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Vitamin B_{12}, folic acid, vitamin D, iron, ferritin, magnesium, and HbA1c levels in patients with diabetes mellitus and dental prosthesis

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Abstract. – OBJECTIVE: Diabetic patients may have vitamin deficiencies, which are important in the follow-up and complications of diabetes for various reasons. It may be beneficial to include the use of dental prosthesis among the parameters that should be investigated as a cause of vitamin deficiency during the management and follow-up of diabetes mellitus. We aimed to investigate the association between serum vitamin B_{12}, folic acid, 25-hydroxyvitamin D, ferritin, iron, magnesium, and HbA1c levels in diabetic patients with and without removable dental prosthesis and in non-diabetic patients with prosthesis.

PATIENTS AND METHODS: This study is a single-center case-control study. Participants were classified into the following groups: 1) Diabetic patients (n = 528) with prosthesis, 2) non-diabetic patients with prosthesis (n = 121) and 3) diabetic patients without prosthesis (n = 100). Vitamin B_{12}, 25-hydroxyvitamin D, folic acid, ferritin, iron, magnesium, and HbA1c levels were measured and compared across the groups.

RESULTS: A significant difference was observed between the groups with respect to the above parameters. Vitamin B_{12} levels were determined to be higher in the diabetic group without prosthesis. 25-hydroxyvitamin D levels were found to be significantly higher in the non-diabetic group with a prosthesis than in the other two groups. There was no statistical difference in the iron levels between the groups. Ferritin levels were observed to be significantly higher in the diabetic group with prosthesis compared to the other two groups. Magnesium levels were significantly different between all the three groups. The highest magnesium levels were found in the non-diabetic group with prosthesis. HbA1c levels were found to be higher in the diabetic group with prosthesis. Magnesium levels were correlated with 25-hydroxyvitamin D levels, but a negative correlation was observed between these and HbA1c.

CONCLUSIONS: Serum vitamin B_{12} levels were lower in the diabetic and non-diabetic groups with prosthesis compared to the diabetic group without prosthesis. 25-hydroxyvitamin D levels were lower and ferritin was higher in the diabetic groups with and without prosthesis. Magnesium levels were significantly lower in the diabetic group with a prosthesis than in the other two groups. The mean HbA1c level was higher in the diabetic group with prosthesis. The comparison of diabetic patients receiving metformin revealed a higher pronounced vitamin B_{12} deficiency in the diabetic group with prosthesis. These findings show that those diabetic patients with prosthesis should be evaluated for vitamin B_{12}, 25-hydroxyvitamin D, and magnesium deficiency.

Key Words:
Diabetes, Vitamin B12, Magnesium, HbA1c, Dental prosthesis.

Introduction

Diabetes mellitus (DM) is a common chronic disease characterized by hyperglycemia that is caused by defects in insulin secretion or insulin sensitivity. According to 2019 data from the International Diabetes Federation (IDF), there are 463 million diabetic patients in the world. It is estimated that this number will approach 700 million by 2045[1]. DM was the direct cause of approximately 1.6 million deaths worldwide in 2015[2]. Although it is considered a serious disease because of its high mortality, it is also associated with high morbidity because of various complications, such as retinopathy, nephropathy, neuropathy, and cardiovascular disease. The prevention and treatment of these complications have become important principles of modern diabetes management. Diabetic patients may have vitamin deficiencies due

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to a variety of causes. Since DM is a disease of oxidative stress, vitamin B_{12} and folic acid deficiencies can be encountered due to hyperhomocysteinemia[3]. Vitamin B_{12} deficiency can mimic peripheral neuropathy in diabetic patients and can occur in patients receiving long-term metformin therapy. 1,25-dihydroxy vitamin D mediates important functions in diabetic patients by directly or indirectly influencing insulin-producing genes. Pancreatic islet cells possess both vitamin D receptors and vitamin D-dependent calcium-binding proteins, suggesting that 25-hydroxyvitamin D [25(OH)D] affects insulin secretion. Hypomagnesemia is not rare in patients with uncontrolled diabetes. It is thought that hypomagnesemia can cause impairment in insulin signaling and hyperglycemia can cause urinary magnesium excretion[4]. It has also been suggested that hypomagnesemia may impair glucose excretion and play a role in the pathogenesis of some complications of diabetes[5]. Although the association between body iron stores and the risk of type 2 DM remains uncertain, emerging evidence suggests a strong link. Excess iron deposition in the pancreas can cause a secondary form of diabetes. A positive relationship between serum ferritin levels and the risk of type 2 DM has been reported[6]. Some scholars[7] have reported that high ferritin levels are associated with the risk of metabolic syndrome.

Oral complications may also be expected in diabetes mellitus as the oral cavity is highly vascularized and innervated. The IDF published the 'Oral Health Guidelines' promoting oral care in diabetic patients in 2009[8]. Associations between DM and several oral diseases have been reported over the last few decades. DM also delays the healing of ulcers in the oral mucosa due to microangiopathy, polymorphonuclear leukocyte dysfunction, decrease in collagen synthesis, and, especially, the increased susceptibility to candida-associated stomatitis. Other oral complications that are common in diabetic patients include xerostomia, neuropathy, gingivitis, periodontitis, periodontal abscesses, alveolar bone loss, and oral infections. When diabetes is not controlled, high glucose levels in the saliva promote the growth of harmful bacteria. The increase in HbA1c is associated with salivary hyperglycemia and tooth decay[9]. Thus, diabetic patients may have more missing teeth than non-diabetic patients, and, accordingly, dental prostheses may be required to replace missing teeth. It has been reported that 34% of diabetic patients over the age of 35 years use removable dental prostheses (RDP), while the rate of RDP use in non-diabetic individuals is 18%[10]. Dental prostheses are artificial organs that mimic the functions of the teeth. Age, as well as socioeconomic and sociodemographic factors, influence the need for prosthetic teeth. Approximately half of the adult population in most European countries have some type of prosthetic tooth and the frequency of RDP use in adults ranges from 13% to 29%[11]. According to the World Health Organization, 78% of adults over the age of 65 years are reported to be edentulous[12]. As the number of adults older than 60 years is expected to exceed 20% of the total population worldwide by 2050, the need for conventional dental prosthetic treatment is predicted to increase[13]. The prevalence of malnutrition is rising in this population and reports classify 46.2% of older adults into the malnutrition group[14]. Therefore, dental prostheses are provided to restore the lost functions and improve the quality of life. Currently, four types of dental prostheses are used: fixed prosthesis, removable prosthesis, maxillofacial prosthesis, and over-implant prosthesis. The decision regarding the type of prosthesis to be used depends on the patient's needs and anatomical condition. Since implant osseointegration is more difficult in patients with uncontrolled diabetes, RDP is recommended rather than implant-supported prostheses[15]. RDP can be easily removed and cleaned. It is classified as a partial and total prosthesis. Partial prostheses are usually supported by the remaining natural teeth. Total prostheses are typically used when no teeth are remaining in the jaw, and it is known to be less stable than the other types of dental prosthesis.

The compatibility of the applied dental prosthesis is important in improving the nutritional status by ensuring dietary adequacy and diversity[16]. The higher prevalence of hyposalivation and xerostomia in diabetic patients leads to a decrease in chewing function and diet variety by reducing prosthesis satisfaction and compliance. The biting force of a person with a total dental prosthesis during chewing is reported to be approximately one-fifth to one-sixth of the chewing ability of a dentate person[17]. Poorly applied RDP can potentially cause dissatisfaction along with certain complications. These complications include traumatic ulcers, stomatitis, abscesses, pain and cracks in the corners of the lips, loss of stability and retention in prosthetic teeth, fracture and decreased sense of taste and smell due to palate coating. All these problems influence the dietary habits that are associated with the regulation of glucose levels in diabetic patients.

This study aimed to investigate the association between serum vitamin B_{12}, folic acid, 25(OH)D, ferritin, iron, magnesium, and HbA1c levels in diabetic patients with and without RDP and non-diabetic patients with RDP, and to compare these patients with respect to the received treatments, the type of prosthesis and the duration of diabetes and prosthesis.

It was hypothesized that there would be a greater decrease in vitamin levels in diabetic patients with RDP and the presence of prosthesis would have a negative effect on glucose regulation.

Patients and Methods

Study Population

Serum samples were obtained from diabetic patients with and without RDP and non-diabetic patients with RDP aged between 34 and 88 years who presented to our outpatient clinic. Exclusion criteria included having taken vitamin and mineral supplements in the last 5 years, and being diagnosed with a disease that causes malabsorption, heart failure, chronic liver disease, or chronic kidney failure. Those in the diabetic group without RDP who had missing natural teeth or diseases that impair oral and dental health were not included in the study. In our study, possible biases were avoided by choosing appropriate groups and measurement methods as well as diligently evaluating the processes of data entry, analysis, and reporting.

Laboratory Measurements

The first group consisted of diabetic patients with RDP (n = 528), the second group consisted of non-diabetic patients with RDP (n = 121), and the third group consisted of diabetic patients without RDP (n = 100) were designed as the patient and control groups. The duration of diabetes and dental prosthesis, whether the prosthesis was total or partial, and the received treatments were compared with each other. Serum samples from the study participants were collected into empty glass biochemistry tubes between 08:00 and 10:00 in the morning and were centrifuged for 10 minutes at 4000 rpm after a 15–20-minute waiting period. The serums were separated and analyzed in the laboratory after centrifugation. Vitamin B_{12}, folic acid, and 25(OH)D levels in serum were measured by the electrochemiluminescence immunoassay (ECLIA) method on a UniCel DxI 800 device (Beckman Coulter Company, Brea, CA, USA), and iron and magnesium levels were measured on an AU5800 device (Beckman Coulter Company, Brea, CA, USA) by the spectrophotometric method and HbA1c levels were measured on a Premier Hb9210 analyzer (Trinity Biotech, Jamestown, NY, USA) by the chromatographic method. Normal serum concentrations were accepted as follows: 130-500 pg/mL for vitamin B_{12}, 3-19 ng/mL for folic acid, 25-80 ng/mL for 25(OH)D, 60-180 µg/dL for iron, 11-306 ng/mL for ferritin, 1.6-2.6 mg/dL for magnesium and 5.7-6.4% (39-47 mmol/mol) for HbA1c.

Statistical Analysis

Data obtained from the biochemical analysis were analyzed using the SPSS 22 version (IBM Corp. Armonk, NY, USA) software. One-way analysis of variance for the study population, Kruskal-Wallis, post-hoc tests, Pearson's correlation, and linear regression analyses was performed to determine the differences between groups. *p*-values less than 0.05 (95% CIs) were considered statistically significant.

Results

Table I shows baseline demographic and clinical data from the 749 participants. Vitamin B_{12}, folic acid, 25(OH)D, iron, ferritin, magnesium, and HbA1c levels were compared between the groups. A significant difference was observed between the groups in terms of vitamin B_{12}, 25(OH)D, ferritin, magnesium, and HbA1c levels (Table II).

Vitamin B_{12} levels were observed to be higher in the patients of group 3 (p=0.015) (Figure 1A). No statistically significant difference was observed between the groups in terms of folic acid levels. 25(OH)D levels were found to be significantly higher in the second group compared with the other two groups (p=0.016) (Figure 1B); however, no statistically significant difference was observed between the first and third groups with respect to the 25(OH)D level. There was no statistical difference between the groups in terms of iron levels. Ferritin levels were found to be higher in group 1 patients as compared to the other groups (p=0.029) (Figure 1C). The mean magnesium level showed a significant difference across the groups, with the highest levels in the second group, followed by the third group and the first group, respectively (p=0.000, p=0.004, and p=0.000, respectively) (Figure 1D). The comparison of HbA1c levels between the first and third

Table I. Demographic and clinical characteristics of study population.

	First group[a] (n = 528)	Second group[b] (n = 121)	Third group[c] (n = 100)	Total (n = 749)	p
Age (year),mean (SD)	63.31 (8.96)	58.75 (9.14)	56.88 (8.65)	61.72 (9.287)	0.000
Sex n (%)					0.011
Female	311 (58.9)	89 (73.6)	61 (61.0)	461 (61.5)	
Male	217 (41.1)	32 (26.4)	39 (39.0)	288 (38.5)	
Types of denture n (%)			_		0.630
Total RDP	429 (81.2)	96 (79.3)		525 (80.9)	
Partial RDP	99 (18.8)	25 (20.7)		124 (19.1)	
Prosthesis Duration n (%)					0.087
0-3 months	3 (0.6)	4 (3.3)			
4 months-1 year	44 (8.3)	10 (8.3)			
2-5 years	114 (21.6)	29 (24)			
6-10 years	93 (17.6)	26 (21.5)			
>10 years	274 (51.9)	52 (43)			
Diabetes Duration n (%)		_			0.01
0-3 months	38 (7.2)		5 (5)		
4 months-1 year	41 (7.8)		8 (8)		
2-5 years	107 (20.3)		35(35)		
6-10 years	90 (17)		18 (18)		
>10 years	252 (47.7)		34 (34)		
Treatment for Diabetes n (%)		_			0.13
OAH[d]	236 (44.7)		56 (56)	292 (39)	
İnsulin	54 (10.2)		9 (9)	63 (8.4)	
Insulin+OAH	191 (36.2)		31 (31)	222 (29.6)	
Untreated	47 (8.9)		4 (4)	51 (8.1)	

SD: standard deviation, OAH: oral antihyperglycemic agent. [a]First group: Diabetic group with RDP, [b]second group: Nondiabetic group with RDP, [c]third group: Diabetic group without RDP. [d]Oral Antihyperglycemic agent; includes metformin, sulfonylureas, pioglitazone, dipeptidyl peptidase 4 inhibitors and sodium-glucose cotransporter 2 inhibitors.

groups revealed statistically higher levels in the first group (p = 0.012) (Figure 1E). Magnesium levels were correlated with 25(OH)D levels. Meanwhile, there was a weak negative correlation between magnesium-HbA1c (p=0.000, r= -0,199) and 25(OH)D-HbA1c (p=0.000, r = -0,127) (Table III).

In the comparison of diabetic patients receiving metformin, the first group had statistically lower levels of vitamin B_{12} deficiency than the third group (p = 0,000), and lower vitamin B_{12} levels were found in metformin users in both groups (Table IV). Vitamin B_{12} levels, age, and gender correlations were not subjected to statistical analysis as the groups were not homogeneously distributed. Vitamin B_{12} levels did not differ in terms of gender in the first group. Mean vitamin B_{12} levels were analyzed according to gender, type of dental

Table II. Comparison of vitamin B12, folic acid, iron, ferritin, magnesium, 25(OH)D and HbA1c levels of the groups.

	First group (n = 528)	Second group (n = 121)	Third group (n = 100)	p
B12 (pg/ml)	184.99±56.94; 181 (48-384)	194.93±69.31; 179 (65-400)	225.54±101; 191.5 (68-607)	0.012 (1-3 groups)
Folic Acid (ng/ml)	10.08±3.85; 9 (1-23)	9.74±4.76; 8 (1-24)	10.54±4.14; 10 (4-23)	0.063
Iron (ug/dl)	63.17±29.61; 58 (1-196)	68.36±29.67; 67 (8-223)	64.44±29.97; 62 (5-172)	0.063
Ferritin (ng/ml)	76.81±88.55; 50 (2-994)	60.51±60.51; 46 (2-324)	64.90 ±67.9; 42 (3-320)	0.029 (1-2 groups)
Magnesium (mg/dl)	1.75±0.20; 1.77 (1.1-2.4)	1.92±0.16; 1.94 (1.00-2.30)	1.82±0.22; 1.86 (1.31-2.4)	0.000 (1-2.,2-3., 1.-3 groups)
25(OH)D (ng/ml)	15.63±7.84; 15 (1-83)	18.7±6.98; 17 (4-39)	16.99±8.36; 16 (2-58)	0.000 (1-2 groups)
HbA1c (%,mmol/mol)	8.39 (68)±2.06; 7.9 (5.1-18)	_	7.59 (59)±1.49; 7.2 (5-14)	0.012 (1-3 groups)

Data are mean±SD; median [min-max].

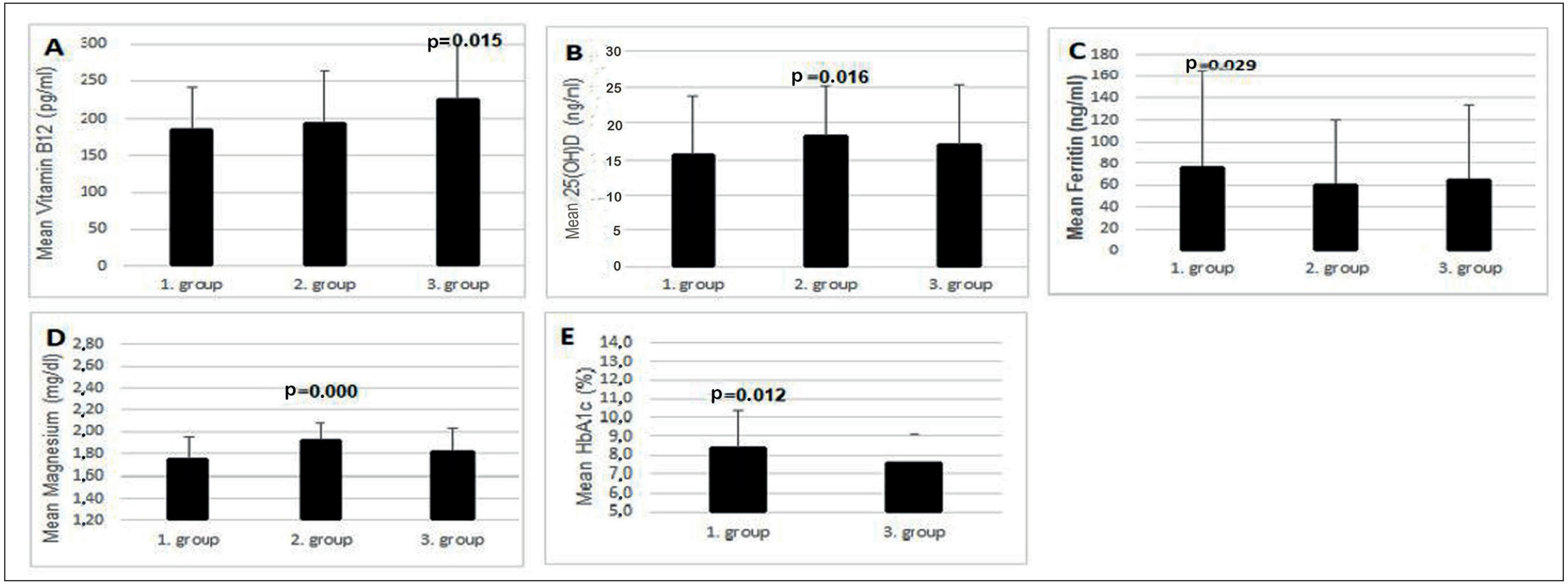

Figure 1. Comparison of mean vitamin B_{12} levels (**A**), comparison of mean 25(OH)D vitamin levels (**B**), comparison of mean ferritin levels (**C**), comparison of mean magnesium levels (**D**), comparison of mean HbA1c levels between groups (**E**).

Table III. Mean serum vitamin B_{12} level in groups 1 and 3 by metformin use or not.

		DM with RDP (n = 528)	DM without RDP (n = 100)	*p*
Metformin	Yes n (%)	179.98 (65.3%)	217.09 (80%)	0.000
	No n (%)	194.43 (34.7%)	259.35 (20%)	
		0.001	0.045	

prosthesis, and antidiabetic treatments in the first group (Table V). The mean B_{12} levels were not different across genders. There was no difference in the vitamin B_{12} levels of patients with total and partial RDP in the first group. Vitamin B_{12} levels were found to be statistically lower in patients receiving OAH alone compared with patients receiving other treatment methods in the first group (p=0.001). In the comparison of vitamin B_{12} levels according to dental prosthesis durations and DM durations, no significant associations were found between any of the groups (Figure 2).

Discussion

This study measured vitamin B_{12}, folic acid, 25(OH)D, iron, ferritin, magnesium, and HbA1c levels in a large patient population, with respect to the presence of RDP in diabetic patients and the presence of diabetes in patients with dental prosthesis. To the best of our knowledge, our study is the first in the literature in terms of the study population and the parameters researched in this population.

Vitamin B_{12} levels were found to be lower in the diabetic and non-diabetic patient groups with RDP compared to the diabetic patient group without RDP. Vitamin B_{12} levels of the diabetic group without RDP were found to be closer to the normal reference range when compared with the RDP groups, which may indicate a close association between vitamin B_{12} levels and denture use. It should also be noted that the groups with RDP, which had lower vitamin B_{12} levels, also had a higher mean age. Although the mechanism of vitamin B_{12} deficiency in the elderly has not been fully elucidated yet, the underlying causes include a decrease in vitamin B_{12} intake, intestinal bacterial overgrowth, and cobalamin malabsorption.

Vitamin D and magnesium were found to be higher in the non-diabetic group with RDP. Ferritin levels were found to be higher in the diabetic group with RDP compared to the other two groups. It should be noted that the average age was higher in the diabetic group with RDP that had higher ferritin levels. HbA1c levels were higher in the group with RDP and lower in the group without RDP among the diabetic groups. HbA1c levels were found to be higher while magnesium and vitamin D levels were low.

Nutrition plays an important role in the prevention and treatment of systemic diseases. Balanced and adequate nutrition is an important determinant of health, including immune function, cognitive function, and mortality. It also allows and maintains a high quality of life. Balanced and adequate nutrition is influenced by various biological, physiological, and pathological factors, particularly oral and dental health. The presence of natural teeth and dentures compatible with the jaw is closely related to an adequate nutrient intake, contributing to the consumption of a fiber-rich diet.

Some scholars[18] have observed that patients with dental prostheses consume less calcium, fiber,

Table IV. Comparison of mean vitamin B_{12} level by Gender, Denture Type, Treatment Method in the diabetic group with RDP.

		Mean B12 (pg/mL)	SD	*p*
Sex	Female	184.49	57.12	0.809
	Male	185.71	56.80	
RDP Type	Total	185.43	60.34	0.055
	Partia	192.82	55.68	
	Only OAH	174.24	58.62	
Treatment Method	Only insulin	197.56	55.96	0.001 [OAH-(Insulin+OAH), OAH– Insulin]
Insulin+OAH		193.44	52.95	

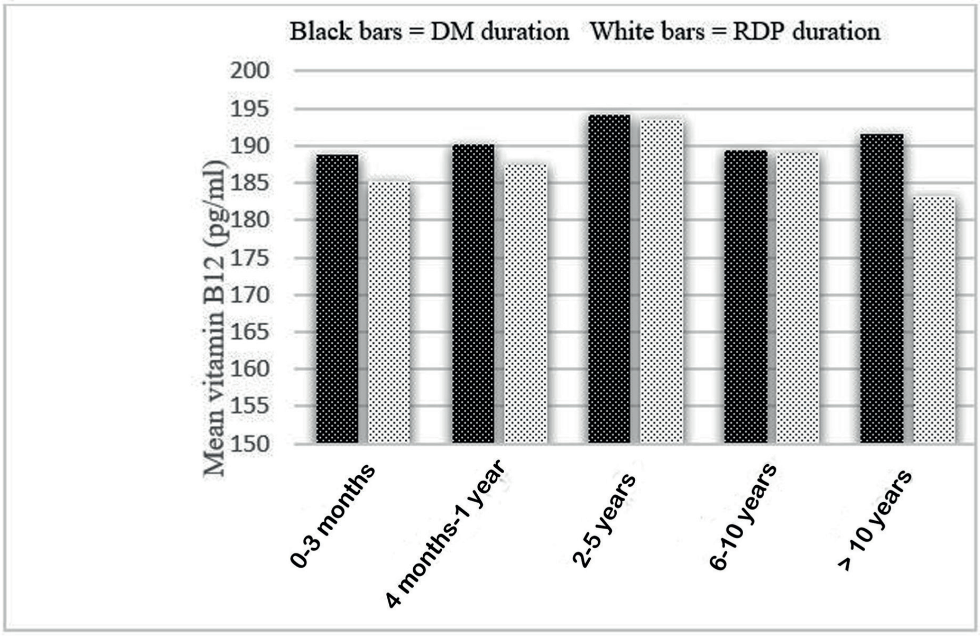

Figure 2. Comparison of mean vitamin B_{12} levels according to durations of denture usage and diabetes.

and vitamins because of their reduced intake of vegetables and fruits and reduced chewing ability. Patients using RDP may be at higher risk of malnutrition than those with normal teeth[19-21]. Sahyoun et al[22] reported that those with sufficient teeth had a better dietary quality index (healthy eating index; consumption of cereals, fruits, vegetables, meat, dairy products, etc.) than individuals with dental prostheses; however, no significant difference was observed in serum vitamin B_{12} levels. In the comparison of natural teeth, compatible prostheses and incompatible prostheses, dietary intake quality was determined to be highest in those with natural teeth, followed by compatible prostheses and incompatible prostheses, respectively. Serum vitamin C, E, and folate values were higher in the natural teeth group[23]. In the evaluation of the nutritional status in patients who received a total dental prosthesis six months prior, no decrease was observed in vitamin B_{12} and 25(OH)D levels, but a decrease in magnesium and iron levels was determined[20]. In our study, vitamin B_{12} levels were found to be lower in diabetic patients with RDP even after as little as three months. The low level of vitamins may be since our patient group was diabetic and the average age of patients in this group was higher. 25(OH)D levels were found to be lower in the diabetic groups with and without RDP. These results indicate that diabetic patients may have low 25(OH)D levels regardless of the presence of a dental prosthesis and should be followed up for 25(OH)D levels.

In a cross-sectional study on the removable prosthesis type in community-based elderly adults, the partial prosthesis was thought to be better than total prosthesis in terms of the risk of malnutrition[24]. However, in this study, vitamin B_{12}, folic acid, ferritin, iron, and magnesium levels did not differ based on the type of prosthesis. The absence of a significant difference is attributable to the potentially poor health status of the remaining natural teeth in individuals with partial dentures. Dental health is affected by many systemic diseases while also being important in the chronic courses of some of these diseases. Dental health is crucial in patients with DM, which is included in the common chronic diseases in dentistry. Oral and dental diseases are more frequent and more severe in diabetic patients; loss of teeth, reduction in chewing function, and the consequent insufficient and unbalanced nutrition complicate the diabetic metabolic control. RDP use was determined to be a risk factor for uncontrolled diabetes[25,26]. In this study, HbA1c levels were found to be significantly higher in diabetic patients with RDP. Diabetic patients with poor blood glucose control should also be examined regarding dental health and RDP use along with diet, treatment, and insulin dose adjustments. The patient should also be informed about the need for periodic den-

Table V. HbA1c Correlation with magnesium and 25(OH)D.

		HbA1c
Magnesium	r	-0.199
	p	0.000*
25 (OH)D	r	-0.127
	p	0.000*

tal check-ups for oral and dental health, prosthesis compatibility, care, and renewal need.

Since vitamins play important roles in glucose metabolism, adequate intake of these vitamins in diabetic patients is very important in the course and complications of the disease. Vitamin B_{12} levels were lower in diabetic patients[27,28]. This study did not include a healthy control group as a third control group. We compared vitamin B_{12} levels between diabetic patients according to the presence of dental prosthesis and found that vitamin B_{12} levels were lower in diabetic patients with RDP. Long-term metformin therapy increases the risk of vitamin B_{12} deficiency by causing cobalamin malabsorption[29,30]. We also investigated the use of metformin in diabetic patients. In the comparison of diabetic patients receiving metformin, vitamin B_{12} deficiency was more pronounced in the diabetic group with RDP than in the diabetic group without RDP. This may indicate that the use of dental prosthesis and receiving metformin reduce B_{12} levels further in diabetic patients. Meanwhile, lower vitamin B_{12} levels were detected in patients receiving OAH compared to insulin.

The primary role of 25(OH)D in diabetic patients is associated with insulin secretion and sensitivity, while the secondary role is thought to be related to inflammation. Despite the presence of discrepancies between studies associating serum 25(OH)D levels with the risk of DM, diabetic patients appear to have lower 25(OH)D levels[31,32]. Type 2 DM is the most common metabolic disease associated with magnesium deficiency. Hypomagnesaemia is known to be a cause of insulin resistance and DM as well as a result of hyperglycemia and has been specifically associated with chronic complications of DM. This study reported lower 25(OH)D levels in diabetic patients regardless of the presence of dental prosthesis, and magnesium levels were found to be significantly lower in the diabetic prosthetic group compared to the other groups. HbA1c was reported to have a negative association with magnesium and vitamin D levels. This negative correlation reveals the importance of magnesium and 25(OH)D in normalizing the HbA1c level in diabetic patients. These findings suggest that magnesium and vitamin D replacement may be beneficial in patients with poor glycemic control.

Ferritin levels were found to be higher in diabetic patients with RDP compared to the other groups. No significant difference was detected between the groups with respect to serum iron levels. Although serum ferritin is a good indicator of body iron stores, it may reflect the presence of inflammation caused by DM or prosthesis as it is an acute phase reactant.

Regarding the evaluation of the possible complications of diabetic patients who present for routine follow-up, a deficiency in vitamin B_{12} levels may also be due to dental prosthesis besides the pharmacological treatments and underlying malabsorption. Therefore, the presence of dental prosthesis should be investigated as one of the causes of vitamin B_{12} deficiency. We think that our study can contribute to daily practice in terms of effective treatment and dietary planning for the management of vitamin B_{12} deficiency in diabetes mellitus. In addition to vitamin B_{12}, it may be useful to monitor 25(OH)D and magnesium levels in the follow-up of DM and its complications.

Limitations

Our study is one of the few in the literature in terms of the study population and the measured parameters. The limitations of this study are as follows: it was a single-center study and a third control group, therefore, a healthy control group without DM and dental prosthesis, was not included. Hence, multi-center clinical studies with larger patient populations representing a wide geographic distribution would be more informative.

Conclusions

The prevalence of DM and the frequency of dental prosthesis are increasing. The use of dental prostheses in diabetic patients may lead to vitamin B_{12}, 25(OH)D, and magnesium deficiency, which are important in the metabolic control and complications of diabetes mellitus. It may be beneficial to include the use of prostheses among the parameters that should be questioned during the management and follow-up of diabetic patients. Therefore, more professional collaboration between endocrinologists and dentists is of great importance in countering these health problems that can be avoided with a preventive approach.

Conflict of Interest

The authors have no conflicts of interest to declare.

Authors' Contributions

S. Ciftel researched the data, contributed to the discussion, and wrote the manuscript. A. Bilen, R. Dayanan, E. Ciftel, and F. Mercantepe conducted the research and contributed to the discussion. N. Yanıkoglu contributed to the study design. I. Capoglu and H. Bilen conceived the project and made critical revisions to the manuscript. K. Kasalı contributed to data analysis.

Informed Consent

All volunteers signed a written informed consent form to participate in the study.

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Ethical Approval

This study was approved by The Research Ethics Committee of the Medical Faculty, Erzurum Atatürk University (Number: B.30.2.ATA.0.01.00/ Decision: 16/13.03.2019). The study was carried out according to the principles of the Declaration of Helsinki.

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