Article published online: 2020-12-07

Periodontal Disease as a Predictor of Undiagnosed Diabetes or Prediabetes in Dental Patients

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Eur J Dent 2021;15:216–221

Abstract

Objectives The study investigates whether periodontal parameters can identify subjects with undiagnosed diabetes mellitus (DM) or pre-DM in patients seeking dental treatment at a university dental hospital.

Materials and Methods Adults older than 35 years, not being diagnosed with DM before and have at least one of the risk factors of DM were included in the study. All subjects received a complete periodontal examination, filled a medical history survey, and a fasting blood glucose measurement was obtained. A multiple logistic regression test using a backward elimination method to assess factors that predict if the participant is healthy, prediabetic or diabetic was done. A *p*-value of <0.05 was considered significant.

Results A total of 61 subjects were enrolled with an average age of 42.9 ± 9.4 years. Having a family member diagnosed with DM was reported by 64.5% of the subjects; 59% were diagnosed with advanced periodontal disease. The final logistic regression model included smoking, hypertension, family history of DM, and percentage of clinical attachment loss >3 mm was statistically significant ($P < 0.001$). The model explained 47.7% of the diabetes condition and correctly classified 69.4% of cases. Participants with a family history of diabetes are 4.98 times more likely to exhibit prediabetic or diabetic status. Each unit increase in the percentage of clinical attachment loss increases the likelihood of participant to be prediabetic or diabetic by 1.104 times.

Conclusion Dental patients presenting with severe clinical attachment loss and family history of DM have increased likelihood of undiagnosed DM or pre-DM and would benefit from screening at the dental office.

Keywords
- diabetes mellitus
- oral health
- periodontal disease
- clinical attachment loss

Introduction

Diabetes mellitus (DM) is a prevalent medical problem associated with increased morbidity and mortality rates in many populations. The World Health Organization (WHO) categorizes Saudi Arabia as the second highest country in the Middle East in the prevalence of DM, with an estimated 7 million people have DM, and 3 million have pre-DM.[1] The prevalence rate of DM increased from 23.7% between 1995 and 2000 to 25.4% between 2007 and 2009.[2] One study found almost half of the people with the age of 50 years or older had DM, and 10 to 15% had pre-DM.[3] In addition, the prevalence of pre-DM was 10% in men and 11.8% in women aged 30 to 40 years.[3] The results highlight the importance of utilizing

published online
December 7, 2020

DOI https://doi.org/10.1055/s-0040-1719208
ISSN 1305-7456.

Thieme Medical and Scientific Publishers Pvt. Ltd., A-12, 2nd Floor, Sector 2, Noida-201301 UP, India

the available information to develop prevention strategies for type 2 diabetes in Saudi Arabia.

Type 2 diabetes can remain undiagnosed for years due to its asymptomatic nature. Studies estimated an average of 2 to 7 years of delay between the onset of the disease and the time of clinical diagnosis.[1,4] During this period, vascular damage progress undetected, which increases the prevalence of diabetes complications.[4] Screening for diabetes is encouraged in different health care settings, especially when the patient presents with the risk factors. Screening aims at identifying asymptomatic individuals who are unaware of their condition and at discovering prediabetic patients.[5] Early intervention of pre-DM by diet modification and increasing physical activities will help prevent or delay the progression of the condition into diabetes, which, once established, cannot be reversed.[6] The American Diabetes Association (ADA) recommends screening for type 2 diabetes in adults older than 45 years or at any age who have one or more diabetes risk factors.[7] Risk factors include impaired fasting blood glucose (FBG) (> 125 mg/dL), family history of diabetes, hypertension, hyperlipidemia, obesity or overweight, high-risk race, or ethnicity.[7]

Dental visits provide a great opportunity for the screening of undiagnosed medical conditions since most adults have regular visits and dental checkups throughout their life.[8] Most dentists believe early detection and treatment of DM improves both general and oral health and enhance the dentist's ability to prevent and treat periodontal disease.[9] Dentists were willing to perform chairside screening of DM and to refer the patient for medical consultation.[10] Herman et al (2015) demonstrated that ~30% of adults visiting general dental offices have dysglycemia and can be identified using a structured questionnaire that recognizes general risk factors for DM.[11] For every 10 adults who had their risk assessed in a dental setting in the United States, 2 might have had undiagnosed prediabetes or diabetes.[8] In a Saudi university dental clinic, 40% of the patients seeking dental treatment were found to have dysglycemia.[12]

Although many studies have shown that periodontal disease is a complication of DM,[13] the evidence of periodontal disease as a predictor of diabetes has not been established yet.[14] Analyses from National Health and Nutrition Examination Survey (NHANES) 2003 to 2004 demonstrated that 93% of individuals with periodontal disease and 63% of those without periodontitis met ADA guidelines for diabetes screening.[15] However, chronic periodontitis patients are rarely screened for DM.

This study's objective is to investigate whether periodontal findings can identify subjects with undiagnosed hyperglycemia (undiagnosed DM and pre-DM) in patients seeking dental treatment at a university dental hospital.

Materials and Methods

This study was performed on subjects seeking dental treatment at Dental Teaching Hospital, Umm Al-Qura University. The inclusion criteria were new dental patients older than 35 years who are not being diagnosed with DM before and have at least one of the risk factors of DM, as indicated by the ADA guidelines. Factors included a family history of diabetes, hypertension, high cholesterol, and overweight/obesity.[7] Subjects were excluded if they were pregnant or had less than 20 teeth.

The study protocol was approved by the Institutional Review Board at Umm Al-Qura University, Faculty of Dentistry (90–18). All participants provided informed written consent before enrollment in the study.

Risk Factor Assessment

Self-reported survey data were collected, included age, gender, nationality, weight (kg) and height (cm), family history of DM, history of hypertension, hyperlipidemia, and smoking status. Subjects were classified as either current smokers or nonsmokers. Body mass index (BMI) was calculated from weight and height (kg/m^2). BMI ≥ 25 is considered overweight, and obesity is considered when BMI ≥ 30.

Blood pressure measurement was obtained using an electronic sphygmomanometer (EDAN Vital Sign Monitor; EDAN Instruments, Inc., China). FBG level obtained by using CONTOURNEXT meter (Ascensia Diabetes Care Inc, United States). FBG was considered normal, if < 100 mg/dL; prediabetic, if FBG = 100 to 125 mg/dL; diabetic, if FBG ≥ 126 mg/dL.[7] Subjects with abnormal FBG were advised to seek further medical evaluation.

Periodontal Examination

All subjects received a complete periodontal examination by trained and calibrated general dentists. Intraexaminer reproducibility was between 0.69 and 0.82, and an interexaminer correlation was 0.71.

The periodontal examination included recording full mouth probing depth (PD), clinical attachment level (CAL), bleeding on probing, and gingival recession at six sites of each tooth excluding third molars. Using a manual periodontal probe, PD was determined by measuring the distance between the gingival margin and the base of the gingival sulcus, and CAL was determined by measuring the distance between the cementoenamel junction and the base of the sulcus. The number of missing teeth was recorded, and the orthopantomograph was screened for the percentage of bone loss. Subjects were classified as having mild bone loss if more than 30% of the teeth had < 15% bone loss, while the advanced bone loss was defined as having ≥ 15% bone loss in more than 30% of the teeth. Also, subjects with more than 30% of their teeth having CAL ≥3 mm were classified as having severe periodontal disease.

Statistical Analysis

All statistical analysis was performed using IBM SPSS statistic 20 statistical software. Mean and standard deviation were reported for continues variable and percentage for categorical variables. Significant differences between groups were assessed using *t*-test. As the outcome of the main research question is dichotomous (healthy/pre-DM or DM), multiple logistic regression was used as the statistical method to assess factors that predict if the participant is healthy or

prediabetic and diabetic. Backward elimination was used to detect confounding and remove insignificant variables. A *p*-value of <0.05 was considered significant throughout the study.

Results

A total of 61 subjects met the inclusion criteria. The average age of the participants was 42.9 ± 9.4 years, and 75% (*n* = 46) were females. The average BMI was 30.01 ±7.35 (range: 17.1–50.9). The mean PD was 2.5 ±1.2 mm, and the mean clinical attachment loss was 3.5 ± 8 mm. Subjects lost an average of 4.1 ± 3.6 teeth (range: 0–10 teeth). The average percentage of PD ≥5 mm was 5.9 ± 11.2, and the average percentage of CAL ≥3 was 14.7 ± 23.6%.

Risk Factors

Having an immediate family member diagnosed with DM was the most reported risk, with 64.5% of participants had a positive response to this item, followed by having hypertension (22.6%). The majority (75.8%) of the participant were overweight or obese. And 14.5% of participants had more than one risk factor for DM with a family history of DM and hypertension being the most common combination. The demographic and risk factors are shown in ►**Table 1**.

Analyzing FBG, 48.4% of the participants had FBG ≥ 100 mg/dL. This group's average age was 43.1± 7.5 years, and it did not differ from the age of subjects with normal glycemic status (42.7 ± 11 years, $p > 0.05$).

Table 1 Participants' demographic, including relevant risk factors

	Number (%)
Total	61 (100)
Age (mean ± SD), y	42.9 ± 9.4
Gender: female	46 (75)
Nationality: Saudi	24 (40)
Family history of DM	40 (64.5)
Hypertension	14 (22.6)
Hyperlipidemia	3 (4.8)
Overweight/obese	47 (75.8)
History of gestational diabetes	2 (3.2)
Smoking: yes	6 (9.7)

Abbreviations: DM, diabetes mellitus; SD, standard deviation.

A multiple logistic regression test was performed using backward elimination method to assess the effects of age, gender, nationality, family history of DM, gestational diabetes, smoking status, hyperlipidemia, hypertension, BMI, number of missing teeth, percentage of pocket depth above 5 mm, percentage of clinical attachment loss above 3 mm, and if the participant has advanced bone loss to predict if the participant is healthy or prediabetic and diabetic. The final logistic regression model included only smoking status, hypertension, family history of DM, and percentage of clinical attachment loss above 3 mm, and was statistically significant, chi-square test (4) = 27.473, $p < 0.001$. The model explained 47.7% of the diabetes condition and correctly classified 69.4% of cases. Participants with a family history of diabetes are 4.98 times more likely to exhibit prediabetic or diabetic cases than participants with no family history of diabetes. Each unit increase in the percentage of clinical attachment loss increases the likelihood of participant to be prediabetic or diabetic by 1.104 times. Smoking and hypertension were not significant in the model, but they were included as they are effect modifiers for the model (►**Table 2**).

Periodontal Findings Description

The subjects were divided based on the severity of periodontal disease into group A who had generalized advanced bone loss and CAL ≥ 3 in 30% of the teeth (59% (*n* = 36) and group B with mild bone loss and CAL < 3 in 30% of the teeth (41%, n = 25). Group A was significantly older than the subjects in group B (46.5 +9.6 vs. 38.6 +8.1 years, respectively, p = 0.002).

Group A had an average PD of 2.89 ± 1.4 mm and clinical attachment loss of 3.73 ± 0.89 mm which was significantly higher than in group B (PD = 1.8 ± 1.7 mm, Cal = 3.1 ± 0.89 mm and $p = 0.0001$, $p = 0.009$, respectively). Group A has lost an average of 4.45 ± 2.99 teeth, while group B has lost 3.68 ± 4.5 teeth ($p > 0.05$). Percentage of PD >5 mm was 7.9 ± 13.6% in group A and 3.3 ± 6.5% in group B, while the average percentage of CAL >3 mm was 21 ± 27.1% in group A, and in group B, the corresponding average was 7.08 ± 11.1 mm.

The BMI of both groups was not different (29.8 ± 6.7 vs. 29.1 ± 6.3 in groups A and B, respectively, $p > 0.05$). In group A, the average FBG was 113 ± 29.1 mg/dL compared with group B with average FBG of 100.93 ± 25.8 mg/dL ($p < 0.05$).

Table 2 The final logistic regression model included only smoking, hypertension, family history of DM, and the percentage of clinical attachment loss more than 3 mm

	B	SE	Wald	Df	Significance	Exp (*B*)	95.0% CI for EXP (*B*)	
							Lower	Upper
Smoking	2.851	1.503	3.596	1	0.058	0.058	0.003	1.100
Hypertension	2.273	1.227	3.432	1	0.064	0.103	0.009	1.141
Family history of DM	1.606	0.851	3.559	1	0.059	4.983	0.939	26.433
% of CAL > 3 mm	0.099	0.032	9.578	1	0.002	1.104	1.037	1.175
Constant	2.210	0.896	6.088	1	0.014	0.110		

Abbreviations: CAL, clinical attachment level; CI, confidence interval; DM, diabetes mellitus; SD, standard deviation.

None of the other risk factors was different between the two groups (►**Fig. 1**).

Discussion

This study confirmed that periodontal findings can identify subjects with undiagnosed DM or pre-DM. Severe clinical attachment loss was associated with prediabetes or diabetes condition. Moreover, each unit increase in the percentage of attachment loss increased the likelihood of the subject to have pre-DM or DM by 1.104 times. When risk factors such as family history of DM, hypertension, and smoking were considered, the model correctly classified 69.4% of the cases. Subjects who showed an advanced bone loss on the radiographs had a higher FBG level than those who had normal or mild bone loss.

Identifying subjects with undiagnosed DM or pre-DM is crucial to initiate early management and control of the disease and to reduce the economic impact of DM. Several studies aimed to develop a predictive model with high sensitivity using intraoral findings. Lalla et al[16] identified two factors (the presence of ≥4 missing teeth or ≥26% of teeth with deep pockets) that correctly identified 73% of true cases of DM or pre-DM in adults with risk factors of DM but never were diagnosed. When glycosylated hemoglobin measurements were considered, the sensitivity of the predictive model increased from 73 to 92%. However, in their study, they looked at a very specific community, and their results might not be generalizable to others. Also, they did not evaluate clinical attachment loss, which is a more reflective measurement of periodontal disease severity as compared with periodontal pocket depth. Using CAL, this study model explained 47.7% of the diabetes condition and correctly classified 69.4% of cases confirming advanced clinical attachment loss can identify subjects with hyperglycemia. Tooth loss, on the contrary, was not significant in the model. Group A has lost more teeth than group B, but both groups had on average more than four extracted teeth. The causes of tooth loss were not analyzed in this study, but other studies confirmed that caries is the leading cause of tooth loss in the Saudi Arabian population.[17] In contrary to Lalla et al, this study used FBG to identify subjects with hyperglycemia. FBG is more feasible in the dental offices as compared with the use of end of care glycosylated hemoglobin. False-positive results will not be of a significant impact as the patient is referred to a general physician for confirmation of the diagnosis and treatment.

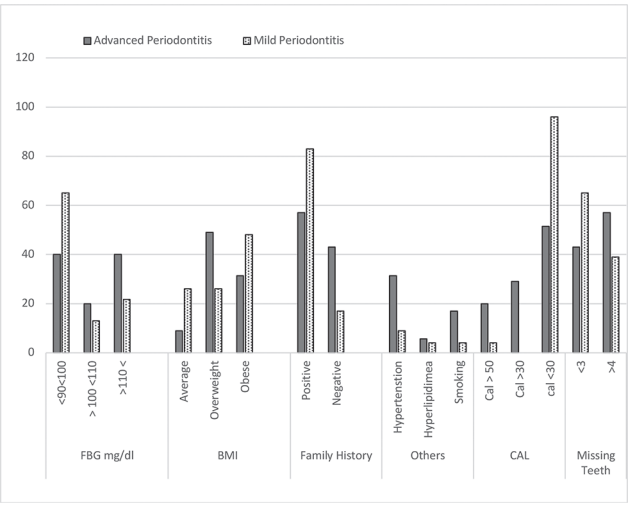

Fig. 1 FBG level, risk factors, and periodontal findings among the subjects with advanced and mild periodontal disease. BMI, body mass index; CAL, clinical attachment loss; FBG, fasting blood glucose.

On a larger scale, Strauss et al[15] analyzed data from NHANES-3 that looked at general health data coupled with the periodontal pocket depth and clinical attachment loss measurement. They predicted probabilities of undiagnosed diabetes between 27 and 53%. In Danish population, Holm et al[18] reported that periodontal disease status could identify DM and pre-DM with a sensitivity of 0.91, although the specificity was low (0.19). Their study population, unlike ours, included any dental patients regardless of their risk for DM. Acharya et al[19] presented a model that utilized the patient's demographic, detailed medical, and dental examinations and identified 70% of dental patients with undiagnosed DM. However, access to patient's comprehensive medical records might not be possible for all dental offices.

Those findings advanced our understanding of the association of periodontal disease and DM. Most studies have confirmed the bidirectional relationship between DM and periodontal disease in which uncontrolled hyperglycemia results in advanced glycation products that exacerbate periodontal destruction.[20-22] Moreover, the activated immune response in diabetic subjects affects subgingival biofilm and contributes to chronic inflammation and insulin resistance.[23] Although most literature addressed uncontrolled diabetes effects on the periodontal condition,[13,24] it is possible that hyperglycemia in the prediabetic stage contributes to the shift in subgingival microbes and subsequently predispose to inflammation.[25-27] Higher periodontal parameters were reported in prediabetic subjects compared with normoglycemic subjects.[28] And it is possible that severe periodontitis can be an early sign of undiagnosed DM.[13,29] Also, the control of DM can be relevant to the control of periodontal disease.[30] In our finding, higher FBG was found in patients with periodontitis when compared with those without which is in agreement with previous studies.[23,30,31] Furthermore, Islam et al showed a significant association of periodontitis to impaired FBG after adjustment for confounding factors such as age, sex, BMI, smoking, and hypertension.[23]

Considering the prevalence of DM in Saudi Arabia, it is not surprising that most of the patients enrolled in the study had a family history of DM as a risk factor. Family history is a known, strong independent risk factor for diabetes, and those with a parental family history of DM are more susceptible to develop DM later on life.[32] Family members share genetic, environmental, and behavioral factors that affect their risk of DM.[33] In this study, participants with a family history were almost five times more likely to have DM or pre-DM. Similarly, family history was strongly associated with diabetes status but interestingly, not with prediabetes in Jeddah city residents.[3] A family history of chronic

disease is important not only to identify subjects at risk of certain chronic diseases but also to improve awareness and motivate subjects to adopt a risk-reducing behavior.[34]

The second most common reported risk factor in our study was the history of hypertension. The small number of subjects reporting hypertension could explain the lack of a significant effect on the model. However, hypertension and smoking were included as effect modifiers.

BMI, in this study, was not significantly different between the groups. Many studies have confirmed the relationship between obesity and the risk of DM.[3,8,27] WHO reports a prevalence rate of 68 and 33.7% for overweight and obesity in the Saudi Arabian population.[35] In this study, 78% of the participant were overweight or obese. We relied on self-reported weight and height in the calculation of BMI. Also, we did not consider calculating abdominal obesity, which might have a better correlation with DM.[36] Obesity and abdomen obesity are risk factors for periodontal disease with a triangular relationship between obesity, diabetes, and periodontitis may exist.[37,38] However, waist circumference measurement is not performed in dental clinics.

Our study has many limitations. It only addresses a small population who are seeking dental treatment at a university-based hospital. The cross-sectional nature of the study does not establish any association between different factors. The validity self-reported medical data are considered another limitation. The possibility of a recall error or underestimation is a potential concern with self-reported data. FBG was used to identify DM or pre-DM. Ideally, the test has to be repeated, or a glycosylated hemoglobin test is done to confirm the diagnosis and avoid errors. The study has to be applied to a larger sample size with a wide diversity of patients.

This study supports that dentists should be updated with the ADA guidelines for type 2 diabetes screening[7] and advised screening of their patients if they fit the guidelines regardless of their oral health status. The dentist's role is not to establish the diagnosis or provide treatment but rather to identify and refer the at-risk patients to medical care.

Conclusion

This study confirms that the dental profession can help identify patients with a risk of undiagnosed DM or pre-DM using findings from the periodontal examination. In patients with a risk factor for DM, especially a family history of DM, the presence of advanced clinical attachment and bone loss may indicate undiagnosed DM or pre-DM and worth the screening and referral to medical care.

Funding
None.

Conflict of Interest
None declared.

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