Type 2 diabetes mellitus and oral health: A case-control study

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Abstract

Background: Type 2 diabetes mellitus (T2DM) is one of the main causes of disability and mortality in human societies. This study aims to investigate oral health changes in patients with T2DM.

Methods*:* A total of 70 T2DM cases and 140 non-diabetic controls were selected. A questionnaire was applied to gather data of the clinical history. An oral exam was performed to determine taste disorder, xerostomia, community periodontal index (CPI), premalignant lesions of the oral cavity, geographic tongue, *candida*-related lesions, and decayed, missing, and filled teeth (DMFT) index.

Results*:* The mean age of cases and control group was 52.29±6.62 years and 49.64±12.78 years Respectively. Participants with T2DM were more likely to had a higher DMFT index [odds ratio (OR), 1.24; 95% confidence interval (95% CI), 1.11-1.38, p<0.0001], coated tongue (OR, 3.25; 95%CI, 1.08-9.79, p=0.04), and xerostomia (OR, 5.64; 95%CI, 1.01-31.50, p=0.04) compared with non-diabetic participants. Also, among diabetic patients, the use of oral diabetes medication or insulin, as well as good (HbA1c ≤ 7%) or poor glycemic control, was not associated with oral health disorders.

Conclusion*:* This study revealed that physicians should pay more attention to the oral and dental issues of diabetic patients regardless of diabetes control status.

Background

Diabetes mellitus (DM) characterized by hyperglycemia resulting from defects in insulin action, insulin secretion, or both. Over 90% of all kinds of DM is type 2 diabetes mellitus (T2DM). This metabolic disease is one of the most important problems in the health care system of countries [1]. Of note, the prevalence of T2DM in developing regions such as East Asia, South America, and the Middle East was more than in developed countries in the past decade [2, 3].

T2DM is associated with several micro and macrovascular complications, such as neuropathy, retinopathy, nephropathy, stroke, and cardiovascular diseases (CVDs). The pathogenesis of these consequences of diabetes is very complex and includes insulin resistance (IR), hyperglycemia, hyperlipidemia (HLP), hypertension (HTN), immune system dysfunction, and autoimmune disease. These disturbances mainly exert their damaging effect on the endothelial and nerve cells. Therefore, oral complications can also be expected since the oral cavity contains a rich vascular bed and nerve network [4, 5].

Oral hygiene is critical concerning T2DM because most patients are unaware of the possible oral disorders of diabetes [6, 7]. In addition, oral health is effective in controlling the glycemic index of these patients. Periodontitis is the most common oral disease and causes tooth loss in patients with T2DM [8, 9]. In this regard, Loë suggested considering periodontal disease as the sixth complication of DM in 1993 [10]. Tooth decay, oral mucosal diseases, burning mouth syndrome (BMS), and sensory and salivary

disorders are some of the problems of these patients [9, 10]. Studies had differing views on these problems and have shown wildly diverging results [4, 11].

This study aims to evaluate the prevalence and severity of oral health diseases in T2DM patients compared to non-diabetic healthy individuals. Also, we evaluate the association of oral diabetes medication or insulin use, as well as good (HbA1c ≤ 7%) or poor glycemic control, with oral disorders.

Material And Methods

Subject and materials

This case-control study was done from September 2020 until January 2022 at the Isfahan Endocrine and Metabolic Research Center, Isfahan, Iran. A group of 70 T2DM patients was cases, and 140 healthy participants was a control group. Inclusion criteria for the case group were all people with T2DM in the age range of 30 to 60 years, at least two years after the diagnosis of diabetes, who completed the consent form. There must be at least 20 teeth in the participant's mouth. Participants must have no history of periodontal treatment, oral mucosal diseases, smoking, orthodontics teeth, systemic and autoimmune diseases, taking corticosteroids and broad-spectrum antibiotics, and no history of taking drugs that have xerostomia side effects, including sympathomimetic drugs, anticholinergics, bronchodilators, and diuretics. All participants must have at least one blood test in the last 3 months from the time they visited for this study. The control group includes people with the same characteristics as the case group except for the history of T2DM. Exclusion criteria included the lack of participant cooperation with completing the questionnaire and performing the tests. The ethics council of the medical university of Isfahan provided consent for this investigation (IR.MUI.MED.REC.1398.627).

The Procedure Of Study And Clinical Examination

Selecting samples for this study was based on simple random sampling. Patients referred to the Isfahan Endocrine and Metabolic Research Center for routine examinations were used for the case group. Among the patients referred to this center, the statistical population was evaluated based on the inclusion criteria, and the sampling framework was prepared. Then, 70 T2DM patients were randomly selected as the case group using simple SPSS software. The past file of blood tests and examinations of patients besides their present blood tests were reviewed and recorded by an assistant; then, a physician asked questions from the participants based on a valid checklist. After that, a dentist examined the participant's mouth and teeth. Taste disorder, decayed, missing and filled teeth (DMFT) index, community periodontal index (CPI), premalignant lesions of the oral cavity, geographic tongue, *Candida*-related oral lesions, and xerostomia were measured and recorded by the trained dentist. The definition offered in Newman and Carranza's clinical periodontology textbook was used to determine periodontal status (16). The participants' oral cavity soft tissues showed pathologic signs of candidiasis lesions, such as various

types of oral candidiasis and associated lesions, like as denture stomatitis, angular cheilitis, median rhomboid glossitis, and complete lingual papilla atrophy.

In order to increase the accuracy of the work, the number of people in the control group was doubled, and these participants were selected from the relatives of the patients participating in the case group. Also, to reduce the risk of bias, these individuals were matched with the case group regarding age and sex. To ensure that the control group did not develop DM before the examinations, a random blood glucose test was performed for each individual by a glucometer. For this study, we took different information based on a valid checklist, including the factors mentioned in Tables 1 and 2 (Table 1 and Table 2).

Table 1
General characteristics of the participants.

Variables		Total	Non-diabetic (n = 140)	Diabetic (n = 70)	P-value
Age		46.48 ± 9.02	49.64 ± 12.78	52.29 ± 6.62	0.35
Sex	female	127(60.5)	88 (69.3)	39 (30.7)	0.32
	male	83(39.5)	52 (37.1)	31 (44.3)	
RBC		5.13 ± 0.97	5.18 ± 0.81	5.02 ± 1.22	0.33*
WBC		8361.67 ± 2387.38	8213.64 ± 1982.31	8657.71 ± 3035.54	0.68**
HbA1c		8.15 ± 2.02	-	8.15 ± 2.02	-
Platelet		274966.89 ± 113037.11	286000 ± 119802.55	262200 ± 104057.31	0.15**
TSH		3.29 ± 1.70	3.34 ± 1.28	3.18 ± 2.33	0.04**
T3		138.21 ± 46.72	138.68 ± 44.80	137.28 ± 50.66	0.73**
T4		9.41 ± 4.29	9.15 ± 3.45	9.92 ± 5.60	0.40**
Creatinine		1.11 ± 0.17	1.13 ± 0.18	1.07 ± 0.15	0.02**
ALT		32.73 ± 8.57	33.14 ± 7.44	31.93 ± 10.49	0.39*
AST		28.47 ± 5.90	28.26 ± 5.28	28.89 ± 6.99	0.51*
LDL (mg/dl)		111.29 ± 34.29	116.12 ± 23.95	101.63 ± 47.59	0.02*
HDL(mg/dl)		49.18 ± 13.03	49.53 ± 11.37	48.47 ± 15.90	0.19**
TG (mg/dl)		168.16 ± 54.40	154.72 ± 34.38	195.03 ± 74.06	< 0.0001**
Total cholesterol (mg/dl)		152.39 ± 41.85	143.55 ± 32.27	170.06 ± 52.27	0.001**

Table 2
General characteristics of the study population according to the diabetic and non-diabetic groups.

variables		Non-diabetic (N = 140)	Diabetic (70)	P-value
DMFT		8.36 ± 6.26	15.51 ± 4.53	< 0.0001
CPI	0	26 (18.6)	1 (1.4)	< 0.0001
	1	42 (30)	6 (8.6)	
	2	43 (30.7)	25 (35.7)	
	3	28 (20)	31 (44.3)	
	4	1 (0.7)	7 (10)	
Burning mouth syndrome	0	140 (100)	58 (82.9)	< 0.0001
	1	0	12 (17.1)	
Taste disturbance	0	138 (98.6)	52 (74.3)	< 0.0001
	1	2 (1.4)	18 (25.7)	
Premalignant lesions	0	140 (100)	70 (100)	-
	1	0	0	
Grooved tongue	0	96 (68.6)	26 (37.1)	< 0.0001
	1	44 (31.4)	44 (62.9)	
candida-related oral lesions	0	139 (99.3)	62 (88.6)	< 0.0001
	1	1 (0.7)	8 (11.4)	
coated tongue	0	105 (75)	36 (51.4)	0.001
	1	35 (25)	34 (48.6)	
Xerostomia	0	134 (95.7)	49 (70)	< 0.0001
	1	6 (4.3)	21 (30)	
Geographic tongue	0	114 (81.4)	51 (72.9)	0.15
	1	26 (18.6)	19 (27.1)	
mouthwash liquid use	0	116 (82.9)	60 (85.7)	0.60
	1	24 (17.1)	10 (14.3)	
Times brushing	0	58 (41.4)	31 (44.3)	0.69
	1	82 (58.6)	39 (55.7)	

variables		Non-diabetic (N = 140)	Diabetic (70)	P-value
Times flossing	0	72 (51.4)	38 (54.3)	0.70
	1	68 (48.6)	32 (45.7)	
Oral care training	0	101 (72.1)	49 (70)	0.75
	1	39 (27.9)	21 (30)	

Statistical analysis

Quantitative variables were expressed as mean ± standard deviation and qualitative variables as frequency (percentages). Mann-Whitney and chi-square tests were used to compare continuous and categorical data between the diabetic and non-diabetic groups. Also, the Mann-Whitney test and independent t-test were used to compare general characteristics between the diabetic and non-diabetic groups. Binomial logistic regression analyses were conducted to identify the association between diabetes status and other characteristics; also, among diabetic patients, binomial logistic regression analyses were conducted to identify the association between taking Insulin or oral diabetes medications, good glycemic control (HbA1c ≤ 7%) and other characteristics. Odds ratios (ORs) and 95% confidence interval (CI) were calculated. All statistical analyses were performed using SPSS 24 (SPSS Inc., Chicago, IL, USA). P-value < 0.05 considered statistically significant.

Result

Of the 210 subjects, 70 (39 female/ 31 male) were diabetic patients, and 140 (88 female/ 52 male) were healthy controls. The two groups were matched in age and gender. Demographic data of the subjects are shown in Table 1. The low-density lipoprotein cholesterol (LDL-C) level (101.63 ± 47.59 mg/dl vs. 116.12 ± 23.95 mg/dl, p = 0.02) was lower, and the triglyceride (TG) (195.03 ± 74.06 mg/dl vs. 154.72 ± 34.38 mg/dl, p < 0.0001) and total cholesterol level (170.06 ± 52.27 mg/dl vs. 143.55 ± 32.27 mg/dl, p = 0.001) were higher in diabetic patients compared with the control group, respectively. There was no significant difference in high-density lipoprotein cholesterol (HDL-C) levels between the two groups (48.47 ± 15.90 mg/dl vs. 49.53 ± 11.37 mg/dl, p = 0.19). Also, the thyroid stimulating hormone (TSH) level (3.18 ± 2.33 mIU/L vs. 3.34 ± 1.28 mIU/L, p = 0.04) and creatinine level (1.07 ± 0.15 mg/dl vs. 1.13 ± 0.18 mg/dl, p = 0.02) were lower in diabetic patients compared with the control group, respectively. There were no significant differences between the other demographic characteristics of the case and control groups (Table 1).

Dmft And Cpi

Participants with T2DM were more likely to have a higher DMFT index (OR, 1.24; 95% CI, 1.11–1.38, p < 0.0001), whereas this association was not found for CPI (OR, 0.04; 95% CI, 0.001–1.68, p = 0.11). The

mean DMFT index in diabetic participants was higher than the control group (15.51 ± 4.53 vs. 8.36 ± 6.26, $p < 0.0001$). (Table 3)

Table 3
The association between diabetes status and other characteristics.

Variables		OR(95% CI)	P-value*
Age		1.11 (1.06–1.18)	0.35
Sex	Female	Ref	0.47
	Male	1.46 (0.53–4.04)	
DMFT		1.24 (1.11–1.38)	< 0.0001
CPI	0	0.03 (0.001-1.60)	0.11
	1	0.01 (0-0.42)	
	2	0.04 (0.001–1.76)	
	3	0.04 (0.001–1.68)	
	4	Ref	
Grooved tongue	0	Ref	0.05
	1	2.89 (0.98–8.52)	
coated tongue	0	Ref	0.04
	1	3.25 (1.08–9.79)	
Xerostomia	0	Ref	0.049
	1	5.64 (1.01–31.50)	
Geographic tongue	0	Ref	0.05
	1	3.41 (0.98–11.92)	
Mouthwash liquid use	0	Ref	0.79
	1	0.81 (0.18–3.71)	
Times brushing	Poor	Ref	0.73
	Good	0.84 (0.30–2.34)	
Times flossing	0	Ref	0.97
	1	0.98 (0.36–2.67)	
Oral care training	0	Ref	0.72
	1	1.24 (0.38–4.10)	

Conditions Of The Oral Mucosa

Participants with T2DM were more likely to have coated tongue (OR, 3.25; 95%CI, 1.08–9.79, p = 0.04), and xerostomia (OR, 5.64; 95%CI, 1.01–31.50, p = 0.04) compared with non-diabetic participants. However, this association was not found for the geographic tongue (OR, 3.41; 95%CI, 0.98–11.92, p = 0.05), and grooved tongue (OR, 2.89; 95%CI, 0.98–8.52, p = 0.05). (Table 3)

The prevalence of BMS (17.1% vs. 0.0%, p < 0.0001), taste disturbance (25.7% vs. 1.4%, p < 0.0001), and *Candida*-related oral lesions (11.4% vs. 0.7%, p < 0.0001), were higher in the case group compared with non-diabetic participants. Moreover, premalignant lesions were not found in the two groups. (Table 2)

Oral Hygiene Habits

The two groups did the same number of times brushing and flossing, training in oral care, and mouthwash liquid use. (Table 2)

Also, among diabetic patients, the use of oral diabetes medication (n = 22) or insulin (n = 48), as well as good (n = 23) or poor (n = 47) glycemic control, was not associated with oral health disorders. (Table 4) (Table 5)

Table 4
The association between taking insulin or oral antiglycemic agents and other characteristics among diabetic patients.

Variables		OR(95% CI)	P-value
Age		0.99 (0.90–1.10)	0.90
Sex	Female	0.84 (0.23–3.10)	0.80
	Male	Ref	
DMFT		1.02 (0.88–1.19)	0.79
Burning mouth syndrome	0	Ref	0.74
	1	1.35 (0.23–8.01)	
Taste disturbance	0	Ref	0.76
	1	1.26 (0.27–5.82)	
Grooved tongue	0	Ref	0.83
	1	0.87 (0.24–3.08)	
candida-related oral lesions	0	Ref	0.49
	1	0.47 (0.05–4.06)	
Coated tongue	0	Ref	0.60
	1	0.73 (0.22–2.41)	
Xerostomia	0	Ref	0.90
	1	1.09 (0.27–4.33)	
Dental care training	0	Ref	0.53
	1	1.55 (0.40–6.04)	
Geographic tongue	0	Ref	0.75
	1	0.80 (0.19–3.30)	
Times brushing	Poor	Ref	0.95
	Good	0.96 (0.25–3.63)	
Times flossing	0	Ref	0.65
	1	0.76 (0.22–2.55)	

Table 5
Odds ratios (ORs) and 95% confidence intervals (95% CIs) for the association between controlling diabetic (HbA1c ≤ 7) or not and other Characteristics among diabetic patients.

Variables		OR(95% CI)	P-value
Age		0.99 (0.89–1.11)	0.87
Sex	Female	1.09 (0.24–4.92)	0.91
	Male	Ref	
DMFT		1.07 (0.91–1.26)	0.41
Burning mouth syndrome	0	Ref	0.84
	1	1.20 (0.19–7.40)	
Taste disturbance	0	Ref	0.57
	1	0.61 (0.11–3.38)	
Grooved tongue	0	Ref	0.23
	1	2.45 (0.56–10.70)	
candida-related oral lesions	0	Ref	0.94
	1	0.93 (0.11–7.51)	
Coated tongue	0	Ref	0.16
	1	0.39 (0.10–1.48)	
Xerostomia	0	Ref	0.03
	1	7.72 (1.16–51.35)	
Times brushing	Poor	Ref	0.61
	Good	1.47 (0.33–6.55)	
Times flossing	0	Ref	0.18
	1	2.52 (0.66–9.64)	
Training oral care	0	Ref	0.87
	1	1.13 (0.26–4.89)	
Geographic tongue	0	Ref	0.09
	1	5.10 (0.77–33.91)	
Liquid mouthwash use	0	Ref	0.06
	1	6.52 (0.94–45.01)	

Discussion

In this study, we found that participants with T2DM were more likely to have a higher DMFT index (OR, 1.24; 95% CI, 1.11–1.38, p < 0.0001), whereas this association was not found for CPI (OR, 0.04; 95% CI, 0.001–1.68, p = 0.11). The mean DMFT index in diabetic participants was higher than the control group (15.51 ± 4.53 vs. 8.36 ± 6.26, p < 0.0001). DMFT index has been utilized since the 1930s and is currently the most prevalent population-based metric of caries experience worldwide [4]. Increased salivary glucose level, decreased saliva flow, alteration of biochemical nature of saliva, reduction of salivary buffering effect, cariogenic diet, and bad oral hygiene have been associated with dental caries formation in diabetic patients [12]. However, there are few investigations on the epidemiology of dental caries and T2DM. Several studies have revealed an increase in the frequency of dental caries [13–15]. On the other hand, several studies did not find a significant association between dental caries and T2DM [16, 17]. Interestingly, few studies reported a higher DMFT index in the presence of HTN, IR, or HLP compared with healthy individuals [18–20]. Although the association between dental caries and T2DM is feasible, the absence of well-designed longitudinal research prohibits us from establishing causal inferences. Moreover, it is unclear whether the higher prevalence of dental caries is a direct effect of T2DM or whether other factors contribute to the association. For example, an unhealthy diet with high carbohydrate intake increases the risk for diabetes as well as dental caries.

Unlike the DMFT index, in the case of CPI, we did not find a significant association with T2DM (OR, 0.04; 95% CI, 0.001–1.68, p = 0.11). CPI, which the World Health Organization (WHO) originally developed to measure community oral health, is commonly used for periodontal screening. Patients with diabetes have higher prevalence and incidence rates of periodontitis [4]. Previous studies showed the basement membrane thickening, angiogenesis, and an increase in osmotic tissue pressure in patients with DM [4]. This supports up the hypothesis that DM might damage periodontal tissue by harming blood vessels. According to a large-scale study conducted in India, the prevalence of periodontitis was more than double in people with poorly managed diabetes compared to those with either no DM or well-controlled diabetes [21]. However, we found that good (HbA1c ≤ 7%) or poor glycemic control was not associated with oral health disorders. Of course, the small sample size may play a role in obtaining this result.

We found that participants with T2DM were more likely to have xerostomia (OR, 5.64; 95%CI, 1.01–31.50, p = 0.04), and coated tongue (OR, 3.25; 95%CI, 1.08–9.79, p = 0.04), compared with non-diabetic participants. However, this association was not found for the geographic tongue (OR, 3.41; 95%CI, 0.98–11.92, p = 0.05), and grooved tongue (OR, 2.89; 95%CI, 0.98–8.52, p = 0.05). T2DM patients frequently complain Xerostomia, the subjective impression of a dry mouth [4, 11]. Previous studies suggested the neuropathy and structural changes in the salivary glands as possible mechanisms of xerostomia in diabetes. However, studies investigating these theories present contradictory results [22–24]. Of course, older age, dehydration, and medication use are also important determinants in this association. Contrary to our findings, a number of research have demonstrated that inadequate glycemic management has a deleterious influence on both the prevalence and severity of dry mouth [11, 25]. A study in 2019 reported the presence of a blueish tongue with thick yellow fur in patients with T2DM and suggested screening of

the tongue for early detection of T2DM [26]. In this regard, decreased salivary flow rate may contribute to the coated tongue [4, 11]. Contrary to our results, a review of several studies revealed that geography and grooved tongue were correlated to diabetes [4].

In our study, prevalence of BMS (17.1% vs. 0.0%, $p < 0.0001$), taste disturbance (25.7% vs. 1.4%, $p < 0.0001$), and *Candida*-related oral lesions (11.4% vs. 0.7%, $p < 0.0001$), were higher in the case group compared with non-diabetic participants. Moreover, premalignant lesions were not found in the two groups. BMS is a chronic pain syndrome that was reported in 18.8% of T2DM patients with diabetic neuropathy, whereas others found no variations in the frequency of BMS [27, 28]. Although it is still to be proven, this may suggest that BMS is another sign of diabetic neuropathy. Xerostomia and fungal lesions are common in BMS patients [4]. Several studies found decreased taste sensation in T2DM patients [29, 30]. In this regard, since gustation is a sensory function involving the nervous system, it is likely that diabetic neuropathy is one of the underlying causes of taste alteration in these individuals. However, old age, dry mouth, and vasculopathy could contribute to taste disturbance [4]. Consequently, a lack of comprehensive longitudinal research and a multitude of common risk factors might conceal a potential relationship.). Several cross-sectional studies showed a higher prevalence of *Candida*-related lesions in diabetic patients [4, 11]. According to one study, diabetic patients had a 15% prevalence of lesions related to Candida, comparison to a 3% incidence in healthy people.) [31]. It has been shown that saliva has several innate immune defense mechanisms (mechanical washing, presence of antifungal components, and buffering capacity) to protect the oral mucosa against microorganisms such as *Candida* [4]. Therefore, hyposalivation and impaired innate immune response make diabetic patients susceptible to infections. According to epidemiologic study, the incidence of oral premalignant or malignant lesions appears to be increased in diabetes individuals) [4]. Although hyperglycemia is likely involved in the increased prevalence of oral cancer in diabetic individuals, there is relatively insufficient evidence that supports that hypothesis.) Meisel et al. demonstrated that elevated HbA1c levels are associated with an increased incidence of oral premalignant lesions. [32]. In an animal study, the number of colonic premalignant lesions was considerably reduced by inhibiting the polyol pathway, a downstream pathway of hyperglycemia [33]. It would be interesting to evaluate whether this is the case for oral mucosal tissue. However, premalignant lesions were not found in the two groups of our study, but this may be related to our relatively low sample size.

Finally, we found that, among diabetic patients, the use of oral diabetes medication or insulin, as well as good ($HbA1c \leq 7\%$) or poor glycemic control, was not associated with oral health disorders. Recently, *Verhulst et al.*, in a review of several studies, showed that oral health disorders correlate with glycemic control [4]. Therefore, hyperglycemia seems to be a driving force in the pathogenic association between oral health disorders and DM. However, this theory should be confirmed in well-designed longitudinal studies. In general, we suggest that physicians should pay more attention to the oral health issues of diabetic patients regardless of diabetes control status.

This study had some limitations, such as the study design (cross-sectional), therefore determining a causative relationship was impossible. Furthermore, the small number of participants remains a

significant drawback of this study. Finally, we did not assess other probable confounding factors such as the duration of diabetes, socioeconomic status, and nutrition status of participants. The strength of our study is the evaluation of nearly all oral and dental complications and the impact of the type of anti-glycemic treatments and glycemic control status on these disorders. Therefore, as mentioned above, if we do not know the exact pathology of oral and dental disorders in diabetic patients, programs for targeted prevention and treatment initiatives are unlikely to be successful.

Conclusion

In the present study, participants with T2DM were more likely to have a higher DMFT index, coated tongue, and xerostomia compared with non-diabetic participants. Also, among diabetic patients, the use of oral diabetes medication or insulin, as well as good (HbA1c $\leq$ 7%) or poor glycemic control, was not associated with oral health disorders. This study revealed that physicians should pay more attention to the oral and dental issues of diabetic patients regardless of diabetes control status.

Declarations

Ethics approval and consent to participate

This study was approved by ethical review committee, Medical University of Isfahan, Isfahan, Iran (IR.MUI.MED.REC.1398.627). All subjects were requested to participate in the present study after signing of informed consent form. All methods were performed in accordance with the relevant guidelines and regulations of the Declaration of Helsinki.

Consent for publication

Not applicable

Availability of data and materials

The data underlying this article can be shared on reasonable request to the corresponding author.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

MH, and EF conceived and designed research. AM, YA, and AK conducted experiments. NR and BM contributed new reagents or analytical tools. AN and HR analyzed data. DS wrote the manuscript. All

authors read and approved the manuscript and all data were generated in-house and no paper mill was used.

References

1. Sakran N, Graham Y, Pintar T, Yang W, Kassir R, Willigendael EM, et al. The many faces of diabetes. Is there a need for re-classification? A narrative review. BMC Endocr Disord. 2022;22(1):9. https://doi.org/10.1186/s12902-021-00927-y.
2. Zhu Y, Zhang C. Prevalence of gestational diabetes and risk of progression to type 2 diabetes: a global perspective. Curr Diab Rep. 2016;16(1):7. https://doi.org/10.1007/s11892-015-0699-x.
3. Mirzaei M, Salehi-Abargouei A, Mirzaei M, Mohsenpour MA. Cohort Profile: The Yazd Health Study (YaHS): a population-based study of adults aged 20–70 years (study design and baseline population data). Int J Epidemiol. 2018;47(3):697–8h. https://doi.org/10.1093/ije/dyx231.
4. Verhulst MJL, Loos BG, Gerdes VEA, Teeuw WJ. Evaluating All Potential Oral Complications of Diabetes Mellitus. Front Endocrinol (Lausanne). 2019;10:56. https://doi.org/10.3389/fendo.2019.00056.
5. Ship JA. Diabetes and oral health: an overview. J Am Dent Assoc. 2003;134:4S-10S. https://doi.org/10.14219/jada.archive.2003.0367.
6. Moore PA, Orchard T, Guggenheimer J, Weyant RJ. Diabetes and oral health promotion: a survey of disease prevention behaviors. J Am Dent Association. 2000;131(9):1333–41. https://doi.org/10.14219/jada.archive.2000.0388.
7. Sadeghi R, Taleghani F, Farhadi S. Oral health related quality of life in diabetic patients. J Dent Res Dent Clin Dent Prospects. 2014;8(4):230–4. https://doi.org/10.5681/joddd.2014.41.
8. Costa KL, Taboza ZA, Angelino GB, Silveira VR, Montenegro R Jr, Haas AN, et al. Influence of periodontal disease on changes of glycated hemoglobin levels in patients with type 2 diabetes mellitus: a retrospective cohort study. J Periodontol. 2017;88(1):17–25. https://doi.org/10.1902/jop.2016.160140.
9. Leite RS, Marlow NM, Fernandes JK, Hermayer K. Oral health and type 2 diabetes. Am J Med Sci. 2013;345(4):271–3. https://doi.org/10.1097/maj.0b013e31828bdedf.
10. Löe H. Periodontal disease: the sixth complication of diabetes mellitus. Diabetes Care. 1993;16(1):329–34.
11. Ahmad R, Haque M. Oral health messiers: Diabetes mellitus relevance. Diabetes Metab Syndr Obes. 2021;14:3001. https://doi.org/10.2147/dmso.s318972.
12. Newman MG, Takei H, Klokkevold PR, Carranza FA. Newman and Carranza's Clinical Periodontology. 13th ed. Amsterdam: Elsevier Health Sciences; 2018.
13. Rashmi B, Chinna SK, Rodrigues C, Anjaly D, Bankur PK. Oral Mucosal Changes in Type II Diabetes Mellitus Patients: A Case–control Study. Int J Oral Car Res. 2018;6(2):32–5. https://doi.org/10.4103/2231-0762.178748.

14. Singh I, Singh P, Singh A, Singh T, Kour R. Diabetes an inducing factor for dental caries: A case control analysis in Jammu. J Int Soc Prev Community Dent. 2016;6(2):125–9. https://doi.org/10.4103/2231-0762.178748.
15. Nabee Z, Jeewon R, Pugo-Gunsam P. Oral dysbacteriosis in type 2 diabetes and its role in the progression to cardiovascular disease. Afr Health Sci. 2017;17(4):1082–91. https://doi.org/10.4314/ahs.v17i4.16.
16. Collin HL, Uusitupa M, Niskanen L, Koivisto AM, Markkanen H, Meurman JH. Caries in patients with non-insulin-dependent diabetes mellitus. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1998;85(6):680–5.
17. Patiño MN, Loyola RJ, Medina SC, Pontigo LA, Reyes MJ, Ortega RJ. Caries, periodontal disease and tooth loss in patients with diabetes mellitus types 1 and 2. Acta Odontol Latinoam. 2008;21(2):127–33.
18. Cao X, Wang D, Zhou J, Yuan H, Chen Z. Relationship between dental caries and metabolic syndrome among 13 998 middle-aged urban Chinese. J Diabetes. 2017;9(4):378–85. https://doi.org/10.1111/1753-0407.12424.
19. Ribeiro LS, Santos JN, Vieira CL, Caramelli B, Ramalho LM, Cury PR. Association of dental infections with systemic diseases in Brazilian Native Indigenous: a cross-sectional study. J Am Soc Hypertens. 2016;10(5):413–19. https://doi.org/10.1016/j.jash.2016.02.012.
20. Johnston L, Vieira AR. Caries experience and overall health status. Oral Health Prev Dent. 2014;12(2):163–70. https://doi.org/10.3290/j.ohpd.a31670.
21. Nelson RG, Shlossman M, Budding LM, Pettitt DJ, Saad MF, Genco RJ, et al. Periodontal disease and NIDDM in Pima Indians. Diabetes Care. 1990;13(8):836–40. https://doi.org/10.2337/diacare.13.8.836.
22. Lilliu MA, Solinas P, Cossu M, Puxeddu R, Loy F, Isola R, et al. Diabetes causes morphological changes in human submandibular gland: a morphometric study. J Oral Pathol Med. 2015;44(4):291–5. https://doi.org/10.1111/jop.12238.
23. Monteiro MM, D'Epiro TT, Bernardi L, Fossati AC, Santos MF, Lamers ML. Long- and short-term diabetes mellitus type 1 modify young and elder rat salivary glands morphology. Arch Oral Biol. 2017;73:40–7. https://doi.org/10.1016/j.archoralbio.2016.08.028.
24. Sandberg GE, Wikblad KF. Oral dryness and peripheral neuropathy in subjects with type 2 diabetes. J Diabetes Complications. 2003;17(4):192–8. https://doi.org/10.1016/s1056-8727(02)00220-9.
25. Chávez EM, Borrell LN, Taylor GW, Ship JA. A longitudinal analysis of salivary flow in control subjects and older adults with type 2 diabetes. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2001;91(2):166–73. https://doi.org/10.1067/moe.2001.112054.
26. Hsu PC, Wu HK, Huang YC, Chang HH, Lee TC, Chen YP, et al. The tongue features associated with type 2 diabetes mellitus. Med (Baltim). 2019;98(19):e15567. https://doi.org/10.1097/md.0000000000015567.

27. Nada A, Abdel Moneim W, Fakhr M, El Sawy S. Prevalence of Burning Mouth Syndrome in A sample of Egyptian Patients with Diabetic Neuropathy: A Cross Sectional Hospital-Based Study. Adv Dent J. 2020;2(2):34–42.
28. Vesterinen M, Ruokonen H, Furuholm J, Honkanen E, Meurman JH. Clinical questionnaire study of oral health care and symptoms in diabetic vs. non-diabetic predialysis chronic kidney disease patients. Clin Oral Investig. 2012;16(2):559–63. https://doi.org/10.1007/s00784-011-0543-x.
29. Wasalathanthri S, Hettiarachchi P, Prathapan S. Sweet taste sensitivity in pre-diabetics, diabetics and normoglycemic controls: a comparative cross sectional study. BMC Endocr Disord. 2014;14:67. https://doi.org/10.1186/1472-6823-14-67.
30. De Carli L, Gambino R, Lubrano C, Rosato R, Bongiovanni D, et al. Impaired taste sensation in type 2 diabetic patients without chronic complications: a case-control study. J Endocrinol Invest. 2018;41(7):765–72. https://doi.org/10.1007/s40618-017-0798-4.
31. Guggenheimer J, Moore PA, Rossie K, Myers D, Mongelluzzo MB, Block HM, et al. Insulin-dependent diabetes mellitus and oral soft tissue pathologies: II. Prevalence and characteristics of Candida and Candidal lesions. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2000;89(5):570–6. https://doi.org/10.1067/moe.2000.104477.
32. Meisel P, Dau M, Sümnig W, Holtfreter B, Houshmand M, Nauck M, et al. Association between glycemia, serum lipoproteins, and the risk of oral leukoplakia: the population-based Study of Health in Pomerania (SHIP). Diabetes Care. 2010;33(6):1230–2. https://doi.org/10.2337/dc09-1262.
33. Saxena A, Shoeb M, Tammali R, Ramana KV, Srivastava SK. Aldose reductase inhibition suppresses azoxymethane-induced colonic premalignant lesions in C57BL/KsJ-db/db mice. Cancer Lett. 2014;355(1):141–7. https://doi.org/10.1016/j.canlet.2014.09.006.