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Relationship between glycemic control and oral health status in patients with type 2 diabetes mellitus

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ABSTRACT

Aims: Diabetes mellitus (DM) is associated with dry mouth, reduced saliva, taste changes, and periodontal disease. This study aimed to evaluate and determine the correlation between oral health status and glycaemic control levels in patients with type 2 DM (T2DM).

Methods: This cross-sectional study was conducted on patients with T2DM aged 35-65 years. Glycemic control levels were categorized as good control (≤7% of HbA1c) and poor control (>7% of HbA1c). Full mouth plaque score (FMPS), full mouth bleeding score (FMBS), probing depth (PD), and clinical attachment level (CAL) were determined, along with xerostomia (using a standard questionnaire) and hyposalivation (using modified Schirmer test, MST).

Results: This study included 70 individuals with T2DM, comprising 49 males (70%) and 21 females (30%) with a mean age of 55.36±8.3 and 49.36±6.8 years, respectively. Among those with poor glycemic control, a significantly higher prevalence of xerostomia (52.2%), hyposalivation (47.8%), and periodontitis (moderate; 47.8% and severe; 21.7%) was observed compared with those with good control (p=0.027, 0.001, 0.007, respectively). HbA1c exhibited a significant moderate positive correlation with FMPS (r=0.447; p=0.001) and a low correlation with FMBS (r=0.283; p=0.018) and CAL (r=0.301; p=0.011).

Conclusions: The study concluded that individuals with poor glycemic control for T2DM have a higher incidence of xerostomia, hyposalivation, and compromised periodontal health, resulting in a decline in their oral health status.

Introduction

The development of type 2 diabetes mellitus (T2DM), a common metabolic disorder worldwide, is primarily driven by two key factors: dysfunctional insulin secretion from pancreatic β-cells and the resistance of insulin-sensitive tissues to insulin action (1). Periodontitis is an inflammation-induced disease affecting the supportive tissues of teeth. It is caused by specific microorganisms or groups of closely related microorganisms, leading to the gradual destruction of the periodontal ligament and alveolar bone, accompanied by increased probing depth (PD), gingival recession, or both (2). Periodontitis is the sixth consequence of diabetes mellitus (DM), and both type 1 DM (T1DM) and T2DM are significant risk factors for periodontal disease (3). Patients with T2DM may be more susceptible to or experience a more severe periodontal disease if they have poor glycemic control. Moreover, periodontitis has a systemic link with adverse cardiovascular outcomes. Furthermore, subsequent tooth loss associated with periodontitis can lead to deleterious dietary modifications, potentially worsening comorbidities in patients with T2DM (4).

Saliva, the main environment for oral flora, mechanically cleanses the remnants of nonadherent bacteria and other debris from the mouth (5). Certain medications, head and neck radiation therapy, Sjögren's disease, and other systemic conditions, including DM, may reduce salivary flow. The diabetic condition associated with prolonged hyperglycemia can infer salivary gland function and influence the amount and nature of saliva produced (6). The subjective feeling of mouth dryness is known as xerostomia (7). Of the patients with DM, 10-30% exhibit xerostomia, a condition characterized by decreased saliva production (8). Hypofunction of the salivary glands can cause changes in the oral mucosa, including elevated concentrations of glucose and mucin, a reduction in the generation of antimicrobial agents, loss of taste perception, halitosis, periodontal disease, dental caries, inefficient wound healing, and a predisposition to oral mucosal disease (9). Saliva's wide range of antibacterial agents, antibodies, and buffers gives it a protective role; hence, periodontal health can deteriorate by a decrease in its flow rate (10). Given the significant burden of oral diseases and their association with DM, oral health problems contribute to pain, impaired mastication, and xerostomia, significantly impacting the overall quality of life, loss of work productivity, and high treatment costs (11,12). Nevertheless, oral health is still a neglected and underestimated health concern globally (13). Hence, the present study aimed to assess and correlate the oral health status and glycemic control level of patients with T2DM.

Methods

Study design and patient selection

In this cross-sectional study, patients who applied to the Department of Periodontics at AB Shetty Memorial Institute of Dental Sciences, Mangalore, Karnataka, underwent screening and clinical examinations between July 2022 and June 2023. Patients in the age group of 35 to 65 years, medically diagnosed with T2DM for the past five years with good glycemic control ≤7% of glycated hemoglobin (HbA1c), and poor glycemic control of >7% of HbA1c, with a minimum complement of 20 natural teeth, were included in the study (14). Patients diagnosed with any systemic illness other than T2DM and those under medication that affects the periodontium (such as antiepileptic drugs and immunosuppressants), those who underwent periodontal therapy three months before the study, smokers, and pregnant or nursing women were excluded. The study was approved by the AB Shetty Memorial Institute of Dental Sciences Institutional Ethics Committee (ref. no: ETHICS/ABSMIDS/269/2022, date: 25.06.2022) and was conducted in compliance with the principles outlined in the Helsinki Declaration, revised in 2013. Written informed consent was obtained from the participants.

Data collection

Demographic and clinical data

Standard demographic data, including age, sex, and body mass index (BMI), were collected using a standardized proforma for the participants. Glycemic control was estimated based on HbA1c values. Participants without an HbA1c report within the past three months of the study were referred to the institution's medical center for HbA1c level measurement.

Assessment of oral health

Oral and periodontal health was assessed using the following parameters: Oral hygiene status was evaluated using the full mouth plaque score (FMPS) (15). The full mouth bleeding score (FMBS), PD, and clinical attachment level (CAL) were measured with a marked periodontal probe (UNC-15 probe, Hu-Friedy, Chicago, IL, USA) (16,17). All teeth were probed at six sites: mesio-lingual, mid-lingual, disto-lingual, mesiobuccal, mid-buccal, and distobuccal. Plaque and bleeding scores were based on the absence or presence of plaque and bleeding, respectively.

Salivary flow and xerostomia assessment

The unstimulated salivary flow rate was assessed using the MST (Schirmer strips®). This strip was adapted from the Schirmer tear test commonly used by ophthalmologists. Patients were instructed to sit upright in a dental chair, swallow all saliva before the test, refrain from swallowing during the test, and rest their tongue on the hard palate. Using a cotton plier, the MST strip was held vertically with the rounded end at the floor of the mouth on either side of the lingual frenum. The wetness of saliva ascended the strip upon contact with the round end, and its distance was measured at 1, 2, and 3 min, with the readings promptly recorded. If the strip's moisture content was <25 mm after three minutes, hyposalivation was considered (18). A 10-item questionnaire on the experience of xerostomia was used (19). Xerostomia is considered present if the patient responds positively to one or more of the following questions: Do you feel your mouth dry when you eat? Do you have difficulty swallowing food? Do you need to drink while eating? Do you feel like the amount of saliva in your mouth is too low most of the time? (adapted according to Fox criteria) (20,21).

Statistical Analysis

The collected data were analyzed using nMaster software version 2. For scale variables, data were expressed as mean and standard deviation, and for categorical variables, data were expressed as frequency percentages. The chi-square test was employed to compare xerostomia, hyposalivation, and periodontal status with glycemic control levels in patients with T2DM. Pearson's correlation was used to assess the correlation

between HbA1c and the clinical variables FMPS, FMBS, and CAL. P values less than 0.05 were considered statistically significant.

Results

Seventy patients with T2DM, comprising 49 males (70%) and 21 females (30%), participated in the study. The mean age of the participants was 53.7±8.3 years (males 55.3±8.3 and females 49.3±6.8 years, respectively). As shown in Table 1, the participants had a mean HbA1c level of 6.9±0.9 % among patients with T2DM. Notably, most participants exhibited good glycemic control (67.4%), with 32.8% demonstrating poor glycemic control. The mean PD and CAL were 2.8±1.5 mm and 4±1.5 mm, respectively. Over half (67.1%) of the T2DM patients exhibited good glycemic control. Gingivitis was present in 50% of the participants, and the remaining population had moderate-to-severe chronic periodontitis (41.4% and 8.6%, respectively). Xerostomia was reported in 65.7% of participants, whereas hyposalivation was present in only 20% of the population.

Among the participants with poor glycemic control, approximately 52.2% had xerostomia, whereas only one-fourth (24.5%) of participants with good glycemic control reported xerostomia, and the difference was statistically significant (p=0.027). Additionally, it was observed that among the T2DM individuals with poor glycemic control, approximately 47.8% had hyposalivation, whereas among those with good control, only 6.4% exhibited hyposalivation, and the distribution was statistically significant (p=0.001). Within the group of individuals exhibiting poor glycemic control, 47.8% and 21.7% had moderate and severe periodontitis, respectively. Conversely, among participants with optimal glycemic control, 59.6% developed gingivitis, whereas only 2.1% developed severe periodontitis. This distribution was statistically significant (p=0.007) (Table 2).

Table 1. Demographic and clinical characteristics of the study population

Age, years, mean±SD	
Male	55.3±8.3
Female	49.3±6.8
Overall	53.7±8.3
Sex, n (%)	
Male	49 (70)
Female	21 (30)
BMI, kg/m^2, mean±SD	
Male	25.1±5.8
Female	23.0±4.3
Overall	23.2±4.9
HbA1c, %, mean±SD	6.9±0.9
FMPS, %, mean±SD	38.7±5.3
FMBS, %, mean±SD	20.1±6.1
PD, mm, mean±SD	2.8±1.5
CAL, mm, mean±SD	4±1.5
Glycemic control, n (%)	
Good	47 (67.1)
Poor	23 (32.8)
Periodontal status, n (%)	
Gingivitis	35 (50)
Moderate periodontitis	29 (41.4)
Severe periodontitis	6 (8.6)
Xerostomia, n (%)	24 (34.3)
Hyposalivation, n (%)	14 (20)

SD: Standard deviation, BMI: Body mass index, HbA1c: Glycated hemoglobin, FMPS: Full mouth plaque scores, FMBS: Full mouth bleeding scores, PD: Probing depth, CAL: Clinical attachment level, n: Number, %: Percentage

Correlation of glycemic control with clinical variables

HbA1c had a moderate positive correlation with FMPS that was statistically significant (r=0.447; p=0.001) and a low degree of correlation with FMBS (r=0.283; p=0.018) and CAL (r=0.301; p=0.011), respectively (Pearson's correlation, statistically significant at p<0.01 and p<0.05).

Discussion

The sensation of having a dry mouth (xerostomia) is one of the most prevalent symptoms of DM (22). Hyperglycemia and diabetic neuropathy in uncontrolled T2DM can lead to xerostomia because excessive glucose is converted into sorbitol, damaging nerve cells and causing abnormalities in salivary secretion (23). The onset and progression of numerous symptoms and oral manifestations are significantly influenced by glucose regulation (24).

In this regard, the present study illustrated that the prevalence of xerostomia was higher in patients with T2DM who had poor glycemic control than those with good glycemic control. In support of the present study, an investigation by Shrivastava et al. (25) reported that individuals with T2DM exhibited a higher prevalence of xerostomia with increased HbA1c levels. However,

Table 2. Distribution of clinical conditions of the study participants based on the glycemic control levels

Clinical conditions		Glycemic control		p value
		Good	Poor	
Xerostomia, n (%)		12 (25.5)	12 (52.2)	**0.027***
Hyposalivation, n (%)		3 (6.4)	11 (47.8)	**0.001***
Periodontal status	**Gingivitis,** n (%)	28 (59.6)	7 (30.4)	**0.007***
	Moderate periodontitis, n (%)	18 (38.3)	11(47.8)	
	Severe periodontitis, n (%)	1 (2.1)	5 (21.7)	

n: Number, %: *Statistically significant

contrary to the current study findings, another study revealed no significant difference in the incidence of xerostomia reported by patients with controlled and uncontrolled T1DM and T2DM (26). Several pathological alterations, including malfunction of the salivary glands and decreased salivary production, are frequently evident in hyperglycemia (27). The current investigation revealed that patients with poorly controlled T2DM exhibited a higher number of individuals experiencing hyposalivation compared with those with good control. Al-Maweri et al. (26) observed a similar pattern in participants with T1DM or T2DM, but the results were nonsignificant. Additionally, findings from another study suggest a possible association between salivary flow and composition and poor glycemic control in patients with T2DM (28). Conversely, Dodds and Dodds (19) found no noticeable differences in the salivary flow rate of patients with T2DM.

Changes in the salivary glands driven by the detrimental effects of DM can cause a decrease in saliva, which can have adverse consequences like a higher risk of developing periodontal disease and dental caries (29). Moreover, inadequate regulation of glucose levels has been identified as a significant factor contributing to periodontitis (30). The present study revealed a higher prevalence of chronic periodontitis in individuals with T2DM who exhibited inadequate glycemic control compared with those with good glycemic control. Many hypotheses have been established to explain the plausibility of uncontrolled DM and periodontal diseases, such as host response alterations, collagen metabolism, and vascularity (31). Similarly, Awartani (32) showed an increased mean CAL in individuals with poor glycemic control compared with those with good glycemic control. Hence, the negative impact of T2DM on periodontal health increases with poorer glycemic control.

Notable alterations in poorly controlled DM include diminished defense mechanism and vulnerability to infections, ultimately resulting in destructive periodontal disease (33). Elevated glucose levels in the gingival fluid and bloodstream in individuals with DM may cause qualitative shifts in bacteria, potentially worsening the severity of periodontal disease in those with poorly controlled DM (34).

In this regard, in the current study, participants with poorly controlled T2DM had a higher number of individuals with severe periodontitis than those with good glycemic control. These results align with observations from another study, in which patients with poorly controlled T2DM had a higher prevalence of severe periodontitis (2.5%) than those with normal or good glycemic control (0%) (35). However, contrary to this, a study in an Indonesian population found no correlation between any measure of periodontitis severity and HbA1c levels in individuals with T2DM. The authors outlined several factors, such as diverse medications for blood sugar control, the potential impact of BMI on insulin resistance, and ethnic variations across different study populations, for the absence of a relationship between HbA1c and periodontitis severity (36).

The current study findings corroborate those reported by Kumar et al. (2013) (37), who observed an association between good oral hygiene and lower HbA1c levels in patients with T2DM. Qureshi et al. (2020) (38) found a significant correlation between periodontal parameters and HbA1c levels in patients with T2DM, similar to the present findings. Another cross-sectional study further substantiated the findings of the current study. The study revealed that participants with T2DM and poor glycemic control exhibited higher mean plaque, bleeding, and CAL (39).

Study Limitations

The main limitation of this study is that it only included a convenience sample of patients with DM from a particular institution. Consequently, these findings may not be fully generalizable to individuals with diabetes in other geographic regions. Future longitudinal studies are warranted to explore causality and better understand the dynamics over time. Second, the questionnaire we used to determine xerostomia was subjective. Third, we were not able to evaluate socioeconomic status, including occupation and education level, the frequency of dental checkup visits, and awareness of the connections between oral and systemic diseases that determine oral health.

Conclusion

The study concluded that individuals with poor glycemic control for T2DM have a higher incidence of xerostomia, hyposalivation, and compromised periodontal health, resulting in a decline in their oral health status. These findings suggest that poor glycemic control negatively impacts oral health. More comprehensive observational studies are required to explore oral health concerns and associated factors among individuals with T2DM.

Ethics

Ethics Committee Approval: The study was approved by the AB Shetty Memorial Institute of Dental Sciences Institutional Ethics Committee (ref. no: ETHICS/ABSMIDS/269/2022, date: 25.06.2022) and was conducted in compliance with the principles outlined in the Helsinki Declaration, revised in 2013.

Informed Consent: Written consent was obtained from the participants, who were informed about the study objectives.

Authorship Contributions

Concept: B.A.K., N.S., A.S., Design: B.A.K., N.S., A.S., Data Collection or Processing: B.A.K., K.S.C., Analysis or Interpretation: B.A.K., N.S., Literature Search: B.A.K., N.S., K.S.C., Writing: B.A.K., N.S., K.S.C.

Conflict of Interest: No conflict of interest was declared by the authors.

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