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RESEARCH ARTICLE

The Association of Hypothyroidism and Periodontal Diseases in Tikrit City Patients

Takea Shaker Ahmed[1*], Raghad Tahseen Thanoon[2], Jamal K. M[3]

[1,2,3]Department of Basic science, Collage Of Dentistry, Tikrit University , Tikrit, Iraq

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***Corresponding Author:**

takea.shaker@tu.edu.iq

ABSTRACT

Periodontal disorders are inflammation caused by microbial-host interaction in tooth-supporting tissues. The most prevalent periodontal illnesses are gingivitis and periodontitis. Hypothyroidism means the thyroid gland produces too little thyroid hormones.

The objective of this study was to assess and establish a relationship between the concentrations of thyroid stimulating hormones (TSH), thyroxin (T4), and triiodothyronine (T3) in the bloodstream and the clinical periodontal parameters (plaque index, gingival index, bleeding on probing, probing pocket depth, and clinical attachment level) in patients diagnosed with chronic periodontitis (CP) and participants with a healthy gum.

The study encompassed a sample of 140 participants, with ages spanning from 20 to 45 years old. One group consisted of thirty five individuals who had both hypothyroidism and chronic periodontitis, another group consisted of thirty five individuals who had hypothyroidism but no chronic periodontitis, a third group included of thirty five individuals who had chronic periodontitis but no hypothyroidism, and the final group consisted of thirty five individuals with a clinically healthy periodontium. After conducting a clinical examination to assess periodontal health using measures such as plaque index (PLI), gingival index (GI), bleeding on probing (BOP), probing pocket depth (PPD), and clinical attachment level (CAL), blood samples were obtained from the participants. These samples were then analyzed using an automated blood analyzer to determine the concentrations of TSH, T4, and T3 hormones.

Significant statistical differences were seen in PLI, GI, BOP score1, PPD, and CAL across the four groups: hypothyroidism with CP, hypothyroidism without CP, non-hypothyroidism with CP, and the control group. The group of individuals with hypothyroidism and chronic periodontitis exhibited the highest average TSH value (7.58), whereas the control group had the lowest value (0.9). The group without hypothyroidism but with chronic periodontitis exhibited the highest average T4 value of 70.18, whereas the group with hypothyroidism but without chronic periodontitis had the lowest average value of 33.31.The average T3 level in individuals with hypothyroidism and chronic periodontitis was 2.33, whereas in the control group, it was 1.28. A moderate inverse correlation was seen between TSH, T4, and T3 levels and clinical periodontal markers.

Hypothyroidism affects oral and periodontal health, destroying the periodontium and causing periodontitis. It must be detected early to prevent disease development and oral tissue damage. If thyroid

dysfunction is discovered, therapy must be adjusted to avoid consequences.

INTRODUCTION

Periodontal disorders encompass a range of diseases that specifically target the gums, bones, and ligaments responsible for anchoring teeth in their sockets. These inflammatory problems might appear in many ways. These problems can result in systemic inflammation and, in the most severe situation, tooth loss (1, 2). The imbalance of the symbiotic oral microbiota, known as dental plaque, is the primary cause and spreader of periodontal disease. Subsequently, the immune system of the host responds to this imbalance in the microbial community, resulting in inflammation and subsequent sickness (3, 4). This pathological condition continues to exist in both active and latent stages until the involved tooth is removed or the bacterial black is eliminated by treatment, at which time the inflammation begins to diminish (5,6). Genetic predisposition is an inherent risk factor for periodontal disease, although environmental factors like as smoking can be modified. Consistent daily dental hygiene practices and professional eradication of the bacterial biofilm every three months or biannually can prevent periodontal disease (4). Current research is exploring several therapeutic methods such as antimicrobial therapy, laser therapy, host modulator therapy, and regenerative medicine (7, 8).

Hypothyroidism, also known as hypothyreosis, low thyroid, or underactive thyroid, is characterized by an inadequate synthesis of thyroid hormone to fulfil the body's metabolic needs. The symptoms of hypothyroidism can be classified into four main types: primary symptoms, which are caused by low levels of thyroid hormones; secondary symptoms, which are caused by low levels of thyroid stimulating hormone; tertiary symptoms, which are caused by low levels of thyrotropin-releasing hormone; and peripheral symptoms, which are caused by low levels of thyroxine outside of the thyroid gland. Central hypothyroidism, encompassing peripheral hypothyroidism as well as secondary and tertiary hypothyroidism, is an exceedingly uncommon condition, manifesting in fewer than 1% of cases (11). Hypothyroidism in adults can present with a diverse array of symptoms, which might vary depending on characteristics such as age, gender, and the time between the beginning of symptoms and diagnosis (12, 13). The predominant symptoms of hypothyroidism are fatigue, sluggishness, intolerance to cold, gaining weight, fecal impaction, dehydrated skin, and changes in voice.

Untreated, it can lead to severe health issues and, in the most extreme situation, mortality. Due to the lack of identifiable symptoms and wide range of clinical presentations, most definitions of hypothyroidism rely on biochemical criteria (14) instead TSH and, in certain cases, T4 levels are measured by blood tests to diagnose hypothyroidism, taking into account the symptoms. Low thyroxine levels and high TSH levels might be indicative of the hypothyroidism (15).

The thyroid, a tiny gland located in neck, produces two essential hormones. It exhibits the visual characteristics of a butterfly. Thyroxin (T4) is a thyroid hormone associated with the thyroid gland. The amount to which your body consumes energy is contingent upon the presence or lack of an abundance of T4. The anterior pituitary gland is responsible for the synthesis of TSH, which is a glycoprotein hormone. This is the main impetus behind the thyroid gland's fundamental role in producing thyroid hormone. Moreover, it has the ability to stimulate the proliferation of thyroid follicular cells, resulting in an expansion of the thyroid gland. The coordinates are (16, 15). The release of TSH is regulated by hypothalamic-pituitary axis ·

Levothyroxine, a synthetic thyroid hormone sold under several brand names such as Synthroid and Levo-T, is often used orally once day for the treatment of hypothyroidism. This oral drug helps improve symptoms of hypothyroidism by restoring hormone levels to a normal range. Improvement is expected to occur shortly after commencing therapy. This medicine has the potential to reverse weight gain associated with the illness, while also progressively reducing cholesterol levels.

Levothyroxine treatment is expected to be lifelong. However, your doctor will probably monitor your TSH level annually (17, 18) as your dosage may require adjustment .

Multiple systemic inflammatory conditions have been demonstrated to exert a reciprocal influence on periodontal disease. Conditions such as osteoporosis, diabetes, heart disease, and adverse pregnancy outcomes are encompassed within this group.1. Consequently, we postulated that hypothyroidism may influence the severity of periodontitis. Hypothyroidism was correlated with a greater prevalence of periodontal disease, as indicated by an increased number of teeth that were probed to greater depths. While assessing a patient, endocrinologists should consider the patient's clinical history or symptoms of periodontal disease. On the contrary, periodontists should consider thyroid illness while evaluating the patient (19, 20).

The objective of the present research is to evaluate and analyses the relationship between hypothyroidism and various periodontal problems. To achieve this objective, blood tests will be conducted to measure levels of TSH, T4 and T3, among other substances. The primary objective of this research is to establish a potential association between hypothyroidism and different periodontal disorders (20).

MATERIALS AND METHODS

This case-control study included of 140 patients, with ages ranging from 20 to 45. During a six-month period from January to June, participants were carefully selected from the periodontology departments of Tikrit's teaching hospitals and the Salah Al-Din Hospital.

The study enrolled patients who satisfied the following conditions: each patient possessed a minimum of twenty teeth, all teeth except for third molars were evaluated, patients with chronic periodontitis required a PPD of at least 4mm for four visits, and CAL needed to fall within the range of 1 to 2mm. Endocrinology professionals diagnosed individuals with hypothyroidism based on laboratory blood tests measuring TSH, T4, and T3 hormone levels. Those who did not show signs of gingivitis, pocket development, or CAL were deemed to have a healthy periodontium .

Individuals who engaged in smoking, had a history of alcoholism, were pregnant, were undergoing treatment for hypothyroidism, or had any other systemic illness were deemed ineligible to partake in the study. Patients who have recently taken hormone supplements during the previous 20 days, undergone periodontal therapy within the last 3 months, or used any medication for inflammation, infection, or other medical issues are ineligible to participate in this study .

The signatures of the participants on a well-designed informed consent form serve as evidence of their agreement. One group consisted of thirty five patients who had both hypothyroidism and chronic periodontitis, while another group consisted of thirty five patients who had hypothyroidism but no chronic periodontitis. A fourth group consisted of thirty five patients who had chronic periodontitis but no hypothyroidism, and the last group consisted of thirty five subjects who had a clinically healthy periodontium. The information of all participants was gathered via a specifically produced case sheet .

Following the Assessment of clinical periodontal parameters using a graduated periodontal probe, which involved the PLI (21), GI (22), BOP (22), PPD (22), and CAL (23), a 5 ml sample of venous blood was obtained from the ante-cubical fossa in a sterile environment for assessment of TSH, T4, and T3 using Roche COBA kit (Roche, German)

The research applied statistical procedures such as correlation coefficients (r), Kruskal-Wallis H test, standard deviation (SD), and mean percentages. During the execution of statistical tests, the levels are deemed significant (S) if the value of P falls between 0.01 and 0.05, nonsignificant if P value is more than 0.05, and highly significant (HS) if P is less than or equal to 0.01. We confirm that this research involving human participants has been approved by relevant institutional Ethical Committee and is in accords with the 1975 Declaration of Helsinki, as corrected in 2013.

RESULTS

Table 1 indicates that the age parameter had the greatest average value (42) among individuals with chronic periodontitis and hypothyroidism, whereas the control group had the lowest average value (25). Statistical analysis of the PLI, GI, and BOP scores across the four groups (hypothyroidism with chronic periodontitis, hypothyroidism without chronic periodontitis, non-hypothyroidism with chronic periodontitis, and the control group) demonstrated substantial variations (Table 2). Table 3 demonstrated considerable variations in TSH, T4, and T3 levels across the different groups. The mean TSH level of the control group was 0.9, which was the lowest, while the group with hypothyroidism and chronic periodontitis had the highest level at 7.58. The group without hypothyroidism and chronic periodontitis had the greatest mean T4 value (70.18), whereas the group without hypothyroidism and chronic periodontitis had the lowest mean T4 value (33.31). The T3 hormone level was the lowest in the control group, measuring 1.28, and the highest in the group with hypothyroidism and chronic periodontitis, measuring 2.33. The data is shown in Table 3. The tables (4), (5), and (6) demonstrated a moderate correlation between TSH, T4, and T3 with PLI, GI, BOP, and PPD, as well as CAL. The statistical significance of this association was quite insignificant.

Table 1: Group and control-level descriptive statistics based on age-related variables.

Groups	`No.	Mean	`SD±
Hypothyroidism+Periodontitis group	35	42	0.22
Hypothyroidism+ non-Periodontitis group	35	38	0.51
Non-Hypothyroidism+Periodontitis group	35	30	0.34
Control group	35	25	0.44

Table 2: Clinical periodontal indicators were analyzed statistically for both the study and control groups.

	PLI		GI		BOP Score1		PPD		CAL	
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD±	Mean	±SD
Hypothyrosisim +periodontitis	2.65	0.23	2.74	0.73	35.1	10.12	5.53	0.21	4.02	0.307
Hypothyroidism+nonperiodontitis	2.03	0.21	1.23	0.33	21.43	9.02	-	-	-	-
Nonhypothyroidism+periodontitis	2.33	0.53	2.03	0.53	31.19	9.021	4.12	0.42	2.68	0.213
Control group	0.27	0.03	0.42	0.13	-	-	-	-	-	-
Kruskal-Wallis H test without control group	67.21		55.05		89.34		43.44		39.31	
P- value	0.000		0.000		0.000		0.000		0.000	

Table 3: Statistical analysis of TSH, T4, T3 hormones in periodontitis and control group.

	TSH		T4		T3	
	Mean	±SD	Mean	±SD	Mean	±SD
Hypothyrosisim +Periodontitis	7.58	0.31	47.9	0.21	2.33	0.45

Hypothyrosisim +Non-periodontitis	5.67	0.34	33.31	0.26	2.90	0.53
Non-Hypothyrosisim +Periodontitis	3.41	0.11	70.18	0.37	1.67	0.28
Control group	0.9	0.4	60.07	0.31	1.28	0.72
Kruskal-Wallis H test without control group	65.17		43.32		33.12	
P-value	0.000		0.000		0.000	

Table 4: Correlation between gingivitis, chronic periodontitis, and the control group's clinical periodontal parameter and TSH mIU/L hormone level

Groups	PLI		GI		BOP Score1		PPD		CAL		Sig.
	r	p	R	p	r	p	r	p	r	p	
Hypothyroidism +Periodontitis	-0.319	0.432	-0.154	0.321	-0.239	0.091	-0.241	-0.09	-0.923	0.088	n.s
Hypothyroidism +non-Periodontitis	-0.654	0.091	-0.416	0.083	-0.171	0.314	-	-	-	-	n.s
Non-Hypothyrosisim +Periodontitis	-0.124	0.241	-0.613	0.066	-0.651	0.152	-0.324	0.233		0.011	n.s
Control group	-0.238	0.431	-0.721	0.152	-0.255	0.077	-	--	-	-	-

Table 5: Correlation between T4 nmoI/L hormone level with clinical periodontal parameter of gingivitis, chronic periodontitis and control group

Groups	**PLI**		**GI**		**BOP Score1**		**PPD**		**CAL**		**Sig.**
	r	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	
Hypothyroidism +Periodontitis	-0.213	0.091	-0.0432	0.321	-0.432	0.321	-0.210	0.065	-0.0601	0.114	n. s
Hypothyroidism +non-Periodontitis	-0.342	0.211	-0.127	0.094	-0.133	0.543	-	-	-	-	n. s
Non-Hypothyrosisim +Periodontitis	-0.455	0.075	-0.532	0.066	-0.330	0.094	-0.321	0.0421	-0.099	0.321	n. s
Control group	-0.241	0.163	-0.245	0.153	-0.521	0.144	-	--	-	-	n. s

Table 6: Correlation between gingivitis, chronic periodontitis, and control group clinical periodontal parameters and T3 nmoI/L hormone level

Groups	PLI		GI		BOP Score1		PPD		CAL		Sig.
	r	p	r	p	r	p	r	p	r	p	
Hypothyroidism +Periodontitis	-0.299	0.049	-0.180	0.533	-0.150	0.654	-0.453	0.321	-0.408	0.246	n.s
Hypothyroidism +non-Periodontitis	-0.043	0.725	-0.100	0.732	-0.220	0.123	-	-	-	-	n.s
Non-Hypothyrosisim +Periodontitis	-0.24	0.067	-0.098	0.236	-0.432	0.923	-0.531	0.146	-0.523	0.120	n.s
Control group	-0.020	0.24	-0.19	0.321	-0.230	0.312	-	--	-	-	-

DISCUSSION

Endocrinologists should consider the possibility of periodontitis, whereas periodontics should consider the possibility of thyroid illness while assessing a patient. The anticipation is that early detection and treatment of these disorders would lead to improved patient outcomes (25, 26). Hypothyroidism causes an enlarged tongue (macroglossia), periodontal disease, and slow healing of oral ulcers, tooth infections, and gum disease (27, 28).

The prevalence of adult-onset thyroid hypo function is increasing (29). Timely detection and, if possible, preventive screening are essential for preventing the detrimental effects of thyroid deficiency, such as periodontitis. Hypothyroidism can increase mobility and enlarge the gap in the periodontal membrane, both of which are factors that lead to periodontal disorders. The presence of fluid in the space between the periodontal membrane and the tooth has resulted in the development of a condition referred to as "periodontal edema." One idea suggests that enhanced serotonin metabolism, lower constrictor tone, and greater capillary permeability may all contribute to the phenomenon. Hypothyroid individuals have a reduced rate of bone turnover as a result of decreased resorption during the process of bone remodeling (30, 31). There is a suggestion that thyroid hormone can have a direct impact on osteocyte through particular nuclear receptors or an indirect impact on the activity of osteoblasts and osteoclasts by elevation the production of somatotropin and insulin-like growth factor (32,33,34). As a results, the impacted teeth shifted towards the apex .

In their study, Yerke et al. (2019) conducted a comprehensive analysis and found a positive association between hypothyroidism and periodontitis characterized by deep pockets exceeding 50- or 6-mm. Individuals with severe periodontitis may exhibit more compelling evidence of this correlation compared to individuals with mild periodontal disease (35).

Attard and Zarb conducted cross-sectional research in 2002, which found a positive connection between hypothyroidism and bone deterioration (36).

In a 2019 publication published in the Journal of the Endocrine Society, researcher Lisa Yerke discovered that individuals with hypothyroidism had a greater severity of periodontal disease, as evidenced by an increased number of teeth with probing depths. 61.4% of the teeth in patients with both periodontitis and hypothyroidism, and 48.1% of the teeth in patients without hypothyroidism, had periodontal probing depths of 5mm or greater, when measured as a proportion of the total

number of teeth. The data shows a mean difference of 13.3% with a 95% confidence interval ranging from 7.9% to 18.8% (P = 5E-06), indicating a 27.7% increase. Patients who had both periodontitis and hypothyroidism had a higher likelihood of having probing depths of 6 millimeters or more (36.2% vs. 28.2%, representing a 28.4% increase). The mean differences between the groups were 8.0%, with a 95% confidence range of 3.1% to 12.9%. The p-value was 0.002, illustrating statistically significant differences. This was in comparison to patients who did not have hypothyroidism, Moreover, animal with hypothyroidism have shown changes in osseous metabolism (38).

The study's small sample size may have led to potentially minor adverse associations.

The Research Ethical Committee, with the endorsement of Iraq's Ministries of Environment, Health, and Higher Education and Scientific Research, is responsible for clarifying ethical quandaries in scientific research.

The writers unequivocally assert that there are no conflicts of interest in response to the inquiry.

CONCLUSION

The data indicate a favorable correlation between hypothyroidism and periodontitis. The findings indicate that thyroid problems, particularly hypothyroidism, might impact the severity of periodontal diseases. Untreated hypothyroidism can result in periodontitis, a condition that can cause the deterioration of the periodontium and ultimately lead to tooth loss. The time lapse between the onset of symptoms and the initiation of treatment for thyroid problems might be critical. The proportion of teeth with a probing depth of four millimeters or more was used to identify the prevalence of periodontal diseases. The thyroid gland's hormones production has a major impact on how physiological processes are regulated. The relationship between thyroid disease—characterized by an irregularity in thyroid hormone levels—and periodontal health has not received much attention in the literature. Thyroid illness manifests as two symptoms: an imbalance in the body's equilibrium and a reduction in the tissue's capacity for healing.

REFERENCES

1- Sophie Marbiax, Assem Soueiden, Maya Roman, Gullaume Capard, Gilles Amador, Zahi Badren. Helicobacter pylori and periodontal diseases: An update and proposal of a multidisciplinary clinical protocol .Open Journal of stomatology. 2013, 3, 318-322.

2. Relationship of obstructive sleep apnea with periodontal condition and its local and systemic risk factors. Arango Jimenez N, Morales Vera DZ, Latorre Uriza C, Velosa-Porras J, Téllez Corral MA, Escobar Arregocés FM. Clin Oral Investig. 2023; 27:2823–2832. [PMC free article] [PubMed] [Google Scholar].

3. Ghada Ghalib Hussien, Omar Hisham Ali. Evaluation of Salivary Osteoprotegerin in Hypothyroidism and Periodontitis Patients Case-Control Study. The Egyptian Journal of Hospital Medicine 2023; 91: 3877-3884.

4. Astrid Nilsen, Anette Thorsnes, Stein Atle Lie. Paal Methlie, Dagmar F. Bunaes, Karen K. Reinholtsen1and Knut N. Leknes. Periodontitis in obese adults with and without metabolic syndrome: a cross-sectional study. Nilsen et al. BMC Oral Health (2023) 23:439.

5- Carranza, Newman Taki and Klokevold. Carranza's clinical periodontology. Elsvier Saunders.2015, 12th edition.

6- Carranza, Newman Taki and Klokevold. Carranza's clinical periodontology. Elsvier Saunders.2012, 11th edition, (chapter 4, p 41-42) and (chapter 27, p305- 308).

7- Noor Sabah Irhayyim, Maha Abual Aziz Ahmed, Haydar Jamal Mahmmoud. Evaluation of salivary aspartate aminotransferase enzymes levels in smoker patients with peptic ulcer in relation to periodontal condition.Research Journal of Pharmaceutical, Biological and Chemical Sciences.2018, 9(1), page No.901.

8- Ebersole JL, Stevens MJ, Dawson III D, Novak MJ. Systemic endotoxin levels in chronic periodontitis infection. J periodontal Res.2010, 45:1-7.

9. Prolonged bleeding after dental extraction due to decreased serum level of von Willebrand factor caused by untreated profound hypothyroidism. Dagdeviren Cakir A, Yildirmak ZY, Eren S,

Özdemir EM, Özdemir M, Uçar A. J Pediatr Hematol Oncol. 2023;45:0–1. [PubMed] [Google Scholar].
10. : Duda-Sobczak, A.; Zozulinska-Ziolkiewicz, D.; Wyganowska, M. Better Gingival Status in Patients with Comorbidity of Type 1 Diabetes and Thyroiditis in Comparison with Patients with Type 1 Diabetes and No Thyroid Disease—A Preliminary Study. Int. J. Environ. Res. Public Health 2023, 20, 3008. https://doi.org/10.3390/ ijerph20043008
11- Halawani M et al. Causes, Diagnosis, and Management of Hypothyroidism. The Egyptian Journal of Hospital Medicine (April 2018) Vol.71(1), Page 2250-2252.
12- Carlé A, Pedersen IB, Knudsen N, Perrild H, Ovesen L, Laurberg P. Gender differences in symptoms of hypothyroidism: a population-based DanThyr study. Clin Endocrinol 2015; 83: 717–25.
13- Carlé A, Pedersen IB, Knudsen N, et al. Hypothyroid symptoms fail to predict thyroid insufficiency in old people: a population-based case-control study. Am J Med 2016; 129: 1082–92. [PubMed: 27393881].
14- Khandelwal D, Tandon N (January 2012). "Overt and subclinical hypothyroidism: who to treat and how". Drugs (Review). 72 (1): 17–33.
15- Igari K, Kudo T, Toyofuku T, Inoue Y, Iwai T. Association between periodontitis and the development of systemic diseases. Oral Biology and Dentistry. 2014:2053–5775. [Google Scholar]
16. Farasat T, Liaqat A, Mughal T. Assessment Of Thyroid Hormones Level In Premenopausal And Postmenopausal Females. J App Pharm. 2010;1(3):165–178. [Google Scholar]
17. Vondra K, Stárka L, Hampl R. Vitamin D and Thyroid Diseases. Physiol Res. 2015;64(2):S95–S100. [PubMed] [Google Scholar]
18- Wang J, Lv S, Chen G, Gao C, He J, Zhong H, Xu Y. Meta-Analysis of the Association between Vitamin D and Autoimmune Thyroid Disease. Nutrients. 2015;7:2485–2498. [PMC free article] [PubMed] [Google Scholar]
19. Subramanium P, Jagannathan N. Oral Manifestations of Hypothyroidism. International Journal of Pharmaceutical and Clinical Research. 2014;6(4):281–283. [Google Scholar]
20. Monea A, Elod N, Sitaru A, Stoica A, Monea M. Can Thyroid Dysfunction Induce Periodontal Disease? European Scientific Journal. 2014; 10(15):1857–7431. [Google Scholar].
21. Sliness J and Löe H. Periodontal disease in pregnancy II. Acta. Odonto Scand, 1964, 24:747-749.
22. Carranza, Newman Taki and Klokevold. Carranza s clinical periodontology. Elsvier Saunders.2012, 11th edition, (chapter 4, p 41-42) and (chapter 27, p305-308).
23. American Academy of periodontology (AAP).Parameters on chronic periodontitis with slight to moderate loss of periodontal support (supplement).J periodontal. Volume. 1999, 71 no.5, P 853-8.
24. World Medical Association. Declaration of Helsinki Ethical Principles for Medical Research Involving Human Subjects. JAMA.2013, 310(20):2191 55.
25. Feitosa D, Marques M, Casati M, Sallum E, Nociti I, de Toledo S. The influence of thyroid hormones on periodontitis-related bone loss and tooth-supporting alveolar bone: a histological study in rats. J Periodont Res. 2009; 44:472–478. [PubMed] [Google Scholar]
26. Tuchendler D, Bolanowski M. The influence of thyroid dysfunction on bone metabolism. Thyroid Research. 2014; 7(12) [PMC free article] [PubMed] [Google Scholar]
27- Bizzaro G, Shoenfeld Y. Vitamin D and autoimmune thyroid diseases: facts and unresolved questions. Immunol Res. 2015; 61:46–52. [PubMed] [Google Scholar]
28-. Kim D. Low vitamin D status is associated with hypothyroid Hashimoto's thyroiditis. Hormones. 2016 [PubMed] [Google Scholar]
29. Shin D, Kim K, Kim D, Hwang S, Lee E. Low Serum Vitamin D Is Associated with Anti-Thyroid Peroxidase Antibody in Autoimmune Thyroiditis. Yonsei Med J. 2014; 55(2):476–481. [PMC free article] [PubMed] [Google Scholar]

30. Demille D, Piscitelli M, Ocker A, Vuong C, Hartner L, Lynch M. Vitamin D deficiency in the oncology setting. J Community Support Oncol. 2014;12:13–19. [PubMed] [Google Scholar]
31. Agmon-Levin N, Theodor E, Segal R, Schoenfeld Y. Vitamin D in systemic and organ-specific autoimmune diseases. Clin Rev Allergy Immunol. 2013;45:256–266. [PubMed] [Google Scholar]
32. Al-Hasani N, Al-Bustani A, Ghareeb M, Hussain S. Clinical Efficacy of Locally Injected Calcitriol In Orthodontic Tooth Movement. Int J Pharm Pharm Sci. 2011;3(5):139–143. [Google Scholar]
33. Brent G. Environmental Exposures and Autoimmune Thyroid Disease. Thyroid. 2010;20(7) [PMC free article] [PubMed] [Google Scholar]
34. Garber J, Cobin R, Gharib H, Hennessey J, Klein I, Mechanick J, Pessah-Pollack R, Singer P, Woeber K. Clinical Practice Guidelines For Hypothyroidism In Adults: Cosponsored By The American Association Of Clinical Endocrinologists And The American Thyroid Association. ATA/AACE guidelines for hypothyrodim in adults. Endoc Pract. 2012;18(8) [PubMed] [Google Scholar]
35. 1.Song E, Park M. et.al. Scientific Reports (2021) 11:22127. 10.1038/s41598-021-01682- 9.
36. Hajer A. Abdulaijan et al. Clinical and Experimental Dental Research/ Volume 6, Issue 1/p.147-157. Relationship between hypothyroidism and periodontitis. 26 September 2019.
37.Cohen R. Journal of Endocrine Society, Volume 3. Potential relationship between Dypothyroidism and Deriodontal Disease Severity. 1, April 2019, MON-616.
38. Mahajan S, Machhan P, Sood B, Taneja S, Raina R, Thakur S. Pitting edema in hypothyroidism. J Assoc physicians India. 2003;51(885) [PubMed] [Google Scholar]