The Potential Risk: Evaluation of HbA1c Levels Prior to Dental Implant Surgery in Patients Without a Diagnosis of Diabetes Mellitus

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Purpose: To evaluate glycated hemoglobin (HbA1c) levels in patients who have not been diagnosed with diabetes mellitus (DM) but exhibit oral DM symptoms prior to dental implant surgery. ***Materials and Methods:*** This study was designed as a retrospective cohort. It was conducted on patients who previously presented to the Department of Oral and Maxillofacial Surgery for dental implant surgery and had not been diagnosed with DM. The inclusion criteria were as follows: patients with the need for dental implants and augmentation, presence of oral DM symptoms, and access to blood test results that included HbA1c. Patients with a prior diagnosis of DM were excluded from the study. ***Results:*** A retrospective analysis was conducted on data from 253 patients who applied for dental implant surgery. Among them, 72 patients underwent HbA1c level assessments via blood tests. Patients with previously uncontrolled DM (n = 21) and those whose blood tests were performed at different institutions (n = 8) were excluded from the study. Consequently, the study encompassed a cohort of 43 patients. Among the participants, 55% of them were female and 45% of them were male. The HbA1c values of the patients ranged from 5.1 to 10.9, with an average value of 6.57 ± 1.44. Of the patients, 41.8% were diagnosed with DM, 30.2% were prediabetic (preDM), and 27.9% did not receive any diagnosis. There was no statistically significant relationship between the combinations of xerostomia, delayed wound healing, oral infection, burning sensation in the mouth, periodontitis, and dental caries with HbA1c levels ($P > .05$). In this study, patients presenting to the clinic for dental implant surgery were directed based on oral symptom findings, and the rates of diagnosed DM and preDM were determined to be 7.11% and 5.14%, respectively. ***Conclusions:*** Considering the negative effects and prevalence of uncontrolled DM, it may be recommended to assess the HbA1c levels in patients with oral symptoms before dental implant surgery. *Int J Oral Maxillofac Implants 2025;40:307–312. doi: 10.11607/jomi.11087*

Keywords: diabetes, HbA1c, oral symptoms, undiagnosed diabetes mellitus

Diabetes mellitus (DM) is a significant chronic health condition worldwide. This complex metabolic disorder is characterized by abnormalities in carbohydrate, lipid, and protein metabolism, either due to insulin deficiency (type 1) or metabolic effects resulting from target tissue resistance (type 2).[1] Prediabetic (PreDM) conditions are defined as hyperglycemia that do not reach the diagnostic threshold for DM.[2] It is projected that by 2025, there will be 300 million people diagnosed with DM globally, with a prevalence rate of 6.4%.[3,4] However, it is estimated that one of every two individuals living with DM worldwide remains undiagnosed.[5]

It is estimated that the annual cost of complications associated with DM amounts to $327 billion USD, and this figure could potentially be higher due to the substantial number of undiagnosed cases.[6] Complications arising from undiagnosed DM significantly diminish patients' quality of life and early identification of its risk factors helps to prevent such outcomes.[7] Epidemiologic studies have demonstrated a direct correlation between the degree of hyperglycemia and the incidence of DM-related complications.[8] These complications share a common biochemical basis in the formation of hyperglycemia-induced nonenzymatic advanced glycation end-products. The glycosylated or glycated hemoglobin (HbA1c) test is widely employed to assess glycemic control.[1] Elevated HbA1c levels have been associated with worse postoperative outcomes, and postponing surgical intervention should be considered.[9]

Among the oral complications of DM, xerostomia, hyposalivation, oral infections, increased incidence of caries and periodontitis, delayed wound healing, and burning mouth syndrome can be observed.[10–12] It is known that DM also has a detrimental effect on bone formation.[13] In individuals with uncontrolled DM, decreased implant survival, increased marginal bone loss, and an increased incidence of peri-implantitis have been identified. Therefore, DM should be considered a potential risk factor for delayed osseointegration, peri-implant inflammation formation, and poor implant

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Table 1 Demographic Data of the Patients and Their HbA1c Values

Patient characteristics	No. of patients	Age (y)	HbA1c score	*P*
Female	24	51.16 ± 11.31	6.47 ± 1.4	.59
Male	19	58.57 ± 10.93	6.71 ± 1.5	
Total	43	54.44 ± 11.73	6.57 ± 1.44	.7
P		.04*	.7	

*$P < .05$ is statistically significant.

survival, not only in patient management and treatment decisions but also in follow-up care.[14]

This study's hypothesis was the necessity of evaluating the HbA1c levels in patients showing oral signs of DM but not diagnosed with DM before dental implant surgery. This study aimed to assess the HbA1c levels in patients showing oral signs of DM before dental implant surgery. Other objectives of this study included *(1)* evaluating the number of patients diagnosed with DM and preDM, *(2)* assessing the correlation between oral signs and HbA1c levels, and *(3)* evaluating patients for whom surgical procedures were postponed.

MATERIALS AND METHODS

This study was conducted with patients routinely attending the Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Kırıkkale University. A retrospective cohort design was employed for this study. Ethical approval was granted by the Kırıkkale University Non-interventional Clinical Researches EthicsCommittee (decision no.: 2023.11.10). The study was conducted in accordance with the principles outlined in the Helsinki Declaration on human rights.

Study Design

The study was conducted retrospectively using blood tests previously obtained from patients routinely attending the Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Kırıkkale University. Patients who had applied for dental implant surgery within the last 6 months and had not been previously diagnosed with DM were included in the study. The inclusion criteria were as follows: patients who applied for dental implant and augmentation procedures, no previous diagnosis of DM, presence of oral signs of DM, and availability of blood test results. The exclusion criteria for the study were as follows: patients with a diagnosis of DM and currently receiving medication for it, patients who smoke, patients who have systemic diseases, patients with a history of medication use including oral mouthwashes and herbal remedies, patients who do not have blood test results, and patients with blood tests conducted at a different institution.

The data of a total of 253 patients who applied for dental implant surgery were retrospectively analyzed. Among these patients, a total of 72 patients who had blood tests assessing the HbA1c levels were evaluated. Patients who had previously been diagnosed with DM but was not under control (n = 21) and those who had blood tests conducted at a different institution (n = 8) were not included in the study. The study was conducted with a total of 43 patients.

Data Collection Method

Demographic data such as age and sex of the patients were recorded. Planned surgical procedures and conditions potentially associated with DM—including delayed wound healing, xerostomia, oral infections, burning mouth sensation, multiple caries, and periodontitis—were documented using consultation forms. Based on the blood test results, the HbA1c levels and diagnoses of preDM or DM were recorded. Attention was given to ensuring that the blood test results originated from the same institution. As per the evaluation conducted according to the institution's guidelines, an HbA1c range of 5.5 to 6.5 was considered indicative of preDM, while a score of > 6.5 was determined as the diagnostic threshold for DM.

Statistical Method

The primary determinant was the HbA1c value. The data obtained in the study were statistically analyzed using the IBM SPSS statistics (version 20) software. Descriptive statistics such as mean, SD, and maximum to minimum values were used for quantitative data. The chi-square test was used to examine the relationship between variables. The chi-square and ANOVA tests were employed to determine the relationship between groups, while the Pearson correlation test was applied to ascertain the correlation between variables.

RESULTS

The mean age of the participants in the study was 54.44 ± 11.73 years. Of the participants, 55% (n = 24) were female while 45% (n = 19) were male. The mean age was 51.16 ± 11.31 years and 58.57 ± 10.93 years for males and females, respectively. The mean age for males was significantly higher than that of the females ($P < .5$) (Table 1).

A total of 48.8% (n = 21) of the patients were scheduled for dental implant surgery only, while 51.2% (n = 22) were planned for dental implant surgery along with a hard tissue augmentation procedure. Upon an examination of symptoms, 53.49% (n = 23) of patients

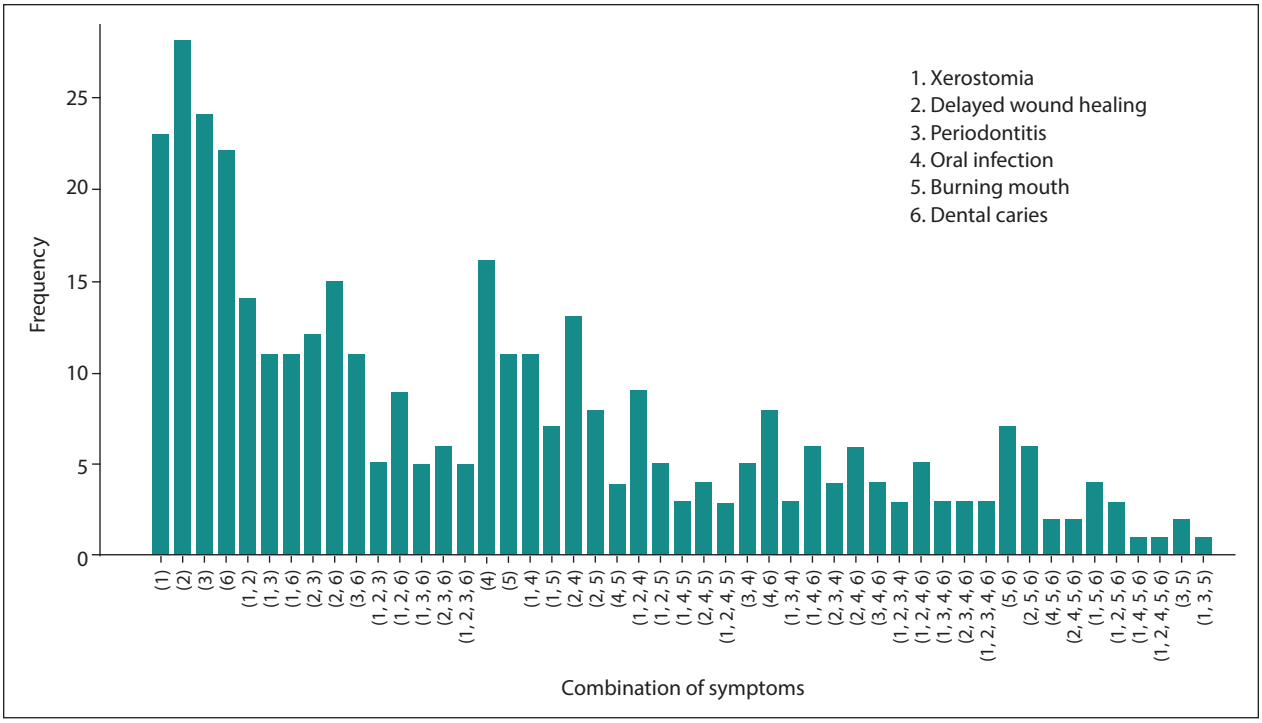

Fig 1 Distribution of oral symptoms.

exhibited xerostomia, 65.12% (n = 28) experienced delayed wound healing, 55.81% (n = 24) had periodontitis, 37.21% (n = 16) presented with oral infections, 25.58% (n = 11) reported burning sensation in the mouth, and 51.16% (n = 22) had multiple dental caries. These symptoms were observed in various combinations (Fig 1).

The HbA1c levels of the patients ranged from 5.1 to 10.9, with a mean value of 6.57 ± 1.44. The mean HbA1c level was 6.47 ± 1.4 and 6.71 ± 1.5 for females and males, respectively. No statistically significant relationship was found between the HbA1c levels and age or sex ($P > .05$) (see Table 1). The HbA1c levels demonstrated a weak positive correlation with xerostomia, delayed wound healing, oral infection, and burning mouth sensation (Pearson's correlation coefficient: r = 0.11, r = 0.05, r = 0.11, r = 0.12, respectively). Conversely, the HbA1c levels showed a weak negative correlation with periodontitis and dental caries (r = –0.07, r = –0.11). The HbA1c levels have exhibited variability at different levels according to the combinations of symptoms, including xerostomia, delayed wound healing, periodontitis, oral infections, burning mouth syndrome, and dental caries (Fig 2). However, there was no statistically significant relationship between the HbA1c levels and the combinations of symptoms observed ($P > .05$).

Despite not having a prior diagnosis or treatment for DM, based on the requested tests, 41.8% (n = 18) of the patients were diagnosed with DM and 30.2% (n = 13) were diagnosed with preDM before the surgical operation. No diagnosis was made for 27.9% (n = 12) of the patients. Before all surgical operations, 45% (n = 9) of the patients scheduled for dental implant surgery alone were diagnosed with DM, while 20% (n = 4) were diagnosed with preDM. Among the patients scheduled for both dental implant surgery and augmentation procedures, 39% (n = 9) were diagnosed with DM and 39% (n = 9) were diagnosed with preDM. Therefore, despite the absence of a prior diagnosis, surgical operations were either not performed or postponed in 41.8% (n = 18) of the patients based on the preoperative evaluation.

The mean age of patients diagnosed with DM was 55.67 ± 11.12 years, with 55.56% (n = 10) being female and 44.4% (n = 8) being male. No statistically significant relationship was observed between DM diagnosis, age, and sex ($P > .05$). The mean HbA1c level in patients diagnosed with DM was 7.9 ± 1.2. The mean age of patients diagnosed with preDM was 57.92 ± 7.27 years, with 46.15% (n = 6) being female and 53.8% (n = 7) being male. Consequently, no statistically significant relationship was found between preDM diagnosis, age, and sex ($P > .05$). The mean HbA1c level in patients diagnosed with preDM was 5.9 ± 0.24. The average age of patients without a diagnosis was 48.83 ± 14.63 years, with 66.6% (n = 8) being female and 33% (n = 4) being male. In addition, there was no statistically significant relationship found between age and sex among patients without a diagnosis ($P > .05$). However, the HbA1c levels between groups were statistically higher in the patients with DM ($P > .05$) (Table 2).

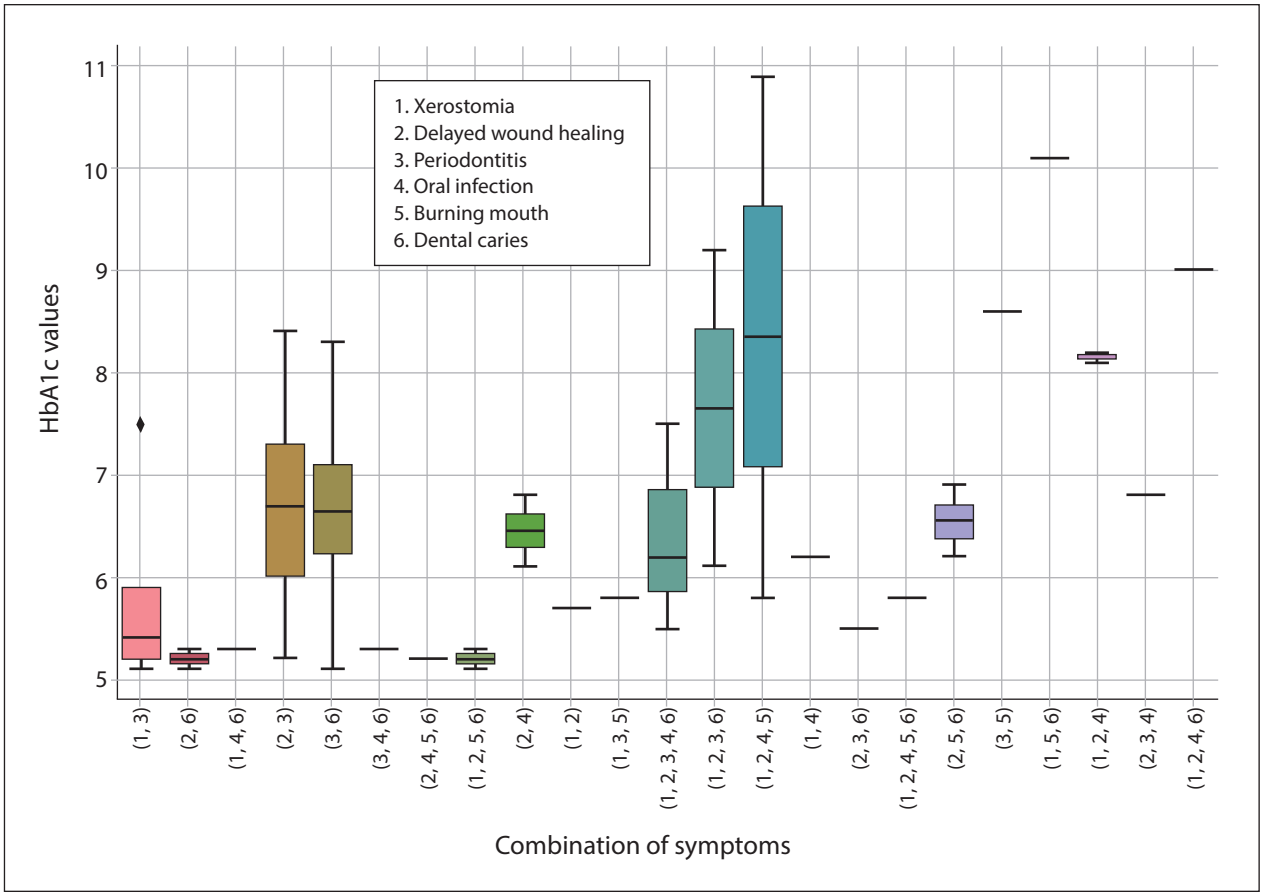

Fig 2 Distribution of oral symptoms by HbA1c levels.

Table 2 Patients' Demographic Characteristics and HbA1c Levels According to Their Diagnoses

Patient demographic characteristics		No diagnosis	PreDM diagnosis	DM diagnosis	*P*
Age, y		48.83 ± 14.63	57.92 ± 7.27	55.67 ± 11.12	.13
No. of patients		12	13	18	—
Sex	Female, n	8	6	10	.58
	Male, n	4	7	8	
HbA1c score		5.22 ± 0.1	5.9 ± 0.24	7.9 ± 1.2	.003*

*$P < .05$ is statistically significant.

Delayed wound healing was the most common symptom in patients with DM, followed by periodontitis, xerostomia, dental caries, infection, and burning mouth sensation. In patients with preDM, delayed wound healing was also the most common symptom, followed by xerostomia, infection, dental caries, and a burning mouth sensation. In patients without a diagnosis, dental caries was the most common symptom, followed by xerostomia, periodontitis, delayed wound healing, infection, and burning mouth sensation. However, no significant relationship was found between the frequency of symptoms and the groups ($P > .05$).

DISCUSSION

A significant proportion of DM cases worldwide remain undiagnosed, posing a risk of severe complications and imposing substantial financial burdens on patients.[15] Comprehensive evaluations of patients prior to oral and maxillofacial surgical procedures, such as dental implant placement, may aid in the identification of previously undiagnosed DM. The hypothesis of this study was that assessing HbA1c levels in patients exhibiting oral signs of DM, but lacking a formal diagnosis, was necessary before proceeding with surgical interventions. The study's findings indicate that among patients presenting with oral signs of DM but without a formal

diagnosis, the mean HbA1c level was 6.57 ± 1.44. Notably, 41.8% of these patients were diagnosed with DM and 30.2% were diagnosed with preDM. Consequently, surgical procedures for 18 patients were postponed and/or canceled until their HbA1c levels were adequately regulated.

According to the International Diabetes Federation, over 210 million DM cases worldwide remain undiagnosed. Furthermore, it is reported that one in every 10 people globally lives with DM, totaling approximately 537 million individuals. This number is projected to rise to 643 million by 2030 and 783 million by 2045. Over the past 15 years, DM has led to a 316% increase in healthcare expenditure, amounting to at least $966 billion.[15] Research from various countries highlights the prevalence of undiagnosed DM and related conditions. For instance, in Bahir Dar, Ethiopia, the prevalence of undiagnosed DM is 10.2%, while in Norway it is 0.7%.[5,16] Similarly, in Germany, the prevalence of undiagnosed type 2 DM is 2.9%, compared to 1.7% in France and 0.8% in the United Kingdom.[17–19] In Turkey, the prevalence of DM is 11%, with an estimated one-third of cases remaining undiagnosed.[20] In the present study, patients that needed dental implant surgery were assessed based on oral symptoms, revealing that the prevalence of undiagnosed DM and preDM was 7.11% and 5.14%, respectively. Additionally, no significant relationship was found between undiagnosed DM and preDM conditions and factors such as age or sex.

Early diagnosis and treatment of DM are essential not only for preventing complications and fatalities associated with DM but also for improving the treatment outcomes.[5] Failure to diagnose DM increases treatment costs and negatively impacts the disease's progression.[9] If not effectively managed, DM can result in chronic hyperglycemia, leading to microvascular disorders, impaired bone metabolism, and increased susceptibility to infections.[21] Additionally, it may cause delays in wound and bone healing.[22] It can adversely affect bone formation by influencing osteoclasts, osteoblasts, and mesenchymal stem cells.[13] Furthermore, microvascular disease—which compromises blood supply—can delay the healing of oral wounds and increase susceptibility to infections.[23] Patients with DM frequently exhibit dysfunctions such as reduced salivary flow, opportunistic infections, delayed wound healing, xerostomia, increased incidence of dental caries, burning mouth syndrome, and a higher prevalence of periodontal disease.[10–12] The prevalence of oral mucosal changes—including potentially malignant disorders and fungal infections—is also higher in this population.[24] In the present study, the most common symptom observed in individuals with DM was delayed wound healing, followed by periodontitis, xerostomia, dental caries, infections, and a burning sensation in the mouth. However, no statistical relationship was found between the HbA1c levels and the combination of these symptoms. This finding suggests that the number and combination of symptoms may not be critical for diagnosing DM, and even a single symptom should raise suspicion.

In patients with DM, altered healing processes can lead to reduced bone formation and decreased bone-to-implant contact, making implants less resistant to micromovement and more prone to failure.[23] High blood glucose levels can jeopardize the clinical performance of dental implants (negatively affecting osseointegration and primary stability) and are considered a significant risk factor for peri-implant diseases, including peri-implantitis.[25–27] Patients with DM may experience higher implant failure rates compared to individuals without DM.[28] A recent systematic review found that patients with DM have a statistically significant higher risk of dental implant failure and greater marginal bone loss compared to patients without DM.[22] Another systematic review identified a statistically significant difference in marginal bone loss between patients with and without DM; however, it did not find a significant impact on implant failure rates.[29] Conversely, a different systematic review reported lower implant survival rates in patients with DM.[30] Although patients with DM may not show significant differences in short-term dental implant survival rates compared to healthy individuals, the risk of implant loss may increase in the long term.[31] For these reasons, DM should be considered a potential risk factor for delayed osseointegration, peri-implant inflammation, and reduced implant survival.[32]

Patients with uncontrolled DM are considered to have suppressed immune systems, given the negative impact of hyperglycemia has on the immune system.[33] In patients with uncontrolled DM, preoperative prophylaxis, use of the aseptic technique, and atraumatic tissue management are necessary. Therefore, in patients with undiagnosed DM, it is necessary to follow certain procedures in surgical operations such as dental implant surgery.[34] Moreover, since DM is a risk factor for peri-implantitis and may be present even in undiagnosed individuals, performing implant surgery without prior identification of DM may predispose patients to peri-implantitis over time.[35] Note that dental implant procedures are not typically emergency interventions. Particularly in elective surgeries, addressing DM treatment as a priority may be feasible.[36] Therefore, it is advisable to ideally assess and optimize the patient's HbA1c levels before the procedure, and to implement preoperative glucose control tests. This approach can facilitate the identification of patients with DM and, as a result, improve the overall survival and prognosis of dental procedures.[37]

The present study has several limitations. Firstly, it is based on a small sample size, and there is a need for

larger and more diverse studies involving a broader range of patients. Additionally, there may be uncertainties regarding the duration of patients' symptoms and some ambiguity in evaluating co-existing symptoms. Other limitations include *(1)* a lack of clear information, *(2)* the inability to assess symptoms such as polyphagia, polydipsia, polyuria, and family history, as well as *(3)* the inability to evaluate postoperative patient information and consultation outcome findings. Given these limitations, more comprehensive and prospective studies could enhance the accuracy and validity of the findings.

CONCLUSIONS

It is recommended to assess the HbA1c levels in patients exhibiting oral symptoms before dental implant surgeries. This situation could contribute to a more rapid diagnosis for patients. In addition, it may be considered that oral and maxillofacial surgeons also play a role in referring patients for the initial diagnosis of DM.

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