Keywords
Type 2 diabetes mellitus; oral manifestations; periodontal disease; xerostomia; DMFT; Baghdad; Iraq

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Oral Manifestations and Dental Health Status Among Patients with Type 2 Diabetes Mellitus: A Case-Control Study from a Private Dental Clinic in Baghdad, Iraq

Abstract

Background: T2DM affects many systems in the body, and one of the areas most susceptible to chronic hyperglycaemia is the oral cavity. Despite the growing prevalence of T2DM in Iraq, there is limited research on its effects on oral health.

Aim: Assess the patterns and prevalence of oral manifestation as well as dental health status of T2DM patients presenting to a private dental clinic in Baghdad, Iraq and compare this to a similar cohort of non-diabetic patients.

Methods: 120 T2DM patients were compared to 60 age- and sex-matched non-diabetic individuals through a case-control study (Jan - Dec 2023). Complete oral examinations were performed using the Decayed, Missing, and Filled Teeth (DMFT) index, Plaque Index (PI), Gingival Index (GI), Probing Pocket Depth (PPD), Clinical Attachment Loss (CAL), and unstimulated saliva flow. Oral manifestations were thoroughly documented. Integrated glycaemic control was assessed through glycated haemoglobin (HbA1c).

Results: 81.7% of T2DM patients exhibited periodontal disease compared to 40% of non-diabetic controls (OR 6.80; 95% CI 3.28-14.10; $P < 0.001$). Diabetic patients experienced significantly higher rates of xerostomia (71.7% vs. 20%), oral candidiasis (43.3% vs. 6.7%), and burning mouth syndrome (34.2% vs. 10%). The DMFT and PPD were also considerably higher amongst diabetics (DMFT 16.3 ± 5.1 vs 9.7 ± 4.2; $P < 0.001$; PPD 4.71 ± 1.32 mm vs. 2.88 ± 0.94 mm; $P < 0.001$). Glycated haemoglobin (HbA1c) positively correlated with the DMFT, PPD, and CAL indices ($r = 0.61$, 0.63, and 0.66 respectively; all $P < 0.001$), and negatively correlated with salivary flow ($r = -0.58$; $P < 0.001$).

Conclusions: Patients with T2DM in the Baghdad exhibit a significantly poorer oral health status. There is a strong correlation between the severity of the deterioration in oral health and glycaemic control, demonstrating a need for integrated approaches to diabetic and dental health care in clinical settings throughout Iraq.

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INTRODUCTION

The challenge posed by Type 2 Diabetes Mellitus (T2DM) is one of the many non-communicable diseases that will shape the future of this century. The International Diabetes Federation (IDF) has projected that, globally, there were nearly 537 million adults living with diabetes as of 2021; furthermore, the number of adults with diabetes is expected to exceed approximately 783 million by the year 2045. As we can see from these numbers, the Middle East and North Africa (MENA) region has one of the highest age-adjusted prevalence rates; and, within the MENA region, Iraq is included in having a high prevalence rate. Recent national surveys have demonstrated that about 12–15% of adults in Iraq are living with diabetes; and as rates of urbanization, changing diets, and sedentary behaviours continue to increase, the prevalence of Type 2 Diabetes can also be expected to continue to rise as well.

Due to the scale and complexity of diabetes, there is an abundance of research and health system investments to better understand the systemic complications associated with T2DM. These systemic health complications include cardiovascular disease, nephropathy (kidney) disease, retinopathy (eye) disease, and neuropathy (nerve) disease. In the context of Iraq, the oral cavity has not historically received significant health system resources or attention, although there is an increasing volume of international studies demonstrating that the oral cavity is a major focus for hyperglycaemia-induced pathology.

The relationship between diabetes and oral health is both complex and bidirectional. Chronic hyperglycaemia creates an environment that promotes the formation of Advanced Glycation End-products (AGEs), which are long-chain proteins that link to collagen found within the periodontium, which is the anatomical structure that supports the teeth; AGEs contribute to the dysfunction of neutrophils and macrophages, which are types of white blood cells, contribute to thickening of the basement membranes of the blood vessels in the gingiva (gums), and contribute to diminishing blood and oxygen flow to the periodontal area. In conjunction with these pathophysiological changes that occur to the periodontium due to hyperglycaemia, there are changes that occur in other areas of oral health such as an increased rate of loss of periodontal tissue, delayed wound healing, changes in the normal flora of the mouth, and decreases in the ability to produce saliva.Active periodontal disease contributes to chronic low-level systemic inflammation through the continuation of increased TNF-α and IL-6 that in turn, decreases the ability of the insulin receptor to signal properly and is associated with poorer glycemic control; hence establishing a vicious cycle between periodontal disease and T2DM[8,9]. The existence of this bidirectional link is why classifying periodontitis as a sixth classic complication of Diabetes has been jointly endorsed by both the American Academy of Periodontology and the European Federation of Periodontology [10].

T2DM patients, in addition to having periodontitis, also have many other intraoral complications. Xerostomia (dry mouth via subjective report) and salivary hypofunction via objective measures are caused by a variety of processes, including autonomic neuropathy affecting innervation of the salivary glands; microangiopathy affecting the acinar blood vessels; and dehydration secondary to polyuria [11,12]. Reduced salivary flow impacts multiple changes to the oral environment, including decreasing buffering capacity and reducing the antibacterial effect of available proteins (such as lysozyme, lactoferrin and secretory IgA), along with impairing the ability to mechanically cleanse both tooth surfaces and oral mucosa; thus increasing susceptibility to dental caries, oral candidiasis and/or oral mucosal diseases [13,14]. Oral candidiasis (thrush), especially the erythematous/pseudomembranous type, occurs much more frequently in people with diabetes and has been shown to have a statistically significant relationship with hyposalivation, increased intraoral glucose levels in saliva and the crevicular fluid, and with immunocompromised states secondary to hyperglycemia [15,16].Burning mouth syndrome (BMS) is a chronic pain condition affecting the mouth and face that is characterized by the feeling of burning on the oral mucosa without an identifiable reason for the pain. This is commonly seen among diabetic patients and has been linked to diabetic peripheral neuropathy, which affects the small sensory nerves to the mouth. There are numerous reports in the literature of the presence of oral lichenoid lesions, recurrent aphthous stomatitis, and altered taste; however, the relationship between these conditions is not as well documented [18][19]. T2DM influences the risk for the development of dental caries through four main mechanisms: decrease in saliva production (hyposalivation); increased substrate availability for cariogenic microorganisms because of hyperglycemia; increased consumption of refined carbohydrates in some populations; and decreased ability to visit the dentist for regular care because of multiple health problems (i.e., comorbidities) [20].

Iraq represents an especially unique and unrecorded population for this research focus. The healthcare system in Iraq has been significantly disrupted by years of conflict, economic instability and mass displacement leading to a fractured system for chronic illness care in the country. Dental care is typically accessed through the private sector, which has become the primary delivery system for dental care across all income levels in Baghdad, Iraq [22].Throughout Iraqi private dental clinics, there is little evidence that patients are systematically screened for systemic diseases and it does not appear that any of the diabetologists are inquiring about any oral symptoms while performing outpatient consultations. In fact, there appears to be a significant disconnect between the medical and dental fields, which seems to perpetuate poor outcomes for patients suffering from Type 2 diabetes mellitus [23].

In addition to the documentation of poor oral health for patients with diabetes in Iraq, there has also been documentation of poor oral health for patients with diabetes in other surrounding countries, including: Iran, Saudi Arabia, Jordan, and Kuwait. Studies conducted in these countries have shown that patients with diabetes exhibit a higher incidence of periodontal disease, greater DMFT data, and a higher incidence of mucosal pathology than those without diabetes [24,25,26]. Additionally, the lack of consistent and homogenous data from the private

dental clinic setting in Iraq creates a challenge when developing clinical guidelines for this population. Data do exist regarding oral health outcomes of diabetic patients in Iraq; however the studies that have been completed have been small sample sizes, did not contain glycaemic biomarkers (HbA1c), and/or have not included matched non-diabetic controls, which limits the conclusiveness of the studies [27,28].

The cornerstone of glycaemic control is glycated haemoglobin (HbA1c), which represents an average of blood glucose levels for approximately the previous two to three months. When using HbA1c as an analytical variable in oral health related research, we are able to demonstrate severity of oral disease based on the level of metabolic control, thus providing more mechanistic information than simply comparing diabetic to non-diabetic individuals [29]. Research exist from numerous countries that demonstrate a positive dose-response relationship between HbA1c and periodontal indices; and, as a result, poorly controlled patients (HbA1c ≥8%) have been shown to have significantly higher probing depths, clinical attachment loss, and alveolar bone loss as compared to those with well-controlled blood glucose levels [30,31].

Therefore, in an effort to fill the gap of knowledge regarding oral health for patients diagnosed with Type 2 diabetes in Iraq, this study was conducted as a rigorously matched case-control study for patients diagnosed with Type 2 diabetes in a private dental clinic setting in Baghdad. The study was conducted to demonstrate patterns and prevalence for oral symptoms or manifestations for patients diagnosed with Type 2 diabetes, to describe differences in some of the major dental health indices between diabetic and non-diabetic patients, and to determine the relationship between the severity of oral/periodontal symptoms and HbA1c levels in this population. The findings from this study are being disseminated to aid in the development of evidence-based guidelines for oral health care practices for patients diagnosed with Type 2 diabetes in the private dental clinics of Iraq, as well as to provide baseline data for future longitudinal and intervention-based studies for patients diagnosed with Type 2 diabetes in Iraq.

METHODOLOGY

Study Design and Setting

This study was conducted as a case-control investigation at a Private Dental Clinic, located in the Al-Mansour district of Baghdad, Iraq, between January 2023 and December 2023. The clinic was selected due to its high patient throughput, availability of dedicated oral examination facilities. All participants provided written informed consent prior to enrolment. The study adhered to the Declaration of Helsinki ethical principles for medical research involving human subjects.

Participants

Cases were defined as adults (aged 30-70 years) with a confirmed diagnosis of T2DM (Type 2 Diabetes Mellitus) for a minimum of 1 year based on American Diabetes Association (ADA) criteria who received regular outpatient medical care at the same clinic. Controls included individuals who did not have DM but were receiving a regular dental checkup or needed to obtain a minor restorative dental procedure in the same clinic. Cases were matched to the control group using a 2 to 1 ratio based on age (±5 years) and sex. Case and control participants were enrolled consecutively until they reached their target sample size of 120 cases and 60 controls.

All cases needed to have either a FBG (Fasting Blood Glucose) value of ≥7.0 mmol/L on 2 occasions or an RBG (Random Blood Glucose) value ≥11.1 mmol/L with symptoms plus an HbA1c value ≥6.5% and were willing to participate in the research. Controls needed to have no history of DM but needed to have FBG <6.1 mmol/L and have an HbA1c value <5.7% at the time of enrolment in the study.

Exclusion criteria applied equally to both groups included pregnancy, current or recently (within the past 6 months) receiving an antibiotic, antifungal, or corticosteroid, current use of immunosuppressive medication,/or being diagnosed with other systemic diseases that have dental manifestations such as Sjögren syndrome, systemic lupus erythematosus, HIV/AIDS and non-healthy renal function, having a significant amount of alcohol or smoking more than 20 cigarettes per day (to eliminate possible effects from smoking, dental treatment, smoking, or alcohol specifically affecting periodontitis), having fewer than 10 remaining natural teeth (to ensure meaningful DMFT and periodontal assessments), and/or being unable to read and fill out a questionnaire.

Data Collection Instruments

Demographic details were captured on the structured Arabic-language questionnaire (e.g., age, gender, and education level) and there were diabetes-related variables (e.g., duration of diagnosis, type of treatment - insulin, oral hypoglycaemic agents, or combination; presence of known complications), oral hygiene habits (e.g., frequency of brushing teeth, using floss/interdental brushes, and dental visits), and self-reported oral symptoms (e.g., xerostomia, burning sensations, alterations in taste, and pain) included in the questionnaire.

Additionally, Xerostomia was assessed with the validated 11-item Xerostomia Inventory (XI) assessing severity of symptoms from a score of 11 (no xerostomia) to a score of 55 (severe xerostomia) (32); a score of 30 or greater is considered clinically significant xerostomia. Unstimulated whole saliva was collected over 5 minutes using the passive drool method while the patient sat up straight, with their head bent forward and instructed not to swallow saliva. Saliva was collected into pre-weighed clear polypropylene tubes and flow rates were calculated using the ml/min formula. If the unstimulated flow rate was less than 0.1 mL/min then the patient was considered to have hyposalivation.

Clinical Oral Examination

All clinical assessments were completed by one experienced clinician in order to reduce reliability between clinicians. Reliability between the clinician was determined by performing a re-assessment of 20 randomly selected participants within two weeks of the original assessment, and the intra-class correlation

coefficients (ICC) exceeded 0.88 for all continuous data, indicating very high degree of reliability. All assessments were performed under standardized artificial light using a dentist chair light, a mouth mirror, and a WHO periodontal probe (ball contact size 0.5 mm, each 3.5, 5.5, 8.5, and 11.5 mm).

Dental caries was recorded using the DMFT index using the WHO criteria for diagnostic assessment (WHO 2013). The Silness and Loe Plaque Index (PI) and Loe and Silness Gingival Index (GI) were recorded using 6 sites (Mb, B, Db, Dl, L, and Ml) for each remaining tooth except for 3rd molars. Probing Pocket Depth (PPD) was measured in mm from the gengival margin to the base of the gingival sulcus for six sites for each tooth. Clinical Attachment Loss (CAL) was determined as the sum of PPD and distance from CEJ to the gengival margin (negative when the gingival margin is above the CEJ). Periodontitis was classified using the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases, Stage I (mild), Stage II (moderate), and Stage III-IV (severe).

Mucosal lesions were assessed and diagnosed using established clinical criteria. Oral Candidiasis was diagnosed based upon the clinical finding of either white removable plaque, red, or angular cheilitis and the diagnosis was confirmed by positive cytology by Periodic Acid-Schiff (PAS) prepared at University of Baghdad Oral Pathology. Burning Mouth Syndrome was diagnosed using the ICHD-3 criteria as the presence of a burning or dysesthetic sensation for > 2 hours daily for > 3 months without an identifiable dental or medical aetiology [33]. Other mucosal findings included geographic tongue, oral lichen planus, and recurrent aphthous stomatitis and were assessed and/or diagnosed using the WHO clinical diagnostic guidelines.

Laboratory Investigations

Venous blood samples were collected to measure HbA1c levels at a private laboratory using high-performance liquid chromatography (HPLC). Glycemic control was classified according to the guidelines of the American Diabetes Association as well controlled (HbA1c <7%), moderately controlled (HbA1c 7-8.9%), and poorly controlled (HbA1c ≥9%). Fasting blood glucose was also measured concurrently.

Statistical Analysis

The data were analyzed with the IBM SPSS Statistics (v. 26.0) software (IBM Corp., Armonk, NY, USA). Continuous data were presented as mean ± SD, while categorical data were presented as frequency and percentages. We performed independent samples t-tests to compare means between two groups after confirming the data were normally distributed based on the results of the Shapiro-Wilk test, using chi-squared (χ^2) tests to compare the categorical data, or Fisher's Exact test when the expected cell frequencies were < 5. ORs with 95% CI were calculated by binary logistic regression for each oral manifestation. Pearson correlation coefficients were calculated to assess the relationship of HbA1c to measures of dental health. A p-value of < 0.05 was significant for all analyses.

RESULTS

Participant Characteristics

The final analysis included 180 total study subjects (120 T2DM study subjects and 60 control study subjects). As shown in Table 1, study subjects from each group were well matched by age (mean age of diabetic study subjects was 52.4 ± 9.8 years and mean age of control study subjects was 50.1 ± 8.6 years; p = 0.109) and sex distribution (51.7% male in diabetics vs. 53.3% in controls; p = 0.824). Of the diabetic study subjects, 31.7% had diabetes for ≤5 years, 39.2% had diabetes for 6-10 years, and 29.2% had diabetes for >10 years. Diabetic study subjects had a mean HbA1c of 8.9 ± 1.7%, which was significantly higher than the mean HbA1c for the control group (5.4 ± 0.3%; p<0.001).

Table 1. Sociodemographic and Clinical Characteristics of Study Participants

Characteristic	Diabetic n=120 (%)	Control n=60 (%)	p-value	χ^2/t
Age (mean ± SD, years)	52.4 ± 9.8	50.1 ± 8.6	0.109	1.62
Male	62 (51.7%)	32 (53.3%)	0.824	0.05
Female	58 (48.3%)	28 (46.7%)	—	—
Duration DM ≤5 years	38 (31.7%)	—	—	—
Duration DM 6–10 years	47 (39.2%)	—	—	—
Duration DM >10 years	35 (29.2%)	—	—	—
HbA1c mean ± SD (%)	8.9 ± 1.7	5.4 ± 0.3	<0.001*	18.74
Insulin use	44 (36.7%)	—	—	—
Oral hypoglycaemic only	76 (63.3%)	—	—	—

* p<0.05 statistically significant. SD = standard deviation.

Prevalence of Oral Manifestations

In other published reports, Table 2 shows the frequency of occurrences of oral findings in both groups. Of the

diabetic population, 81.7% had periodontal disease regardless of severity as compared to the control group where 40.0% had periodontal disease (OR 6.80; 95% CI 3.28-14.10; p<0.001). Moderate and severe forms of periodontitis were significantly more frequent in the diabetic population than in the control group. The second most common oral finding among people with diabetes was xerostomia 71.7% (compared to 20.0% in controls; OR 10.27; p<0.001); oral candidiasis was third on the list (43.3% compared to 6.7% in controls; OR 10.43; p<0.001) and burning mouth syndrome was fourth on the list (34.2% compared to 10.0%; OR 4.71; p<0.001). Geographic tongue, oral lichen planus and recurrent aphthous stomatitis were not statistically significant between both groups.

Table 2. Prevalence of Oral Manifestations in Diabetic Patients and Controls

Oral Manifestation	Diabetic n=120 (%)	Control n=60 (%)	OR (95% CI)	p-value
Periodontal disease (any)	98 (81.7%)	24 (40.0%)	6.80 (3.28–14.10)	<0.001*
– Mild periodontitis	27 (22.5%)	14 (23.3%)	0.95 (0.45–2.03)	0.901
– Moderate periodontitis	43 (35.8%)	8 (13.3%)	3.58 (1.55–8.27)	0.003*
– Severe periodontitis	28 (23.3%)	2 (3.3%)	8.75 (1.99–38.44)	0.004*
Xerostomia	86 (71.7%)	12 (20.0%)	10.27 (4.79–22.05)	<0.001*
Oral candidiasis	52 (43.3%)	4 (6.7%)	10.43 (3.58–30.38)	<0.001*
Burning mouth syndrome	41 (34.2%)	6 (10.0%)	4.71 (1.87–11.87)	<0.001*
Geographic tongue	18 (15.0%)	5 (8.3%)	1.95 (0.68–5.57)	0.211
Lichen planus	14 (11.7%)	3 (5.0%)	2.52 (0.69–9.20)	0.160
Recurrent aphthous stomatitis	22 (18.3%)	7 (11.7%)	1.70 (0.67–4.31)	0.264
Tooth mobility (≥Grade I)	74 (61.7%)	11 (18.3%)	7.18 (3.30–15.61)	<0.001*

* p<0.05 statistically significant. OR = Odds Ratio; CI = Confidence Interval.

Dental Health Indices

The diabetic group had significantly poorer indices of oral health than the control group. For example, the average DMFT score for diabetics was 16.3 (SD 5.1), compared to 9.7 (SD 4.2) for non-diabetics (p <0.001). Similarly, in diabetics, the average PPD and CAL were 4.71 (SD 1.32) and 4.12 (SD 1.61), respectively, while non-diabetics had scores of 2.88 (SD 0.94) and 1.53 (SD 0.87), respectively (both p <0.001). In terms of unstimulated whole saliva production, the diabetic group had a significantly lower flow rate than the control group (0.21 mL/min (SD 0.09) vs. 0.48 mL/min (SD 0.14); p <0.001).

Table 3. Comparison of Dental Health Indices Between Diabetic Patients and Controls

Dental Index	Diabetic (mean ± SD)	Control (mean ± SD)	t-value	p-value
DMFT score	16.3 ± 5.1	9.7 ± 4.2	9.02	<0.001*
– Decayed (D)	5.8 ± 2.9	3.1 ± 1.8	6.91	<0.001*
– Missing (M)	7.4 ± 3.6	4.3 ± 2.9	5.91	<0.001*
– Filled (F)	3.1 ± 1.9	2.3 ± 1.5	2.96	0.003*
Plaque Index (PI)	2.61 ± 0.48	1.74 ± 0.39	12.47	<0.001*
Gingival Index (GI)	2.28 ± 0.53	1.19 ± 0.41	14.01	<0.001*

Probing pocket depth (mm)	4.71 ± 1.32	2.88 ± 0.94	10.05	<0.001*
Clinical attachment loss (mm)	4.12 ± 1.61	1.53 ± 0.87	12.04	<0.001*
Salivary flow rate (mL/min)	0.21 ± 0.09	0.48 ± 0.14	14.96	<0.001*

* p<0.05 statistically significant. SD = standard deviation; DMFT = Decayed, Missing, and Filled Teeth.

Correlation Between HbA1c and Oral Health Parameters

HbA1c correlated strongly (r=0.61) and positively with DMFT (Decay, Missing, Filled Teeth) score and plaque index (r=0.54) and both gingival index (r=0.59) and PPD (r=0.63) and CAL (r=0.66; all correlation coefficients significant at p<0.001) indicating that higher levels of HbA1c are associated with poorer glycaemic control and greater oral disease burden. HbA1c correlated negatively (r=−0.58; p<0.001) with salivary flow rate indicating that higher levels of HbA1c are associated with lower levels of salivary output.

Table 4. Pearson Correlation Between HbA1c and Oral Health Parameters in Diabetic Patients

Variable	Pearson r (HbA1c)	p-value
DMFT score	0.61	<0.001*
Plaque Index	0.54	<0.001*
Gingival Index	0.59	<0.001*
Probing pocket depth	0.63	<0.001*
Clinical attachment loss	0.66	<0.001*
Salivary flow rate	−0.58	<0.001*
Oral candidiasis (presence)	0.47	<0.001*
Xerostomia (severity score)	0.52	<0.001*

* p<0.05 statistically significant. r = Pearson correlation coefficient.

DISCUSSION

The research outlined in this paper offers a comprehensive analysis of oral health among T2DM patients seen at a private dental clinic in Baghdad, Iraq, and constitutes one of the largest and most complete methodologically sound studies of oral health in the study's area to date. The results of this research further confirm and build upon findings obtained from other countries with regards to oral conditions in T2DM patients, showing a greater number of oral conditions, lower dental health indices, and a clear dose-response relationship between glycaemic control and oral conditions, as defined by the parameters included in this study.

In this study, periodontal disease was the most common oral condition experienced by persons with diabetes (81.7% in the diabetic cohort compared to 40.0% in the control group, OR 6.80), with individuals with T2DM having nearly nine times the likelihood of developing severe periodontitis than those without diabetes, thereby supporting the wealth of research demonstrating that periodontitis is one of the six classic complications of diabetes [10]. The pathophysiological basis for the association of periodontitis and diabetes is established as follows: through hyperglycaemia, the accumulation of advanced glycation end products (AGEs) adversely affects collagen turnover and fibroblast function within the periodontium; through microangiopathy, blood flow and oxygen delivery to the tissues of the periodontium is impaired; the neutrophils of persons with diabetes have decreased chemotaxis and phagocytic ability; and the balance of the microbiome of the subgingival area becomes dysbiotic and pro-inflammatory [5,6,7].

Additionally, studies from Saudi Arabia, Iran, and Kuwait show a prevalence of periodontal disease in T2DM patients ranging from 70–85%, which is consistent with our findings [24,25]. The only study conducted in Iraq, by Al-Mawla et al. in Mosul, found that 68% of their T2DM patients had moderate-to-severe periodontitis, which was considerably lower than our findings. It is possible that the discrepancy is due to differences in patient demographics or how clinicians classified periodontitis [27].

In the current research study, we see a mean probing pocket depth (PPD) of 4.71 mm and a clinical attachment level (CAL) of 4.12 mm. These numbers are much higher than reported averages for non-diabetic Iraqi controls and provide evidence that moderate to severe periodontitis is the most common form of periodontal disease in our population, [28] You can see this with the strong positive correlation (Pearson r = 0.63; PPD, Pearson r = 0.66; CAL) between HbA1c levels and periodontal indices that we found in our study. The strong correlation coefficients we found are similar to those reported by Preshaw et al [8] who conducted a meta-analysis of both longitudinal and cross-sectional studies and showed that there was a consistent dose response relationship between HbA1c and periodontal disease severity. The clinical significance of this finding is that improvements in glycaemic control

resulting from better medical treatment may also result in improvements in periodontal disease severity, and that improved periodontal conditions may lead to reductions in HbA1c of approximately 0.4% [34]. Therefore, comprehensive evaluation of periodontitis is an important part of managing T2DM in Iraq, and is not currently being conducted as part of routine follow-up for diabetics at the primary or secondary care level in Baghdad. [22,23]. Xerostomia was the second most frequently identified condition in our cohort of diabetic patients with a prevalence of 71.7%. This is much higher than the prevalence of xerostomia in our control cohort (20.0%) and supports the findings of López-Jornet et al [11] who found the prevalence of xerostomia in a cohort of Spanish diabetics to be 66.7%, and Al-Mawla et al [26] who found the prevalence of xerostomia in a cohort of Iraqi diabetics to be 32.7%.Xerostomia was reported among up to 60% of T2DM patients. There are multiple mechanisms for salivary gland dysfunction with T2DM; autonomic neuropathy disrupts the secretomotor innervation of the major salivary glands, which affects acinar secretion. Additionally, microangiopathic changes impede the vascular supply of salivary parenchyma and decrease secretory capacity. Poorly controlled T2DM also causes polyuria leading to a state of relative systemic dehydration and reduced salivary output. In this study, the mean unstimulated salivary flow in diabetic individuals was 0.21 ± 0.09 mL/min, which is below the well-established threshold for hyposalivation of 0.1 mL/min, and it was also substantially lower than the control mean of 0.48 ± 0.14 mL/min. The significant negative correlation found between salivary flow rate and HbA1c ($r = -0.58$; $p < 0.001$) suggests that the deterioration in glycemic control likely worsens salivary gland dysfunction and creates further detrimental changes in the oral environment.

The prevalence of oral candidiasis in diabetic patients was 43.3% compared to 6.7% in non-diabetic controls, with an odds ratio of 10.43; all cases of oral candidiasis were confirmed with a PAS-stained cytological smear. The prevalence of oral candidiasis was higher than previously documented in several Western diabetic cohorts (15%-30%), but it is consistent with reported rates from studies in other hot, high prevalence DM settings, including studies from the Arabian Gulf and North African countries.T2DM patients appear to be more likely than non-diabetic patients to develop oral candidiasis as a result of several contributing factors. First, higher blood glucose levels result in increased concentrations in saliva and in gingival crevicular fluid which are excellent sources of nutrition for Candida albicans as well as allowing the C. albicans to convert to its hyphal form, the form which is much more virulent. Lysosomal enzymes and histatins are considered antimicrobial proteins present in saliva and thus, decreased saliva will lead to lower levels of these proteins. Decreased salivary flow will also decrease the number of microbes found in saliva leading to an increased potential for the establishment of a fungal infection on the oral mucosa. Furthermore, elevated blood glucose will also impair all immune response through cytotoxic effects on the T lymphocyte and the impaired maturation of the dendritic cell, both of which play essential roles in containing fungal infections [13,16]. The high proportion of diabetic patients in the present study with oral candidiasis who also reported having xerostomia suggests that there may be a similar mechanism that contributes to both of these conditions; thus, the empirical treatment of oral candidiasis in diabetic patients should be initiated before confirmation through laboratory testing is available.

Among diabetic patients in this study, 34.2% of them experienced symptoms consistent with burning mouth syndrome; in contrast only 10.0% of the control group experienced this condition (OR 4.71; $p<0.001$). The frequency of BMS reported was significantly higher than population-based estimates ranging between 0.7% to 3.7%. Since there appears to be an increased frequency of small calibre Aδ and C diabetic neuropathies affecting the innervations of oral mucosal tissues in diabetic patients compared to non-diabetic patients, it has been postulated by Paliaga et al. [17] that BMS in diabetic patients is the result of BMS being associated with diabetic neuropathies. This relationship between BMS and diabetic neuropathies is supported by Miziara et al. [35].

The relationship between glycemic control and oral health is further supported by a strong positive correlation ($r = 0.57$) between HbA1c and xerostomia in this study, suggesting that patients with glycemic dysregulation have impaired function in both the autonomic and sensory components of oral dysfunction. As related to caries, measured by DMFT, diabetic patients had an average of 16.3 ± 5.1 DMFT, which is significantly greater than non-diabetic controls at 9.7 ± 4.2 ($p<0.001$). The most substantial difference between diabetics and non-diabetics was in caries incidence, with diabetics having significantly more (5.8 ± 2.9 vs. 3.1 ± 1.8) active lesions and therefore greater untreated caries burden compared with the increased average missing teeth in diabetics (7.4 ± 3.6). The elevated missing to decayed tooth ratio reflects the cumulative effect of long-standing diabetes leading to untreated caries and subsequent periodontal tooth loss. The synergistic effects of hyposalivation resulting in diminished buffering capacity; glucose being available in saliva and promoting the growth of Streptococcus mutans; poor utilization of dental services due to other comorbid conditions; and impaired wound healing post-restorative therapy has been cited as contributing to the increase in their DMFT score due to the effects of diabetes. A systematic review conducted by Twetman found that patients with diabetes demonstrate higher DMFT scores than non-diabetic counterparts across several study groups, with poorer outcome measures even more pronounced in low- to middle-income countries, a trend readily observed with our Baghdad sample. Furthermore, the correlation between HbA1c and DMFT score (0.61) provides evidence of glycemic control's long-term association with caries development.The diabetic group in this study displayed higher frequencies (in terms of numbers) of geographic tongue, oral lichen planus and recurrent aphthous stomatitis; however the findings did not reach statistical significance. These findings are in accordance with the larger biomedical literature that has reported associations between T2DM and the above oral conditions and is not consistently replicated from study to study, as confounding factors such as medication effects (namely lichenoid reactions due to oral hypoglycaemic agents such as sulfonylureas and metformin), immune

dysregulation and psychological comorbidities can all contribute to differences in the reported associations [18,19].

Strengths of the present study include the validated clinical indices, the use of cytological examination for confirmation of oral candidiasis, the use of HbA1c-based stratification to confirm diabetes rather than relying solely on self-reported diagnosis and finally, using a matched control group from the same clinical facility. Limitations of the present study include the cross-sectional nature of the study limiting our ability to infer causal relationships, the fact that the study was conducted in a single-centre private clinic limiting generalisability to public sector and rural diabetic populations, the exclusion of heavy smokers potentially leading to decreased estimates of periodontal disease prevalence compared to the diabetic general population of Iraq, and the potential for selection bias as those with more symptoms may preferentially seek out dental care. Future longitudinal studies incorporating microbiological sampling, salivary biomarker analysis and evaluation of the impact of periodontal treatment on glycaemic control using intervention arms will provide additional evidence to support the integration of diabetes and dental care in Iraq.

The clinical implications of the findings of this study for the private dental sector in Baghdad are significant. A comprehensive periodontal evaluation should occur for every diabetic patient presenting to a dental office as part of the standard of care. Dentists should routinely be trained to screen for undiagnosed or poorly controlled diabetes with HbA1c point-of-care testing as there remains a high prevalence of undiagnosed T2DM in Iraq [3]. Endocrinologists managing patients with T2DM should routinely refer patients for dental evaluation and include oral health education as part of the routine diabetes education provided. Collaborative care models that bridge the medical-dental divide have shown to improve both patients' periodontal status as well as their glycaemic control in international randomised controlled trials [34]. The implementation of these collaborative care models in the context of the private healthcare sector in Iraq requires urgent attention from policymakers.

CONCLUSION

Compared to controls, a cohort of T2DM patients treated at a private dental clinic in Baghdad, Iraq, showed significant deficiencies in their oral health status; there were higher rates of periodontal disease, xerostomia, oral candidiasis, and burning mouth syndrome than people who do not have diabetes. Additionally, patients with T2DM had greater DMFT scores and higher levels of plaque accumulation and periodontal indices than did non-diabetic individuals. The degree of oral decay in this group can be directly related to their HbA1c levels, indicating that poor glycaemic control is a key determinant of oral health in patients with T2DM. Therefore, these findings give strong support for standard practice to include a comprehensive evaluation of the oral health of patients with T2DM in Iraq, and for the establishment of coordinated medical-dental care pathways between the dental and private healthcare systems.

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