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The Impact of Oral Hygiene on Dental Caries among Patients with Type 2 Diabetes Mellitus: A Study in Alkhoms Municipality

Haytham MeelaAnweeji Ghameedh[1], Atia Ramadan Elkilany[2], Ahlam Abdelwahab Zareg[3]
[1]Periodontology and Oral Biology, Faculty of Dentistry, Elmergib University
[2]Biology, Faculty of Education, Elmergib University
[3]Biomedical,

hhaaamm19881416@gmail.com

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Abstract

Dental caries continues to represent one of the most prevalent chronic diseases globally, exerting a substantial influence on patients' overall quality of life. Patients diagnosed with type 2 diabetes mellitus (T2DM) are particularly susceptible to oral complications, including dental caries, owing to the deleterious effects of prolonged hyperglycemia on the oral microenvironment and host immune competence. Given this heightened vulnerability, elucidating the interplay between oral hygiene behavior and caries prevalence within this population is essential for the development of more effective preventive interventions. This study sought to examine the relationship between oral hygiene practices and the prevalence and severity of dental caries among patients with T2DM. An analytical cross-sectional design was adopted, conducted among 289 T2DM patients in Alkhoms, Libya. Data were obtained through a structured questionnaire complemented by a thorough full-mouth clinical examination, with caries burden assessed via the Decayed, Missing, and Filled Teeth (DMFT) index. The study sample comprised 289 patients with a mean age of 37.0 ± 4.1 years, of whom 68.9% exhibited poor glycemic control, with a mean HbA1c level of 8.1 ± 1.8%. Female participants demonstrated marginally higher DMFT scores relative to their male counterparts. Suboptimal oral hygiene practices were widely prevalent across the sample, and significantly elevated DMFT scores were closely associated with infrequent toothbrushing and limited dental attendance. Notably, a strong positive correlation emerged between DMFT scores and HbA1c levels (r = 0.885). Regression analysis further identified HbA1c level and brushing frequency as the most significant predictors of DMFT outcomes. Collectively, these findings underscore the protective role of adequate oral hygiene in mitigating dental caries among T2DM patients. Accordingly, the incorporation of oral health education into routine diabetes management protocols is recommended to optimize oral health outcomes within this clinically vulnerable population.

Keywords: Oral hygiene, Dental caries, Type 2 Diabetes Mellitus, DMFT index

الملخص

يُعدّ تسوس الأسنان من أكثر الأمراض المزمنة شيوعًا على مستوى العالم، وله تأثيرٌ طويل الأمد على حياة المرضى. ويُعتبر مرضى السكري من النوع الثاني أكثر عرضةً للإصابة بمضاعفات الفم، مثل تسوس الأسنان، نتيجةً لارتفاع مستوى السكر في الدم لفترات طويلة، مما يُغيّر بيئة الفم ويُضعف جهاز المناعة. لذا، من المهم تحديد العلاقة بين نظافة الفم وحدوث تسوس الأسنان لدى هؤلاء الأفراد المعرضين للخطر، وذلك لتحسين سبل الوقاية منه. هدفت هذه الدراسة إلى استكشاف العلاقة بين ممارسات نظافة الفم وحدوث تسوس الأسنان وشدته لدى مرضى السكري من النوع الثاني. استخدمت الدراسة تحليلًا مقطعيًا في مدينة الخمس (ليبيا)، حيث تمّ اختيار 289 مريضًا مصابًا بالسكري من النوع الثاني. وتمّ جمع البيانات من خلال استبيان

مُنظّم وفحص سريري شامل للفم، حيث تمّ تقييم مُحدّدات تسوس الأسنان باستخدام مؤشرDMFT. شملت هذه الدراسة 289 مريضًا مصابًا بالسكري من النوع الثاني. كان متوسط العمر 37.0 ± 4.1 سنة، وبلغت نسبة من يعانون من ضعف السيطرة على مستوى السكر في الدم 68.9%. وبلغ متوسط مستوى الهيموجلوبين السكري 8.1 ± 1.8. (HbA1c) وسجلت الإناث درجات أعلى قليلاً في مؤشر تسوس الأسنان (DMFT) مقارنةً بالذكور. وشاعت ممارسات النظافة الفموية السيئة بين المشاركين. وارتبطت درجات مؤشر تسوس الأسنان المرتفعة ارتباطًا وثيقًا بانخفاض وتيرة تنظيف الأسنان بالفرشاة وقلة زيارات طبيب الأسنان. ووجدت علاقة ارتباط إيجابية قوية بين مؤشر تسوس الأسنان ومستوى الهيموجلوبين السكري (r = 0.885).وحدد تحليل الانحدار مستوى الهيموجلوبين السكري ووتيرة تنظيف الأسنان بالفرشاة كأقوى مؤشرين للتنبؤ بمؤشر تسوس الأسنان. تشير نتائج هذه الدراسة إلى أن تحسين النظافة الفموية يرتبط بانخفاض مستويات تسوس الأسنان لدى مرضى السكري من النوع الثاني. لذا، ينبغي إدراج التثقيف الصحي الفموي ضمن بروتوكولات رعاية مرضى السكري لدعم تحسين نتائج صحة الفم.

الكلمات المفتاحية: نظافة الفم، تسوس الأسنان، داء السكري من النوع الثاني، مؤشر DMFT

Introduction

Tooth decay (dental caries) is one of the most common chronic diseases in the world, affecting individuals of all age groups worldwide (*Shiferaw et al., 2022; Zhou et al., 2024*). Dental caries occurs when high-sugar diets contribute to the demineralization of tooth structure due to bacteria producing acids through the fermentation of dietary sugars. If untreated, dental caries can result in severe pain and infection and eventually loss of teeth (*Zhou et al., 2024*). In addition, dental caries can decrease an individual's ability to eat a healthy diet and reduce their overall quality of life, which places a significant burden on individuals and society as a whole (*Shiferaw et al., 2022; Zhou et al., 2024*). Dental caries is a global issue, yet several systemic conditions may influence the risk of developing or worsening this condition. An example is Type 2 Diabetes Mellitus (T2DM), a metabolic disease that results in prolonged hyperglycemia an increased risk of oral complications (including dental caries) has recently been associated with T2DM (*Petropoulou et al., 2024; Frias-Bulhosa et al., 2025*). Evidence from recent systematic reviews and meta-analyses shows that the DMFT scores for individuals with T2DM are significantly higher than those of non-diabetic individuals (*Frias-Bulhosa et al., 2025; Weijdijk et al., 2023*). One proposed explanation is that chronic hyperglycemia alters the oral environment, causing changes in both the quantity and quality of saliva and a higher concentration of glucose in the saliva resulting in a more favorable environment for acidogenic bacterial growth, such as Streptococcus mutans, and therefore, greater susceptibility to dental caries (*Petropoulou et al., 2024; Frias-Bulhosa et al., 2025*). The relationship between diabetes and oral health is complex due to the existence of a reciprocal relationship between them; where poor oral health interferes with the diabetic patient's ability to maintain glycemic control; thus, resulting in a bidirectional interaction that contributes to poor control over diabetes for patients with T2DM (*Petropoulou et al., 2024*).

Good oral hygiene is associated with a lower prevalence of dental caries among patients with T2DM.The key to reducing the negative impact on the teeth from changes in salivary flow and decreased immune response due to T2DM is to regularly remove plaque from the

teeth and maintain a balanced oral microbiota in the mouth (*Petropoulou et al., 2024; Frias-Bulhosa et al., 2025*). Numerous studies have consistently demonstrated that poor oral hygiene is strongly associated with an increased prevalence of dental caries in those with diabetes (*Zhou et al., 2024*). Many patients with diabetes remain unaware of how important oral health is, which leads to neglecting oral care, resulting in advanced periodontal disease and creates the need to develop additional oral health education programs for those with diabetes (*Petropoulou et al., 2024*).

Understanding how oral hygiene status can affect dental caries in patients with Type 2 Diabetes Mellitus is important for developing integrated clinical strategies. This study aims to examine the relationship between oral hygiene and dental caries among patients with T2DM and its clinical implications. Dental caries prevalence/severity and what this means clinically will lead us toward developing effective preventative strategies for related systemic issues. Combining recent studies and clinical observations to provide justification for including complete oral health management into the standard care plans of T2DM patients, may contribute to improved oral and systemic health outcomes in patients with T2DM.

Literature Review:

Regional and Local Perspectives (Middle East and North Africa)

Evidence from the Middle Eastern region further substantiates this concern. In Saudi Arabia, for instance, two independent investigations conducted in Riyadh and Jeddah revealed a marked deficiency in awareness, among both the general population and diabetic patients, regarding the oral complications associated with diabetes (*Almehmadi et al., 2020*). Interestingly, while patients demonstrated reasonably sound knowledge of well-established systemic complications such as retinopathy and nephropathy, their understanding of the link between diabetes and dental caries remained comparatively limited (*Almehmadi et al., 2020*). This disparity suggests that oral health education has not been afforded the same clinical priority as other diabetes-related complications within patient counseling frameworks.

Studies from Libya and Neighboring Countries

Within the North African context, a growing body of research originating from Libya and neighboring countries, namely Egypt, Tunisia, and Algeria, consistently points to an elevated prevalence of dental caries alongside compromised oral health status among individuals with type 2 diabetes mellitus. In Libya specifically, several studies have contributed to this evidence base. Most recently, *Elmezwghi* (2026) reported a notably higher prevalence of dental caries among T2DM patients in Tripoli. In a related vein, *Keshlaf et al.* (2024) demonstrated that diabetes predisposes patients to xerostomia, which, in turn, exacerbates caries risk through diminished salivary clearance of dental plaque. Complementing these clinical findings, *Elhassy and Ghazal* (2024) identified considerable knowledge gaps among Libyan T2DM patients concerning the association between diabetes and tooth loss, while *Alaqouri et al.* (2025) further examined the broader

prevalence of systemic disorders among adult Libyan dental patients, underscoring the multifaceted health burden faced by this population.

Similar patterns have been documented across neighboring countries. In Egypt, a nationally representative cross-sectional study by *Abou El Fadl et al.* (2021) explored periodontal disease and its associated risk factors among adults, contributing valuable epidemiological data to the regional discourse. Likewise, in Tunisia, *Sebai et al.* (2019) reported a state of poor oral health accompanied by substantial unmet dental care needs among patients with uncontrolled diabetes. Evidence from Algeria similarly reinforces this regional trend; *Pengpid and Peltzer* (2023) found a high prevalence of poor self-rated oral health among individuals with systemic conditions, whereas *Athamena et al.* (2022) demonstrated that diabetes exerts a measurable negative impact on oral health-related quality of life (OHRQoL). More recently, *Khemiss and Ben Messaoud* (2024) extended this line of inquiry by investigating the association between obesity and oral health status among North African adults from both Algeria and Tunisia, highlighting the compounding effect of multiple metabolic risk factors on oral health outcomes.

Research Gap

Taken together, the reviewed literature underscores a consistent and well-documented association between type 2 diabetes mellitus and deteriorating oral health outcomes across the Middle East and North Africa, with recurring evidence of poor glycemic control, inadequate patient awareness, and elevated caries burden. Nevertheless, despite this accumulating regional evidence, the majority of existing studies have predominantly focused on documenting prevalence rates or assessing patient knowledge in isolation, with comparatively limited attention paid to the specific behavioral determinant of oral hygiene practices and its quantifiable relationship with caries severity, particularly within the Libyan context. Moreover, no prior study conducted in Libya appears to have systematically examined this association using a validated clinical index such as the DMFT in conjunction with structured behavioral and glycemic data within a single analytical framework. This gap is particularly evident in localized settings such as Alkhoms Municipality, where population-specific data remain scarce. The present study, therefore, seeks to address this gap by providing empirical, locally derived evidence on the relationship between oral hygiene practices and dental caries severity among T2DM patients, thereby contributing a methodologically robust addition to the existing regional literature.

Research Methodology and Procedures

Study population and sampling

According to official records from the Diabetes and Treatment Center for the year 2025, a total of 10,320 patients with Type 2 Diabetes Mellitus (T2DM) were registered at the time of data collection. This population size served as the basis for the a priori sample size calculation using the standard sample size formula based on the Z-score method.

$$n = \frac{N \times z^2 \times x_P(1-P)}{d^2(N-1) + Z^2 \times x_p(1-P)}$$

n = required sample size, N = population size (10,320), Z = confidence level (1.96 for 95% confidence), p = assumed prevalence (0.5, since no prior prevalence data were available for Alkhoms), d = margin of error (0.05). The minimum required sample size was estimated to be 370 participants. However, after applying the inclusion and exclusion criteria and accounting for non-response and participants who declined to participate, the final study sample consisted of 289 patients with T2DM.

Study design and setting:

This investigation utilized a cross-sectional analytical type of design. As it was a study to assess the correlation of oral hygiene measures with dental caries in T2DM patients, the design enabled the collection of clinical (DMFT) data along with demographic and medical data in an efficient manner.it was also given chance to provide baseline evidence on the association in Alkhoms region.

The sample was taken from the Diabetes Control and Treatment Center and Al Sahel Specialized between April 15, 2025, and July 15, 2025

Study population

Inclusion criteria

1. Confirmed medical diagnosis of T2DM for at least 2 years (The diagnosis of Type 2 Diabetes Mellitus (T2DM) among all participants was established based on documented medical records.)
2. Age 30-45 years
3. Permanent resident of Alkhoms Municipality.
4. Patients with varying degrees of glycemic control (both controlled and uncontrolled diabetes).
5. Willingness to participate, demonstrated by provision of informed consent.

Exclusion criteria

1. History of systemic diseases or medications specifically affecting salivary glands (e.g., Sjögren's syndrome, uncontrolled thyroid disorders, tricyclic antidepressants, antipsychotics, or anticholinergics).
2. Current or past radiotherapy/chemotherapy for head and neck malignancies.
3. Patients unwilling to participate or not providing consent
4. Pregnant or lactating women.
5. Smokers or alcohol consumers.

The final sample of 289 was composed of male and female adults of diverse ages and duration of diabetes. This heterogeneity allowed us to investigate the relationship between oral hygiene methods and dental caries within subgroups defined by sex and glycaemic control. The sampling was selected by using a systematic random sampling method.

Every 4th eligible patient was invited to participate until the sample size was obtained, reducing the risk of selection bias.

Data collection instruments and processes

Questionnaire

A structured interviewer-administered questionnaire was used as the main instrument to obtain demographic, medical, oral hygiene, and lifestyle data. Interviewer administration ensured the completeness of responses and allowed immediate clarification of any ambiguities, which improved the quality of data (*Zhou et al., 2024*).

The questionnaire is divided into four sections:

1. Basic Demographics: Age, gender and residence.
2. Clinical Details: Duration of T2DM and HbA1c most recent value from medical record.
3. Oral Hygiene Practices: Frequency of tooth-brushing, use of mouthwash and patterns of dental attendance.

The finalized version of the questionnaire was then pre-tested with a small pilot sample of 15 patients at the Al-Sahel Specialized Clinic. This pilot confirmed that the instrument was practical, required approximately 10 minutes to complete, and was effective in eliciting the intended data. Minor wording adjustments were made after the pilot, primarily to streamline interviewer recording.

Clinical examination

A clinical examination was conducted to determine the dental caries status of each subject using the globally accepted Decayed, Missing, and Filled Teeth (DMFT) index as suggested by the World Health Organization (*Mehtab et al., 2025*). To maintain uniformity, all the subjects were examined by the same investigator (a dentist). The following operational definitions were used:

1. D (Decayed): A permanent tooth with a cavitated lesion or with undermined enamel.
2. M (Missing): A permanent tooth that was extracted due to caries.
3. F (Filled): A permanent tooth with ≥1 restorations and no signs of recurrent caries.

The examination was done in standardized manner with sterile dental instruments adequate illumination. The DMFT score for every participant was written on the structured data sheet itself, which indicated the total caries experience.

To ensure the reliability of clinical measurements, intra-examiner reliability was assessed for the DMFT index. A random subset of 30 participants was re-examined by the same investigator after a two-week interval under identical clinical conditions. The agreement between the two assessments was evaluated using the Intraclass Correlation Coefficient (ICC), which is an appropriate reliability measure for continuous clinical indices such as DMFT. The results demonstrated strong reliability with an ICC value of 0.77, indicating acceptable to good intra-examiner agreement.

Results

This report presents the statistical analysis of dental health data for study participants (n = 289). Due to overdispersion in the DMFT (Decayed, Missing, and Filled Teeth) data, Negative Binomial Regression was employed instead of standard Poisson Regression to ensure more accurate and robust results. The following six tables provide a comprehensive overview of the demographic characteristics, oral health indicators, and regression analysis.

Table 1. Demographic and clinical characteristics of study participants (n = 289)

Characteristic	Value
Age (Mean ± SD)	37.04 ± 4.25
HbA1c (Mean ± SD)	8.12 ± 1.84
Gender (Male / Female)	146 (50.5%) / 143 (49.5%)

Table 2. Caries experience distribution by gender (n = 289)

Gender	Decayed (Mean ± SD)	Missing (Mean ± SD)	Filled (Mean ± SD)	DMFT (Mean ± SD)
Female	5.50 ± 4.37	3.86 ± 4.44	3.09 ± 2.02	12.48 ± 9.07
Male	4.47 ± 3.63	2.98 ± 3.51	2.93 ± 1.95	10.42 ± 7.59

Table 3 Oral health indicators among study participants (n=289)

Indicator	Category	Percentage (%)
Brushing Frequency	Twice or more	53.6%
	Once	34.6%
	Never	11.8%
Mouthwash Use	Yes	40.5%
	No	38.1%
	Occasionally	21.4%
Dentist Visit	Yes	42.9%
	No	11.1%
	Occasionally	46.0%

Table 4 oral hygiene and DMFT (n=289)

Indicator	Category	DMFT (Mean)	Std. Deviation	Count (n)
Brushing Frequency	Never	24.91	5.91	34
	Once	15.90	5.75	100
	Twice or more	5.61	4.03	155
Mouthwash Use	No	18.57	8.00	110
	Occasionally	8.18	4.72	62
	Yes	6.47	4.96	117
Dentist Visit	No	19.94	7.41	32
	Occasionally	14.20	8.48	133
	Yes	6.29	4.54	124

Table 5 Correlation matrix of continuous variables (n = 289)

Variable	Age	HbA1c	Decayed	Missing	Filled	DMFT
Age	1.000000	0.696185	0.600177	0.519043	0.462149	0.645095
HbA1c	0.696185	1.000000	0.823732	0.740463	0.577655	0.885232
Decayed	0.600177	0.823732	1.000000	0.624686	0.563774	0.910365
Missing	0.519043	0.740463	0.624686	1.000000	0.318342	0.853152
Filled	0.462149	0.577655	0.563774	0.318342	1.000000	0.656512
DMFT	0.645095	0.885232	0.910365	0.853152	0.656512	1.000000

Table 6. Negative Binomial Regression Coefficients for Predictors of DMFT (n = 289)

Predictor	Coefficient (B)	Std. Error	z-value	P-value	95% CI (Lower)	95% CI (Upper)
Intercept	0.7267	0.207	3.515	< 0.001	0.321	1.132
Age	0.0080	0.006	1.323	0.186	-0.004	0.020
Gender (Female)	0.0494	0.039	1.255	0.210	-0.028	0.127
HbA1c	0.2371	0.018	13.462	< 0.001	0.203	0.272
Diabetes Duration	-0.0942	0.048	-1.978	0.048	-0.188	-0.001
Mouthwash Use	-0.0359	0.035	-1.026	0.305	-0.104	0.033
Dentist Visit	-0.0849	0.043	-1.976	0.048	-0.169	-0.001
Brushing Frequency	-0.3285	0.038	-8.549	< 0.001	-0.404	-0.253

Discussion

Impact of Glycemic Control (HbA1c) on Oral Health

The study demonstrates a strong correlation between poor glycemic management and higher levels of dental caries among individuals with diabetes (HbA1c ≥ 7.0%). Two components of the dental caries data clearly illustrate the impact of diabetes: the “missing” (extracted teeth) and “decayed” (i.e., primary decay) components were both significantly elevated among those individuals with uncontrolled diabetes. According to recent meta-analyses conducted in 2024 and 2025, chronic hyperglycemia represents one of the major causes of oral health complications as sustained high blood sugar levels facilitate the proliferation of acidogenic bacteria and impair the natural healing processes of oral tissues (*Almeneessier et al., 2025; Botelho et al., 2026*).

Role of Oral Hygiene Practices

The study found that oral hygiene habits are significant predictors of dental caries status among participants. Specifically, participants who practiced good oral hygiene (brushing their teeth) and therefore had lower DMFT scores, showed that the removal of mechanical plaque is protective (*Almeneessier et al., 2025*). However, a notable "awareness gap" was observed; many participants reported that they do not brush their teeth daily or visit a dentist regularly. This finding aligns with other recent studies in the MENA region, which indicate that while patients with T2DM are often aware of systemic complications like retinopathy or nephropathy, they frequently lack a comprehensive understanding of the relationship between diabetes and oral health (*Mian et al., 2020*).

Conclusion

This study highlights a substantial burden of dental caries among patients with Type 2 Diabetes Mellitus. The findings reveal significant variations in oral health status in relation to oral hygiene practices and glycemic control. A clear pattern emerged where poorer oral hygiene behaviors were associated with higher DMFT scores, while better oral care practices corresponded with lower caries experience. In addition, glycemic status showed a strong relationship with oral health indicators, suggesting that individuals with suboptimal metabolic control tended to exhibit worse dental outcomes.

The analysis further demonstrated consistent associations between DMFT and key clinical variables, particularly measures of glycemic control and components of dental status. Regression findings underscored the importance of glycemic levels and oral hygiene behaviors as important factors linked to variations in DMFT scores, whereas demographic variables showed limited influence.

The study population consisted of individuals within the age range of 30–45 years. Notably, a considerable proportion of participants had a diabetes duration exceeding 20 years. The diagnosis of Type 2 Diabetes Mellitus (T2DM) was confirmed for all participants based on documented medical records at the Diabetes Control and Treatment Center Al-Khums.

Overall, the results emphasize a significant relationship between diabetes management and oral health conditions. These findings underscore the importance of integrating oral health awareness and preventive dental care within routine diabetes management to support comprehensive patient care.

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