



Original Research / Orijinal Araştırma

## ***Oral Health Status and Glycemic Control in Patients With Type 2 Diabetes Mellitus: A Cross-Sectional Study***

### **Tip 2 Diabetes Mellituslu Hastalarda Ağız Sağlığı Durumu ve Glisemik Kontrol Arasındaki İlişki: Kesitsel Bir Çalışma**

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#### **Abstract**

**Aim:** This investigation evaluated clinical oral conditions and patient-reported oral outcomes in adults with type 2 diabetes mellitus (T2DM) and determined whether these outcomes are associated with glycemic control.

**Methods:** This study was cross-sectional and included 305 adults diagnosed with T2DM. Clinical oral status was measured with the Oral Health Assessment Tool (OHAT). In contrast, patient-reported oral health outcomes were evaluated with the structured self-reported oral health questionnaire and the Oral Health Impact Profile-14 (OHIP-14). Glycemic control was represented by HbA1c values obtained from medical records. Group comparisons were performed using nonparametric tests, and correlations between HbA1c and oral measures were explored with Spearman analysis.

**Results:** Median (range) scores were 5 (0–10) for OHAT, 3 (0–7) for the subjective oral health score, and 16 (0–40) for OHIP-14. Participants who reported consistent oral hygiene practices and recent dental visits demonstrated more favorable oral health outcomes and lower OHIP-14 scores ( $p < 0.05$ ). HbA1c levels showed strong positive correlations with OHAT ( $r = 0.676$ ), subjective oral health score ( $r = 0.658$ ), and OHIP-14 scores ( $r = 0.752$ ) (all  $p < 0.001$ ).

**Conclusion:** Among individuals with T2DM, poorer glycemic control was associated with worse oral health status and poorer OHRQoL. Incorporating simple oral health screening into routine diabetes follow-up may facilitate early identification of oral problems when a comprehensive dental assessment is not readily available.

**Keywords:** Type 2 diabetes mellitus, glycemic control, hemoglobin A1c, oral health-related quality of life

#### **Özet**

**Amaç:** Bu çalışmada tip 2 diabetes mellitus (T2DM) hastalarında ağız sağlığı durumu ve ağız sağlığı ile ilişkili yaşam kalitesi (OHRQoL) değerlendirilmiş; bu bulguların glisemik kontrol ile ilişkisi incelenmiştir.

**Gereç ve Yöntemler:** Bu kesitsel çalışmaya T2DM tanısı olan 305 yetişkin birey dahil edilmiştir. Klinik ağız sağlığı durumu Oral Health Assessment Tool (OHAT) kullanılarak değerlendirilmiştir. Algılanan ağız sağlığı yapılandırılmış öz bildirim ağız sağlığı anketi ile, ağız sağlığı ile ilişkili yaşam kalitesi ise Oral Health Impact Profile-14 (OHIP-14) ile ölçülmüştür. Glisemik kontrol, tıbbi kayıtlardan elde edilen HbA1c değerleri kullanılarak değerlendirilmiştir. Grup karşılaştırmalarında parametrik olmayan testler kullanılmış ve HbA1c ile ağız sağlığı ölçütleri arasındaki ilişkiler Spearman korelasyon analizi ile incelenmiştir ( $p < 0,05$ ).

**Bulgular:** Katılımcıların OHAT, öz bildirim ağız sağlığı skoru ve OHIP-14 medyan skorları sırasıyla 5 (0–10), 3 (0–7) ve 16 (0–40) olarak bulunmuştur. Düzenli diş fırçalama alışkanlığı olan ve son bir yıl içinde diş hekimi ziyareti olan bireylerde ağız sağlığı durumu ve ağız sağlığı ile ilişkili yaşam kalitesi anlamlı derecede daha iyi bulunmuştur ( $p < 0,05$ ). HbA1c düzeyleri ile OHAT, öz bildirim ağız sağlığı skoru ve OHIP-14 skorları arasında anlamlı pozitif korelasyon saptanmıştır ( $p < 0,001$ ).

**Sonuç:** T2DM'li bireylerde kötü glisemik kontrol daha kötü ağız sağlığı durumu ve daha düşük ağız sağlığı ile ilişkili yaşam kalitesi ile ilişkilidir. Diyabet takibinde basit ağız sağlığı değerlendirmelerinin yapılması, ağız sağlığı sorunlarının erken dönemde tanınmasına katkı sağlayabilir.

**Anahtar Kelimeler:** Tip 2 diabetes mellitus, ağız sağlığı ile ilişkili yaşam kalitesi, glisemik kontrol, HbA1c

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## Introduction

Type 2 diabetes mellitus (T2DM) is a metabolic condition characterized by elevated blood glucose over time.<sup>1</sup> In addition to these well-recognized outcomes, individuals with diabetes frequently experience several oral manifestations such as xerostomia, plaque accumulation, periodontal inflammation, dental caries, and mucosal changes.<sup>2</sup> These oral manifestations may arise from impaired immune response, altered salivary function, and persistent hyperglycemia, which together compromise oral tissue integrity and healing capacity.<sup>3</sup>

Beyond objective clinical findings, oral health problems in participants with T2DM may adversely affect day-to-day functioning, comfort, and psychosocial health. In this context, oral health-related quality of life (OHRQoL) has gained increasing attention as a patient-based outcome that reflects the influence of oral problems on daily life.<sup>4,5</sup> Instruments such as the Oral Health Impact Profile-14 (OHIP-14) allow for the evaluation of functional limitations, pain, and the psychosocial impact of oral conditions, providing a deeper understanding of the burden of oral disease.<sup>5</sup>

However, clinical oral health indicators alone may not fully capture the patient's subjective perception of oral health.<sup>6</sup> Brief screening tools, such as the Oral Health Assessment Tool (OHAT) and subjective oral health assessments, have been used in various clinical and community-based settings to identify individuals at risk for poor oral health outcomes.<sup>7</sup> Despite their practical value, data on the combined use of clinical screening tools, subjective oral health measures, and OHRQoL assessments in diabetic participants remain limited, particularly in routine clinical settings.<sup>8</sup>

Glycemic control is associated with the occurrence and worsening of diabetes-related complications. Evidence suggests a relationship between poor glycemic control and adverse oral conditions, as well as reduced OHRQoL.<sup>9</sup> Nevertheless, findings across populations and healthcare settings have been inconsistent, and evidence from real-world clinical practice is still insufficient.<sup>8,9</sup>

Therefore, the present study aimed to investigate clinical oral conditions and patient-reported oral outcomes in individuals with diabetes and to explore their relationship with glycemic control reflected by HbA1c levels.

## Materials and Methods

### Study Design and Setting

This investigation employed a cross-sectional design and took place in 2019 at a university-linked outpatient clinic.

### Participants

Participants were recruited consecutively from adults with type 2 diabetes mellitus attending the Endocrinology Outpatient Clinic of Hatay Mustafa Kemal University Hospital between June and September 2019. Eligible participants were aged 18 years or older, had a confirmed diagnosis of T2DM, and had HbA1c measurements obtained within the previous month. Individuals who were unable to communicate verbally, had cognitive impairment preventing completion of questionnaires, were pregnant, or had incomplete questionnaire data were excluded.

A total of 370 individuals were assessed for eligibility. Nine were excluded due to incomplete questionnaires, and fifty-six refused to participate. The final study sample consisted of 305 participants.

### Data Collection

Information was collected during direct interviews with the participants. A structured questionnaire was used to record sociodemographic data, diabetes-related clinical characteristics, and oral hygiene practices.

### Oral Health Assessment

Clinical oral status was assessed using the Oral Health Assessment Tool (OHAT), originally developed by Chalmers et al.<sup>10</sup> as a practical oral health screening instrument. The OHAT evaluates eight domains: lips, tongue, gingival/oral tissues, saliva, oral hygiene, natural teeth, dentures, and dental pain. Each domain is scored from 0 to 2, producing a total score ranging from 0 to 16, with higher scores indicating poorer oral health status. The original OHAT is a valid and reliable screening tool, and the Turkish version has also demonstrated acceptable validity and reliability.<sup>11</sup>

### Subjective Oral Health Assessment

After reviewing pertinent literature, the research team created a systematic self-reported oral health questionnaire to assess subjective oral health status. The questionnaire consisted of six items assessing oral dryness, difficulty eating, oral pain, changes in food selection due to oral problems, dental visits within the previous year, and the presence of oral lesions. Each item was scored from 0 to 2, resulting in a total score ranging from 0 to 12, with higher scores indicating poorer perceived oral health. The questionnaire was used as a complementary subjective assessment tool to support the overall oral health evaluation rather than as a primary outcome measure.

### Oral Health-Related Quality of Life

Oral health-related quality of life (OHRQoL) was assessed using the Oral Health Impact Profile-14 (OHIP-14), a shortened version of the original Oral Health Impact Profile developed by Slade.<sup>5</sup> Total scores range from 0 to 56, with higher scores indicating worse OHRQoL.

The Turkish version of OHIP-14 has been demonstrated to be valid, reliable, and comprehensible in the Turkish population.<sup>12</sup>

### Glycemic Control

Glycemic control was evaluated using HbA1c values retrieved from medical records. HbA1c was analyzed as a continuous variable in the statistical analyses. For clinical interpretation, HbA1c values  $\geq 7.0\%$  were considered indicative of suboptimal glycemic control according to current diabetes management guidelines.

### Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics version 21.0 (IBM Corp., Armonk, NY, USA). Data distribution was assessed using the Kolmogorov–Smirnov test. As the variables were not normally distributed, non-parametric methods were applied. Comparisons between two independent groups were performed using the Mann–Whitney U test, while comparisons among more than two groups were conducted using the Kruskal–Wallis test. Associations between HbA1c values and oral health measures were evaluated using Spearman correlation coefficients. Descriptive statistics were reported as frequency (percentage) for categorical variables and median (minimum–maximum) for continuous variables. A two-sided p-value  $< 0.05$  was considered statistically significant. A post hoc power analysis was conducted to evaluate the adequacy of the final sample size. Based on the final sample size of 305 participants, a significance level of 0.05, and the observed effect sizes, the analysis demonstrated that the study had statistical power greater than 95% to detect the observed associations. Accordingly, the final sample size was considered sufficient for the objectives of the study.

### Results

#### Participant Characteristics

A total of 305 individuals with type 2 diabetes were analyzed. The median age was 58 years (range: 24–82), and 165 participants (54.1%) were female. The median duration of diabetes was 10 years (range: 1–35), and the median HbA1c level was 8.4% (range: 5.2–14.6). An overview of the participants' sociodemographic and clinical profiles is provided in Table 1. The majority of participants were married and had a primary school education. Most participants reported a moderate income level and did not use tobacco or alcohol. Detailed sociodemographic and clinical characteristics of the study population are presented in Table 1.

**Table 1.** Sociodemographic and clinical characteristics of the participants

| Variable                                         | n (%) or Median (Min–Max) |
|--------------------------------------------------|---------------------------|
| <b>Demographic characteristics</b>               |                           |
| Age (years)                                      | 58 (24–82)                |
| <b>Gender</b>                                    |                           |
| Female                                           | 165 (54.1%)               |
| Male                                             | 140 (45.9%)               |
| <b>Marital status</b>                            |                           |
| Married                                          | 290 (95.1%)               |
| Single                                           | 15 (4.9%)                 |
| <b>Educational level</b>                         |                           |
| Illiterate                                       | 66 (21.6%)                |
| Literate                                         | 81 (26.6%)                |
| Primary education                                | 139 (45.6%)               |
| High school or above                             | 19 (6.2%)                 |
| <b>Economic status</b>                           |                           |
| Good                                             | 96 (31.5%)                |
| Moderate                                         | 134 (43.9%)               |
| Poor                                             | 75 (24.6%)                |
| <b>Social security status</b>                    |                           |
| Present                                          | 294 (96.4%)               |
| Absent                                           | 11 (3.6%)                 |
| <b>Lifestyle and oral health characteristics</b> |                           |
| <b>Smoking status</b>                            |                           |
| Current smoker                                   | 31 (10.2%)                |
| Never smoker                                     | 251 (82.3%)               |
| Former smoker                                    | 23 (7.5%)                 |
| <b>Alcohol use</b>                               |                           |
| Current use                                      | 26 (8.5%)                 |
| No use                                           | 275 (90.2%)               |
| Former use                                       | 4 (1.3%)                  |

**Table 1.(continued)** *Sociodemographic and clinical characteristics of the participants*

|                                         |                |
|-----------------------------------------|----------------|
| <b>Obesity</b>                          |                |
| Present                                 | 52 (17.0%)     |
| Absent                                  | 253 (83.0%)    |
| <b>Removable denture use</b>            |                |
| Present                                 | 68 (22.3%)     |
| Absent                                  | 237 (77.7%)    |
| <b>Missing teeth</b>                    |                |
| 1–2 missing teeth                       | 6 (2.0%)       |
| 3–4 missing teeth                       | 44 (14.4%)     |
| 5–6 missing teeth                       | 85 (27.9%)     |
| ≥7 missing teeth                        | 170 (55.7%)    |
| <b>Diabetes-related characteristics</b> |                |
| Diabetes duration (years)               | 10 (1–35)      |
| HbA1c (%)                               | 8.4 (5.2–14.6) |
| <b>Treatment modality</b>               |                |
| Oral antidiabetic drugs                 | 128 (42.0%)    |
| Insulin                                 | 74 (24.3%)     |
| Combination therapy                     | 103 (33.8%)    |
| <b>Diabetes-related complications</b>   |                |
| Present                                 | 188 (61.6%)    |
| Absent                                  | 117 (38.4%)    |
| <b>Comorbid chronic disease</b>         |                |
| Present                                 | 283 (92.8%)    |
| Absent                                  | 22 (7.2%)      |

**Oral Measures and OHRQoL**

Median scores for oral health indices were 5 (0–10) for OHAT, 3 (0–7) for the subjective oral health score, and 16 (0–40) for OHIP-14 (Table 2).

**Table 2.** *Oral health status and oral health–related quality of life scores of the participants*

| Variable                                  | Median (Min–Max) |
|-------------------------------------------|------------------|
| <b>Oral Health Assessment Tool (OHAT)</b> | 5 (0–10)         |
| <b>Subjective Oral Health Score</b>       | 3 (0–7)          |
| <b>Oral Health Impact Profile-14</b>      | 16 (0–40)        |

**Oral Hygiene Behaviors and Oral Health Outcomes**

Participants who reported regular tooth brushing had significantly lower OHAT and OHIP-14 scores compared with those who did not brush regularly ( $p < 0.001$ ). Similarly, participants who had visited a dentist within the last year demonstrated significantly better oral findings and OHRQoL than those who had not ( $p < 0.05$ ). These comparisons are summarized in Table 3.

**Table 3.** *Comparison of oral health status and oral health–related quality of life according to oral hygiene behaviors*

|                                          | <b>OHAT score</b> | <b>OHIP-14 score</b> |
|------------------------------------------|-------------------|----------------------|
|                                          | Median (Min–Max)  | Median (Min–Max)     |
| <b>Tooth brushing frequency</b>          |                   |                      |
| Regular                                  | 4 (0–9)           | 14 (0–36)            |
| Irregular                                | 6 (1–10)          | 20 (2–40)            |
| p-value*                                 | <0.001            | <0.001               |
| <b>Dental visit within the last year</b> |                   |                      |
| Yes                                      | 4 (0–8)           | 13 (0–34)            |
| No                                       | 6 (1–10)          | 19 (2–40)            |
| p-value*                                 | 0.002             | 0.001                |

\* Mann–Whitney U test

**Association Between Glycemic Control and Oral Health Measures**

HbA1c levels showed strong positive correlations with OHAT ( $r = 0.676$ ,  $p < 0.001$ ), the subjective oral health score ( $r = 0.658$ ,  $p < 0.001$ ), and OHIP-14 scores ( $r = 0.752$ ,  $p < 0.001$ ) (Table 4).

**Table 4.** Correlation between glycemic control (HbA1c) and oral health measures

| Variable                     | Spearman's rho (95% CI) | p-value |
|------------------------------|-------------------------|---------|
| OHAT score                   | 0.676 (0.610–0.733)     | <0.001  |
| Subjective oral health score | 0.658 (0.589–0.717)     | <0.001  |
| OHIP-14 score                | 0.752 (0.699–0.797)     | <0.001  |

**Treatment Modality and Diabetes-Related Complications**

Oral health outcomes also differed according to diabetes treatment modality. Patients receiving insulin or combination therapy had significantly higher subjective oral health, OHAT, and OHIP-14 scores compared with those receiving oral antidiabetic drugs alone (all  $p = 0.001$ ). In addition, patients with diabetes-related complications demonstrated significantly poorer oral health outcomes than those without complications (all  $p = 0.001$ ).

**Multivariable Analysis**

Multivariable linear regression analyses were performed to identify independent predictors of oral health outcomes. For OHAT scores, higher HbA1c levels ( $\beta = 0.507$ ,  $p < 0.001$ ), gender ( $\beta = -0.106$ ,  $p = 0.016$ ), and the presence of diabetes-related complications ( $\beta = 0.171$ ,  $p = 0.001$ ) were independently associated with poorer oral health status. For OHIP-14 scores, higher HbA1c levels ( $\beta = 0.624$ ,  $p < 0.001$ ) and diabetes-related complications ( $\beta = 0.106$ ,  $p = 0.030$ ) remained significant predictors. The models explained 43.5% and 53.3% of the variance in OHAT and OHIP-14 scores, respectively.

**Table 5.** Multivariable linear regression analyses for oral health outcomes

| Predictor         | OHAT $\beta$ | p      | OHIP-14 $\beta$ | p      |
|-------------------|--------------|--------|-----------------|--------|
| HbA1c             | 0.507        | <0.001 | 0.624           | <0.001 |
| Gender            | -0.106       | 0.016  | -0.071          | 0.075  |
| Age               | 0.032        | 0.526  | 0.090           | 0.051  |
| Diabetes duration | 0.099        | 0.080  | 0.078           | 0.128  |
| Complications     | 0.171        | 0.001  | 0.106           | 0.030  |

OHAT model:  $R^2=0.435$ , OHIP-14 model:  $R^2=0.533$

**Discussion**

This study evaluated clinical oral conditions and patient-reported oral outcomes in adults with type 2 diabetes in relation to glycemic control. The results indicate that people with greater HbA1c levels typically had worse OHRQoL and oral health problems. In addition, participants who reported regular oral hygiene practices and recent dental visits exhibited more favorable oral health outcomes. The observed correlations were strong in magnitude, indicating a meaningful relationship between glycemic control and oral health outcomes in this study population. However, in addition to glycemic control, behavioral, clinical, and socioeconomic factors also have an impact on oral health.

The association between glycemic control and oral health observed in this study is consistent with previous evidence indicating that chronic hyperglycemia adversely affects oral tissues through impaired immune response, altered salivary function, and microvascular changes.<sup>13,14</sup> These mechanisms may increase susceptibility to oral infections, inflammation, and discomfort in individuals with diabetes. In the present analysis, higher HbA1c levels were associated with poorer scores on both clinical oral health assessment (OHAT) and patient-reported outcome measures (OHIP-14), suggesting that metabolic control is closely linked not only to objective oral findings but also to participants' daily functioning and well-being. As the data were collected at a single time point, causal interpretations should be made with caution. The observed association is likely bidirectional, as chronic hyperglycemia may exacerbate oral disease, while oral inflammation may also negatively influence glycemic control.

Beyond glycemic control itself, treatment modality and the presence of diabetes-related complications were also associated with oral health outcomes. Patients receiving insulin-based treatment and those with diabetes-related complications exhibited poorer oral health outcomes. These findings may reflect greater disease severity, longer disease duration, and cumulative metabolic burden among these patients. The presence of diabetic complications may therefore identify individuals at increased risk for oral health problems who may benefit from closer dental surveillance.<sup>14</sup>

Previous studies have reported similar impairments in OHRQoL among individuals with diabetes. Sandberg and Wikblad<sup>15</sup> found that participants with diabetes experienced more oral discomfort and functional limitations compared with non-diabetic controls. Azogui-Levy et al.<sup>16</sup> demonstrated that oral symptoms such as xerostomia and oral pain were significantly associated with poorer quality of life in diabetic populations. Likewise, de Sousa et al.<sup>17</sup> reported that oral conditions commonly observed in T2DM were associated with worse OHIP-14 scores. The present findings are consistent with these reports and further support the association between glycemic control, oral findings, and OHRQoL in diabetic participants evaluated in a routine clinical environment.

Oral hygiene behaviors emerged as important modifiers of oral health outcomes in this study. Significantly superior oral health status and OHRQoL were shown by those who reported frequent dental visits and tooth brushing throughout the prior year. Similar patterns have been reported in earlier studies, although the magnitude and clinical relevance of these associations appear to vary across populations and settings.<sup>2</sup> Although optimal oral hygiene alone cannot counteract the systemic effects of chronic hyperglycemia, it may reduce oral discomfort and functional limitations, thereby contributing to improved patient well-being.

The combined use of clinical screening and patient-reported outcome measures represents a strength of this study. The Oral Health Assessment Tool (OHAT) enabled a practical evaluation of oral health status, while the Oral Health Impact Profile-14 (OHIP-14) captured the subjective impact of oral conditions on daily life.<sup>6</sup> A structured self-reported oral health assessment was used as a complementary subjective measure to support the overall assessment rather than as a primary outcome. This approach allowed for a broader understanding of participants' perceptions without overshadowing validated clinical and OHRQoL instruments. It should be noted that the subjective oral health questionnaire included both symptom-related items and healthcare utilization-related items, such as dental visits. Therefore, the resulting score should be interpreted as a complementary indicator of perceived oral health rather than a pure measure of oral symptoms alone.

Interpretation of the current findings requires consideration of several methodological limitations. The cross-sectional design poses a significant constraint since it prevents causal conclusions about the connections between glycemic control and oral health results. In addition, comprehensive periodontal examination parameters were not included, as oral health assessment relied on screening tools rather than detailed periodontal evaluation, which may have limited a more precise assessment of periodontal disease severity. Finally, as data were obtained from a single tertiary care center, the applicability of the findings to other clinical settings or populations may be limited. In addition, the data were collected in 2019. Although the biological relationship between glycemic control and oral health is unlikely to have changed substantially, temporal changes in healthcare utilization and oral health awareness should be considered when interpreting the findings.

Overall, the findings emphasize the close relationship between metabolic control, oral condition, and OHRQoL in diabetic participants. Incorporating oral health awareness and basic oral health assessment into routine clinical follow-up may contribute to a more comprehensive approach to diabetes management and improve patient-centered outcomes.

## **Conclusion**

Poor glycemic control appears to be associated with poorer oral condition and poorer OHRQoL in individuals with T2DM. From a practical standpoint, greater attention to oral health during routine diabetes follow-up may contribute to more comprehensive and patient-centered care.

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