

THE EFFECT OF VITAMIN D3 ON TOOTH MOVEMENT IN ORTHODONTIC TREATMENT

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ABSTRACT

Malocclusion is a deviation from the position of the tooth from the dental arch outside the acceptable range or normal occlusion. Malocclusion conditions require proper treatment, namely by performing orthodontic treatment. Treatment with orthodontic appliances that can produce tooth movement is expected to align the teeth to achieve esthetics, prevent malocclusion from becoming severe, and return it to a normal occlusion condition. The acceleration of orthodontic tooth movement is currently the subject of various scientific studies aimed at increasing the duration of orthodontic treatment. **Purpose:** Assessing currently available evidence regarding the effect of vitamin D3 in accelerating orthodontic tooth movement. **Methods:** The databases PubMed, ResearchGate, Google Scholar, EBSCO were searched from 2012-2023 and searched using the keywords Vitamin D, Canine Distalization, Accelerated Orthodontic Tooth Movement, Bone Remodeling. **Conclusion:** The majority of the included studies reported that vitamin D3 can stimulate bone resorption by increasing osteoclast activity which results in the speed of bone resorption resulting in an increase in the speed of tooth movement and helps in stabilizing orthodontic tooth movement.

INTRODUCTION

The condition of dental and oral health in Indonesia and the world is still a serious problem. Malocclusion is a dental and oral health problem with a high prevalence, which is a deviation from normal occlusion that can occur at all ages. During adolescence, many developments occur, such as physical development, personality, and emotional development. Physical development will affect the growth of the dental arch so that teenagers can experience

malocclusion problems which can cause impaired oral function, decreased self-confidence, changes in facial appearance, and difficulty cleaning teeth due to irregular tooth alignment. Malocclusion conditions require appropriate treatment, namely orthodontic treatment (Suala *et al.*, 2021).

Orthodontic treatment is one of the basic needs for humans in maintaining and improving dental and oral health. Orthodontic treatment aims to eliminate all influences that can change the normal

development of the teeth and jaw, prevent the malocclusion from becoming severe, and return it to a condition of normal occlusion. Orthodontic treatment is treatment that aligns teeth to achieve good esthetics and occlusion function. Treatment with orthodontic appliances is expected to achieve regular tooth alignment and a harmonious facial appearance (Suala *et al.*, 2021; Narmada *et al.*, 2019).

The use of orthodontic appliances to correct malocclusion involves the alveolar bone remodeling process, including the resorptive phase and bone formation in the alveolar process. This process can be stimulated using mechanical force obtained from the activation of the components of the tool applied to press the tooth and transmitted to the tissue around the tooth including the gingiva, periodontal ligament and alveolar bone, thereby allowing tooth movement (Narmada *et al.*, 2019; Almoammar, 2018; Amin *et al.*, 2017).

The acceleration of orthodontic tooth movement is currently the subject of various scientific studies aimed at increasing the duration of orthodontic treatment. Several approaches have been taken to reduce the period that patients undergo orthodontic treatment. There are three main approaches related to conventional orthodontic treatment, reducing the treatment period and increasing the rate of tooth movement, namely biological, physical and surgical approaches (Ciur *et al.*, 2016).

In various studies, active vitamin D3 (1,25-dihydroxycholecalciferol) stimulates bone resorption by inducing differentiation of osteoclasts from their precursors and increasing the activity of existing osteoclasts and resulting in the rate of bone resorption leading to an increase in the rate of tooth

movement during canine retraction (Almoammar, 2018).

The aims of writing this paper is so that dentists can better understand and apply the use of vitamin D in orthodontic treatment and it is hoped that more research will be carried out regarding the use of vitamin D to speed up tooth movement in the orthodontic treatment process.

METHOD

This literature review based on reference sources obtained from articles, journals, textbooks and websites accessed via the PubMed, ResearchGate, Google Scholar, EBSCO databases and searched using the keywords Vitamin D, Canine Distalization, Accelerated Orthodontic Tooth Movement, Bone Remodelling. The type of journal taken is a research journal published from 2012 -2023. (Varughese *et al.*, 2019; Ciur *et al.*, 2016; Gowda *et al.*, 2017; Al-Attar *et al.*, 2022)

RESULT AND DISCUSSION

The results found in the databases searched were 18 references found from the Google Scholar, PubMed, ResearchGate, EBSCO databases. After analysis based on the inclusion criteria, 8 articles were selected, and 10 articles were excluded because they were published before 2012-2022. After 8 journals were read, 4 articles were excluded because the five articles were not relevant to the topic discussed, so 4 articles were included in the integrative review (Table 1).

Tabel 1. Hasil Penelitian Pengaruh Vitamin D3 Terhadap Pergerakan Gigi Selama Perawatan Ortodonti.^{9,10,11}

Reference	Objective	Method	Sample	Result
Varughese <i>et al.</i> (2019)	To evaluate the clinical and radiographic effects of Vitamin D3 on the amount of canine distalization and alveolar bone density.	Intraligamentary injection of 0.2 mL Vitamin D3 on the experimental side and 0.2 mL placebo gel on the control side.	15 patients who were undergoing fixed orthodontic treatment who had previously had their maxillary first premolars extracted and used <i>nickel-titanium (NiTi) closed coil spring</i> for canine distalization.	The Vitamin D3 injection group resulted in a higher rate of canine distalization movement and a significant difference in reduction in cancellous bone density compared to the control group.

Dumitrelea et al. (2016)	To analyze the effect of local administration of vitamin D3 on orthodontic tooth movement and to evaluate whether there are secondary effects on the tooth roots after intraligamentary administration of vitamin D3.	Intraligamentary injection of 0.2 mL Vitamin D3 in the experimental quadrant only was given once a week for three weeks.	The patient's 6 jaw arches, namely four maxillary arches and two mandibular arches, previously had four first premolars extracted <i>nickel-titanium (NiTi) closed coil spring</i> for canine distalization.	Administration of vitamin D3 to the experimental tooth group induced higher tooth movement compared to the control group and no root resorption was observed three months after the first injection of vitamin D3.
Gowda et al. (2017)	To compare the effects of local application of vitamin D3 and PGE1 on the level of canine retraction.	Local administration of Vitamin D3 in the distal right region of the maxillary canine and PGE1 in the distal left region of the maxillary canine using a tucker ligature.	15 patients who were undergoing fixed orthodontic treatment who previously had bilateral maxillary first premolars extracted and using Pre-adjusted Edgewise Appliance (PEA) and Enmass retraction maxilla for retraction of anterior teeth.	After 45 days, local application of vitamin D3 resulted in a significant increase in orthodontic tooth movement and there was no significant difference between Vitamin D3 and PGE1 regarding their effect on the amount of tooth movement.
Al-Attar et al. (2022)	To determine the effect of vitamin D3 levels on alignment efficiency, root resorption, and pain perception during the initial phase of orthodontic therapy.	Normal vitamin D3 levels group (ND3G), which were measured and corrected to normal before starting orthodontic treatment. Control group (CG) vitamin D levels remained unknown until the alignment phase was completed.	33 patients with moderately crowding incisors requiring non-extraction fixed orthodontic treatment using 0.016-inch, 0.016 × 0.022-inch, and 0.019 × 0.025-inch heat activated nickel titanium (HANT) arch wires.	The time required for mandibular incisor alignment was one month shorter in ND3G and the percentage improvement was significantly higher in all periods when compared with CG. Amount Orthodontically induced root resorption (OIRR) did not differ significantly between groups; however, pain during the first three days of alignment was significantly less in ND3G.

Orthodontic tooth movement in the presence of a mechanical stimulus depends on the remodeling of the alveolar bone and periodontal ligament. In bone remodeling, bone resorption occurs at places of stress and formation at places of tension. The magnitude of the applied force and the biological response of the periodontal ligament can control orthodontic tooth movement. Bone remodeling that occurs after the application of orthodontic force, includes the resorptive phase and bone formation in the alveolar process (Huang *et al.*, 2014).

Accelerated tooth movement in orthodontic treatment can provide benefits such as shorter treatment duration, reduced

side effects (oral hygiene problems, root resorption, and open gingival embrasure spaces), and increased post-treatment stability. Biological approaches using various pharmacological agents have been used for a long time to accelerate orthodontic tooth movement and have achieved successful results. Vitamin D and 1,25 dihydroxycholecalciferol (1,25 DHC), which is an active metabolite of vitamin D along with parathyroid hormone (PTH) and calcitonin, control total calcium and phosphorus levels. Collins and Sinclair (1988) demonstrated that intraligamentary injection of vitamin D metabolites causes an increase in the number of osteoclasts, and consequently in the rate of bone resorption,

which leads to an increase in the rate of tooth movement during canine retraction (Huang *et al.*, 2014; Raja *et al.*, 2016; Al-Attar *et al.*, 2021).

Research by Varughese *et al.* (2019) which was carried out to evaluate the clinical and radiographic effects of Vitamin D3 in 15 patients undergoing orthodontic treatment using nickel-titanium (NiTi) closed coil spring (delivering 150 mg of force) attached to the tube first molar and canine hook as the initial stage of canine distalization. This study compared the speed and total number of canine distalizations over 3 months between the experimental group given Vitamin D3 (dose 0.2 mL) and the control group given placebo gel (dose 0.2 mL) by intraligamentous injection in the distal maxillary canines (Varughese *et al.*, 2019).

In the first month, a rate of canine movement was faster on the experimental side, but not statistically significant when compared with the control side. During the second and third months, there was a faster rate of canine movement on the experimental side, which was statistically significant. These findings are in accordance with previous research that after 21 days of canine retraction with a light wire retraction spring, the teeth had moved 60% further than the control teeth. During each month, the experimental side showed a clinically higher rate of canine movement compared with the control side. The results obtained in this study during each month on the experimental side showed a clinically higher level of canine movement compared to the control side. This is in accordance with research by Collins *et al.* (1988) which shows that the effect of Vitamin D3 on tooth movement in orthodontic treatment is highest when given in doses that are relatively equivalent to normal physiological levels. (Varughese *et al.*, 2019)

Evaluation of anchorage loss is also seen on the experimental and control sides. The results show there is no significant difference on both sides. This can occur due to the application of optimal orthodontic forces and proper anchor preparation, as reported by Storey and Smith; Bohl *et al.*, and Boester and Johnston. (Varughese *et al.*, 2019)

Changes in alveolar bone density in the distal region of the canine root on the experimental and control sides were also evaluated using multi-slice spiral computed tomography at the first and third months. There was a decrease in bone density in the buccal cortical bone on the experimental side and on the control side, which was not statistically significant. There was a decrease in alveolar bone density in the palatal cortical bone on the experimental side and on the control side, which was also not statistically significant. There was a statistically significant decrease in cancellous bone density on the experimental side; However, on the control side, the decrease in cancellous bone density was not statistically significant. This may occur because the progenitors present in the hematopoietic cells can easily reach the trabecular and endosteal areas, on the bone marrow side. But on the alveolar side, progenitors can be recruited from the circulation or pre-exist in the periodontal ligament. Remodeling occurs more frequently in trabecular bone than in cortical bone. This phenomenon could have been accelerated on the experimental side due to administration of 1,25 DHC. The results showed that there was a decrease in overall alveolar bone density on the experimental and control sides with a decrease in bone density cancellous are significant on the experimental side. This research shows that Vitamin D3 can be an effective ingredient for accelerating tooth movement in orthodontic treatment Mandal *et al.* suggested that a 12-week reduction in treatment time from the median time was clinically significant in terms of efficiency. OTM is influenced by individual variations so the generalizability of the study and results is limited. Factors such as patient age, toothbrushing technique, dietary habits, and quality of tooth extraction can be considered as some potential sources of bias that may influence the rate of canine distalization. Mandal *et al.* suggested that a 12-week reduction in treatment time from the median time was clinically significant in terms of efficiency. OTM is influenced by individual variations so the generalizability of the study and results is limited. Factors such as patient age, toothbrushing technique, dietary habits, and

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Next in 2016 Dumitrel *et al.* conducted research on the effect of local administration of vitamin D3 on orthodontic tooth movement and to evaluate whether there were secondary effects on the tooth roots after administration of intraligamentous vitamin D3. This study uses six patient jaw arches to be examined and studied, namely four maxillary arches and two lower jaw arches. From the results of the examination, there were three patients with malocclusion and lack of space, requiring extraction of four first premolars and one patient whose lateral incisors were diagnosed with bilateral anodontia, which required distalization of the canines. Each maxillary and mandibular arch is divided into two quadrants; Quadrant one is the control area and quadrant two is the experimental area. In quadrants one and two NiTi closed coil springs 12 mm was applied to distalize the canine. In quadrant two, namely the experimental area, the canines were administered intra-ligamentally with vitamin D3 with the vector for administering vitamin D3 being dimethylsulfoxide, lip soluble solvent 0.2 mL given once a week for three weeks. The distillation force on each canine was measured using a dynamometer. Each patient in this study underwent three examinations cone-beam CT, that is before canine distalization, one month after, and three months after the first administration of vitamin D3 and intraoral photographs were taken every month and every week during the follow-up period. Tooth movement in this study was measured on CBCT (Ciur *et al.*, 2016).

The research that has been carried out shows that giving vitamin D3 to the

experimental tooth group can induce higher tooth movement compared to the control tooth group. In percentage terms, tooth movement was 70% higher in the experimental group. Wilcoxon test on differences in tooth movement between the two groups, test, and control showed that tooth movement was systematically more important in the test group compared to the control group. The difference between the two groups is statistically significant and may lead to the conclusion that intraligamentous administration of vitamin D3 appears to increase the speed of movement in the teeth. Additionally, no root resorption was observed three months after the first injection of vitamin D3 (Ciur *et al.*, 2016).

Intraligamentary administration was chosen to provide the effect of vitamin D3 on bone tissue metabolism at physiological doses. Lower amounts (0.2 mL) of vitamin D3 administered via the intraligamentous route were performed according to Malamed's instructions: administration of small amounts of the substance using low pressure to limit the patient's pain. According to data available in the literature, the optimal orthodontic pressure to move maxillary canines is 150-260 cN (152.9-261.01 gm) and 150-200 cN (152.9-203.874 gm) for mandibular canines (Ciur *et al.*, 2016).

Tooth movement measurements are carried out on CBCT to observe the movement of the tooth roots in 3D, not just the tooth crown. Additionally, inspection cone beam CT has been shown to be very effective in identifying early root resorption. In this study, no root resorption was observed three months after the first administration of vitamin D3. For the first time, this study brings information about the effects of vitamin D3 on roots over time follow up three months using a 3D scanner (Ciur *et al.*, 2016).

Research conducted by Gowda *et al.* (2017) to see the comparative results of the level of orthodontic tooth movement during local application of Vitamin D3 and Prostaglandin E1 (PGE1) gel. 15 patients who were indicated for bilateral maxillary first premolar extraction and had a minimum of 3 mm of extraction space

available on both sides before distalization of the maxillary permanent canines and underwent treatment with Pre-adjusted Edgewise Appliance (PEA) who have completed the leveling and alignment phase. Enmass retraction used to retract the anterior region in the 2nd phase using an active ligature placed on tube maxillary first molar and canine hook. Local administration of Vitamin D3 was given to the distal right region of the maxillary canine and PGE1 to the distal left region of the maxillary canine using ligature tucker. All patients were evaluated at baseline, week 2, and week 4 of canine retraction (Gowda *et al.*, 2017).

The results of this study showed that after 45 days, local application of vitamin D3 and PGE1 gel improved tooth movement. No clinical, microscopic, or biochemical side effects occurred. Vitamin D3 increases the number of Howship lacunae, these results are in agreement with many other studies where Vitamin D3 was found to increase the number of active osteoclasts. PGE1 is an inflammatory mediator and paracrine hormone that acts on nearby cells to stimulate bone resorption by directly increasing the number of osteoclasts. In this study there was an insignificant difference between vitamin D3 and PGE1 regarding their effect on the amount of tooth movement (Gowda *et al.*, 2017).

Research on the effects of vitamin D3 in orthodontic treatment was also carried out by Al-Attar *et al.* (2020) which aims to determine the effect of vitamin D3 levels on efficiency alignment, root resorption, and pain perception during the initial phase of orthodontic therapy. This study demonstrated a shorter time required to align mandibular incisors in the ND3G group and a higher percentage improvement of alignment at various time intervals. This study supports the effect of vitamin D3 in increasing bone remodeling, thereby accelerating tooth movement during orthodontic treatment. The effects of vitamin D3 on bone remodeling are emphasized by the effects of the active form (calcitriol) on bone metabolism, the presence of its receptors on osteoblasts, osteoclast precursors, and the fact that vitamin D3 increases bone turnover by stimulating prostaglandin production in

osteoblasts. There were no significant differences between groups regarding root resorption, therefore vitamin D levels were not among the clinical variables that are a potential contributor to OIRR (orthodontically induced root resorption). The average pain score in the first three days on ND3G was less when compared with CG during the same period (Al-Attar *et al.*, 2022).

Relapse cases that occur in patients after active orthodontic treatment have different possibilities for each patient, these relapse cases can occur partially, completely, and can even cause new malocclusions in the patient. Several studies report that administration of vitamin D can increase tooth movement during orthodontic treatment and reduce inclination relapse after orthodontic tooth movement. Vitamin D deficiency can increase bone and root cementum resorption and decrease deposition after orthodontic retention, which may play an important role in the occurrence of relapse (Khamees *et al.*, 2023).

CONCLUSION

Based on the discussion above, it can be concluded that overall, vitamin D3 is effective in accelerating tooth movement during orthodontic treatment. This is because vitamin D3 stimulates bone resorption by inducing differentiation of osteoclasts from their precursors and increasing the activity of existing osteoclasts and resulting in the speed of bone resorption which leads to an increase in the speed of tooth movement during canine retraction and after administration of vitamin D3 there is no resorption of the tooth roots. Throughout our research, there is still very little research discussing the effect of vitamin D3 on tooth movement during orthodontic treatment in humans, so further research in humans is needed.

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