentrations; as Vitamin D levels increase, mean DMFT rates decrease.[14] The primary function of Vitamin

D is the regulation of calcium and phosphate metabolism, which directly affects the mineralization of enamel and dentin.[15] Calcitriol regulates the expression of genes associated with tooth formation and mineralization.[16] Vitamin D deficiency can lead to enamel hypomineralization, increased vulnerability to tooth decay and tooth eruption disorders.[5], [17] The higher Vitamin D concentrations contribute to better absorption of calcium and phosphorus, which is essential for the development of a tooth structure that is strong and resistant to demineralization.[18] What is more, studies have shown that supplementation of Vitamin D3 has a positive effect on caries remineralization.[19] Children and adults with Vitamin D deficiency are more prone to caries, which suggests that appropriate supplementation of this Vitamin D can be an effective measure in the prevention of dental disease.[20] In addition, Vitamin D has antimicrobial and immunomodulatory properties that can limit the growth of bacteria responsible for tooth decay, such as *Streptococcus mutans* and *Streptococcus sobrinus*.[21] [22] Therefore, Vitamin D not only strengthen tooth structure, but also promotes oral health by modulating the immune response and reducing the risk of bacterial infections.[23]

Vitamin D and periodontal disease

The role of Vitamin D in the regulation of the immune system, anti-inflammatory and antimicrobial effects can affect the severity and progression of periodontal disease.[24] Study by Agrawal A. et al. showed that low levels of vitamin D and calcium are linked to gingivitis and periodontitis. There is also an inverse relationship between vitamin D and calcium levels and probing pocket depth and clinical attachment loss, which may contribute to increased periodontal disease activity.[25] Calcitriol impacts the expression of genes related to the immune system, including those involved in pro-inflammatory and anti-inflammatory cytokines; decreases the expression of pro-inflammatory cytokines such as interleukin-6 (IL-6) and tumor necrosis factor alpha (TNF-α), also simultaneously increases the expression of anti-inflammatory cytokines such as interleukin-10 (IL-10).[26] The research by Lu E-C. et al. indicated that vitamin D supplementation reduces systemic inflammation and promotes the induction of autophagy-related proteins associated with antimicrobial funcions.[27] A study by Govindharajulu R. et al. has shown that vitamin D has antimicrobial properties against red complex periodontal microorganisms such as *P. gingivalis, T. denticola, and T. forsythia* and may help stop or delay the progression of periodontitis.[28] In addition, meta-analysis by Liang F. et al. suggest that serum levels of vitamin D in people with periodontitis are lower than in healthy people.[29] Considering evidence, vitamin D can be seen as a potential factor

in supporting periodontal health, which emphasizes the importance of assesment and supplementation as part of periodontal treatment.[30] Vitamin's D role in regulating inflammatory, immune and regenerative processes that are also essential for effective healing of injuries. Anti-inflammatory effect of Vitamin D contributes to reducing the severity of oral inflammation and promotes a more effective wound healing process. Calcitriol binds to the vitamin D receptor (VDR) thereby regulating transcription in various target cells by promoting the production of mitogenic growth factors and receptors such as platelet-derived growth factor (PDGF), epidermal growth factor receptors (EGFR) and keratinocyte growth factor receptor (KGFR).[31] In response to bacterial stimulation, VDR activation in periodontal keratinocytes, monocytes, and macrophages can induce the production of the antimicrobial factors cathelicin and β-defensin, and thereby play a role in decreasing bacterial severity; vitamin D supplementation can enhance the local cellular antimicrobial effector response against periodontal bacteria.[32]

Vitamin D and malocclusion

Vitamin D is a crucial regulator of calcium and phosphorus homeostasis, which are essential for proper bone mineralization. The active form of vitamin D, calcitriol, acts through the vitamin D receptor (VDR), which is present in many cells, including osteoblasts and osteoclasts. Calcitriol increases intestinal absorption of calcium and phosphorus, renal reabsorption of calcium and mobilization of calcium from bone. These actions are fundamental for maintaining proper bone mineralization and prevention of diseases such as osteomalacia and rachitis.[4] Malocclusion can develop as a result of insufficient or excessive growth of the craniofacial bones, which leads to skeletal and dental defects.[33] Karłowska refers rachitis, caused by vitamin D3 deficiency, as one of the causes of stomatognathic abnormalities such as hypoplasia of the tongue, flattening of the front part of the lower dental arch, V-shaped maxilla, a narrow and high palate, an increase in the angle of the mandible and consequent elongation of the lower face, an open bite or posterior bite, and delayed teething.[34] The study by Leszczyszyn A. et al. pointetd a correlation between low vitamin D levels and a higher incidence of teeth crowding in the upper and lower dental arches, as well as skeletal defects and significantly more patients with vitamin D deficiency had upper dental arch narrowing.[35] These suggest that appropriate levels of vitamin D might be important for maintaining the proper shape and function of the maxillary and craniofacial bones. Studies of VDR polymorphisms are being conducted for their impact on systemic diseases with regard to bone metabolism and related diseases. Dominiak M. et al. conducted the first prospective

study to initially determine if there are associations between specific vitamin D receptor (VDR) polymorphisms and the development of malocclusion. The study showed a significant effect of VDR polymorphisms Cdx2 (rs11658820) and a possible trend of FokI (rs2228570) and BsmI (rs1544410) on jaw development, and the results identified a correlation between jaw growth, especially underdevelopment and vitamin D; a decrease in vitamin D levels leads to a decrease in jaw size.[36]

Vitamin D and temporomandibular disorders

Temporomandibular joints (TMJ) perform a major role in chewing, speaking and swallowing. Temporomandibular disorders (TMD) is a term that encompasses disfuncion in the masticatory muscles as well as in TMJ. Common symptoms of TMD involve pain in TMJ and masticatory muscles, as well as reduced mobility of the jaw and TMJ sounds.[37], [38] The etiology of TMD is multifactorial, and the leading factors include psychological ones like stress, anxiety or depression, biomechanical and neuromuscular factors like bruxism or other parafunctions and occlusal overload, as well as genetic, biological and postural factors.[38], [39] Alkhatatbeh MJ et al. conducted a study to investigate the connection between sleep bruxism, low serum vitamin D, low dietary calcium intake, psychological symptoms and frequent headaches. The results showed that sleep bruxism was significantly associated with vitamin D deficiency and low dietary calcium intake, and was also correlated with increased anxiety and depression scores. They also concluded that there is a need for further research to see if vitamin D and calcium supplementation can improve sleep bruxism. [40] Vitamin D is a crucial regulator of calcium and phosphate metabolism.[29] Calcitriol activates a number of metabolic processes via binding to VDRs present in muscle tissue; it affects muscle cell differentiation and proliferation, improves muscle function, stimulates the synthesis of specific muscle proteins and increases the number of type II muscle fibers.[41] A study by Abdul-Razzak KK. et al. showed that low serum vitamin D levels were associated with musculoskeletal pain along with low calcium intake, depression and anxiety, and after vitamin D supplementation, the measured outcome parameters improved significantly.[42]. Vitamin D impacts cartilage health by regulating chondrocyte differentiation, proliferation and maturation, as well as it influences the sythesis of proteoglycans. Vitamin D deficiency can contribute to cartilage degeneration, which can lead to the development of osteoarthritis,[43] including temporomandibular joint osteoarthritis (TMJ OA).[44] In a study conducted by Hong SW. et al. vitamin D revealed potential for therapeutic treatment in TMJ OA in young women and postmenopausal women.[45] Vitamin D, due to its effects on the skeletal and

muscular systems and its anti-inflammatory properties, might have a significant impact on TMJ health.[46]

Vitamin D deficiency risk groups

There are some specific groups of the population that are at heightened risk of vitamin D deficiency owing to several factors associated with diet, lifestyle, health conditions and exposure to sunlight.[2] The elderly are one of the leading groups at risk of vitamin D deficiency. As people age, their skin loses the efficiency to synthesize vitamin D when exposed to UVB radiation, and at the same time, the elderly spend less time outdoors, limiting their exposure to the sun. In addition, older people often have a lower intake of vitamin D-rich foods and may suffer from diseases that affect the absorption of vitamins from food.[47] Individuals with darker skin have more melanin in their skin, which acts as a natural sunscreen and reduces skin's ability to produce vitamin D. As a result, these people are at higher risk of vitamin D deficiency, especially in areas with less sunny days throughout the year. Residents of regions with less exposure to sunlight at northern latitudes, especially during the winter months, have an increased risk of vitamin D deficiency. Short days and long winters limit the amount of time one can be exposed to sunlight. People suffering from obesity have a increased risk of vitamin D deficiency because vitamin D is fat-soluble and can be sequestered in fat tissue. This makes less vitamin D available for metabolism and action in the body.[2], [48] Infants being exclusively breastfed may be at risk of vitamin D deficiency, especially if the mother has low vitamin D levels. Breast milk contains reduced amounts of vitamin D, which may be insufficient to meet the needs of a developing baby.[49] People with gastrointestinal diseases that affect fat absorption, such as celiac disease, cystic fibrosis, or pancreatitis, are at higher risk of vitamin D deficiency. These diseases can impair the absorption of vitamin D from food.[2] Some pharmaceutical drugs can affect the metabolism of vitamin D, decreasing its levels in the organism. For example, examples include anticonvulsants, glucocorticoids, antifungal drugs, and some medications used to treat HIV.[50] Renal or hepatic disease can affect vitamin D metabolism, as these organs are essential in converting vitamin D to its active form, calcitriol. People with kidney or liver failure often have difficulty maintaining adequate levels of vitamin D. The above conditions may require tailored vitamin’s D supplementation plans and regular monitoring of serum 25(OH)D levels. [2], [11]

Vitamin D supplementation

Vitamin D supplementation is an effective way to prevent and treat vitamin D deficiency.[11] Vitamin D supplements are available in two forms: vitamin D2 (ergocalciferol) and vitamin D3 (cholecalciferol).[1] Vitamin D intake is dependent on age, health status and vitamin D levels in the body.[11], [12] Although vitamin D is considered to be safe in recommended doses, over-supplementation can lead to hypervitaminosis D as serum 25(OH)D >100 ng/mL, which can cause hypercalcemia (high levels of calcium in the blood) and hyperphosphatemia. Symptoms of hypercalcemia can include nausea, vomiting, weakness, frequent urination and kidney stones.[2], [11] It is important that vitamin D dosing should be based on 25(OH)D concentrations and be monitored, although routine screening of serum 25(OH)D levels is not recommended for the general population but is highly suggested for risk groups.[11], [12] As for preventive treatment for high-risk groups, the same guidelines should be followed as for the general population, but with adjustments based on specific needs and serum 25(OH)D levels.[11], [12] The guidelines for vitamin D supplementation for the general population in Poland are given in Table 1.

Vitamin D supplementation in the general population - recommended daily doses

Age	Daily doses in IU*
0-6 months	400 - regardless of feeding method, throughout the year
6-12 months	400-600 - depending on the daily amount of of vitamin D received with food, throughout the year
1-10 years	600-1000**
11-18 years	800-2000**
>18 years	800-2000**
>75 years	2000-4000 - throughout the year
Pregnancy and lactation	2000***
Diagnostic thresholds determining vitamin D status based on serum 25(OH)D concentration [ng/ml]**	- Deficiency - 10-20 deficiency <10 severe deficiency - Insufficiency - 20-30 - Sufficiency - 30-50 - Toxicity - >100
The upper limits for daily vitamin D intake for a healthy population	- Newborns and infants - 1000 IU/day - Children 1-10 years - 2000 IU/day - Adolescents 11-18 years - 4000 IU/day - Adults and seniors - 4000 IU/day

*40 IU = 1 µg
** From September to April, or throughout the year if no adequate sunlight is provided
*** Supplementation should be administered under monitoring of 25(OH)D concentrations to achieve and maintain ranges >30-50 ng, in case serum 25(OH)D assessment is unavailable then supplementation is 2000 IU/day, throughout pregnancy and lactation.
**** 1 ng/mL = 2.5 nmol/L

Table 1. The guidelines for vitamin D supplementation in the general population of Poland. Based on: Płudowski, P.; Kos-Kudła, B.; Walczak, M.; Fal, A.; Zozulińska-Ziółkiewicz, D.;

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SUMMARY

Vitamin D is essential for maintaining oral health and benefits include the promotion of stomatognathic system development (bones,teeth, joints), reducing the risk of periodontal disease and tooth decay as well as supporting mucosal immunity. Ensuring adequate levels of vitamin D through diet, supplements and reasonable sun exposure can contribute significantly to oral health and overall well-being. It is vital to increase patient awareness of the significance of vitamin D, especially in groups at risk for vitamin D deficiency.

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AUTHOR'S CONTRIBUTION

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