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Association Between Periodontal Disease Severity and Glycemic Control in Patients with Type 2 Diabetes Mellitus

Osama Khalil[1*], Muhammad Asad Riaz[2]

[1*]Venus Health, Lahore, Pakistan [2]Surraya Azeem Teaching Hospital, Lahore, Pakistan

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CORRESPONDING AUTHOR

Osama Khalil
Venus Health, Lahore, Pakistan
dr.osamakhalilpt@gmail.com

ABSTRACT

Background: Type 2 diabetes mellitus and periodontal disease are interconnected chronic conditions linked through inflammatory and metabolic pathways. Prolonged hyperglycemia promotes the formation of advanced glycation end products and increases pro-inflammatory cytokine release, accelerating periodontal tissue breakdown. Untreated periodontal disease can increase systemic inflammation and negatively affect glycemic regulation. **Objective:** To determine the association between periodontal disease severity and glycemic control in patients with type 2 diabetes mellitus and to examine whether poor glycemic control predicts greater periodontal tissue loss. **Methodology:** A cross-sectional analytical study was conducted among 120 adults with type 2 diabetes mellitus. Periodontal status was evaluated using the Community Periodontal Index, probing pocket depth, and clinical attachment level. Glycemic control was assessed using glycated hemoglobin values extracted from medical records. Patients who had any systemic disease that directly affects periodontal tissues, such as rheumatoid arthritis or connective-tissue disorders, were excluded. We also excluded pregnant females and patients who had periodontal treatment in the past three months to avoid changes in baseline readings. Data were analyzed using Pearson's correlation and multivariate linear regression adjusting for age, gender, smoking status, duration of diabetes, and oral hygiene practices. **Results:** Among the 120 participants (mean age 52.7±8.6 years), 65% had poor glycemic control (HbA1c ≥8%). Patients with poor control exhibited significantly higher mean PPD (5.0±1.1 mm) and clinical attachment level (4.7±1.0 mm) compared with those having HbA1c <7% (PPD 3.5±0.8 mm; clinical attachment level 3.1±0.9 mm) ($p<0.001$). HbA1c demonstrated a moderate positive correlation with CAL ($r=0.43$, $p<0.001$). On multivariate regression, HbA1c remained an independent predictor of periodontal destruction ($\beta=0.37$, $p<0.01$) after adjusting for confounders. **Conclusion:** Poor glycemic control is significantly associated with increased periodontal disease severity among Pakistani patients with type 2 diabetes mellitus. Incorporating periodontal assessment and treatment into diabetes management programs may help improve overall health outcomes.

Keywords: Glycemic control, Hyperglycemia, Periodontitis, Type 2 diabetes mellitus

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INTRODUCTION

Type 2 diabetes mellitus (T2DM) is one of the most common chronic diseases in the world. It is also rising fast in Pakistan, where many adults live with diabetes and many more are newly diagnosed every year. Poor glycemic control in T2DM affects different organs, including the oral cavity. One important complication seen in diabetic patients is periodontal disease, which includes gingivitis and periodontitis. The relationship between diabetes and periodontal disease has been studied for many years, and researchers describe it as a bidirectional link. Diabetes can make periodontal disease worse, and severe periodontal disease may itself make glycemic control poor. This relationship has been explained by different biological mechanisms.

Chronic hyperglycemia leads to the formation of advanced glycation end products (AGEs), increased oxidative stress, and higher levels of inflammatory cytokines. These factors weaken the body's immune response and healing ability in gum tissues, making them more vulnerable to infection and tissue breakdown.[1,2] Periodontitis may also increase systemic inflammation, which can worsen insulin resistance and disturb glucose levels.[3] Several systematic reviews and observational studies have confirmed that people with T2DM usually have deeper periodontal pockets, more bleeding, and more clinical attachment loss than people without diabetes.[4] Poor glycemic control, especially high HbA1c levels, is associated with more severe periodontal destruction.[5] Some interventional studies also show that treating periodontal disease can help improve HbA1c levels in diabetic patients.[6] This suggests that oral health should be considered an important part of diabetes care.

In Pakistan, the population has different risk factors, such as limited oral hygiene awareness, limited access to dental care, and different dietary habits. Therefore, understanding this association in Pakistani diabetic patients is very important. Alam et al. (2024) reported that almost 78% of diabetic patients had periodontal disease, showing a high burden of oral complications among diabetics.[7] Batool et al. (2022) compared periodontal status in diabetics and found that patients with type 2 diabetes showed more severe periodontal disease than type 1 diabetics.[8] Mariyam et al. (2023) conducted a study that also showed significantly deeper periodontal pockets in diabetic patients than in non-diabetic people.[9] Similarly, a clinical trial among T2DM patients showed that non-surgical periodontal treatment led to a reduction in HbA1c after three months, supporting the positive link between periodontal therapy and glycemic control.[10] Despite these findings, Pakistan still lacks well-designed studies that use periodontal clinical attachment level (CAL) and probing pocket depth (PPD) to examine how glycemic control (HbA1c) directly relates to periodontal severity in T2DM patients.

A study by Qureshi et al. (2024) highlighted that awareness is also a major issue among diabetic patients who were not aware that poor glycemic control can aggravate gum disease.[11] Therefore, when patients lack awareness, it results in delayed dental care, leading to advanced disease before finally seeking treatment. Because of this gap in local research, it becomes important to generate evidence in the Pakistani context. Studies conducted locally can help health professionals understand how strongly glycemic control and periodontal disease are linked in our population. It may also encourage integration of dental screening into diabetic clinics, which is currently not a routine practice in Pakistan.

The objective of the present study is to evaluate the association between periodontal disease severity and glycemic control in patients with T2DM, and to determine whether poor glycemic control predicts greater periodontal tissue loss using periodontal measures such as PPD and CAL in a tertiary-care hospital setting in Pakistan. This study aims to contribute to the limited local literature and help improve diabetes management by highlighting the importance of oral health.

METHODOLOGY

This study followed a cross-sectional analytical design, very similar to earlier research exploring the link between diabetes and periodontal disease.[12,13] The study was done in two tertiary care hospitals in Pakistan over six months. Adults with T2DM who came for routine follow-up were approached. The age range for inclusion was 30 to 60 years. Both men and women were taken. Participants who smoked cigarettes were also included because smoking is common in Pakistan, and many previous periodontal studies also included smokers to see the real population pattern. A total of 120 adults with diagnosed T2DM were selected using non-probability consecutive sampling. Every eligible patient during data

collection days was invited until the sample size was completed. T2DM duration of at least one year was required. Patients who had any systemic disease that directly affects periodontal tissues, such as rheumatoid arthritis or connective-tissue disorders, were excluded. We also excluded pregnant females and patients who had periodontal treatment in the past three months to avoid changes in baseline readings.

All participants signed written informed consent. Privacy and confidentiality were maintained throughout the study. Data was collected using a structured proforma. This method has been widely used in earlier studies examining diabetes and oral health.[12] Basic demographic information was collected (age, sex, BMI, duration of diabetes, smoking status, tooth-brushing frequency, use of mouthwash, and dental visit history were included). Each participant underwent a periodontal examination. A single trained dentist carried out all examinations to minimize examiner variability, which is a common approach in similar cross-sectional periodontal studies. In this study, three periodontal parameters were assessed which are as follows.

The Community Periodontal Index (CPI) was used to screen periodontal health in participants. The CPI is recommended by the World Health Organization (WHO) and has been used in many diabetes periodontitis studies because it is simple and standardized.[12] Bleeding, calculus, and pocket scores were noted according to WHO criteria. Probing Pocket Depth (PPD) was measured at six sites on each tooth: mesio-buccal, mid-buccal, disto-buccal, mesio-lingual, mid-lingual, and disto-lingual. Pocket depth helps identify active periodontal breakdown. CAL was also measured at the same six sites. CAL reflects long-term tissue destruction and is considered a more stable and reliable indicator of periodontitis progression.[13] CAL was recorded in millimeters.

Assessment of glycemic control was assessed using HbA1c reports, which is the standard marker for long-term glycemic control and is used in almost all previous studies linking diabetes with periodontal outcomes.[13] Participants were classified as controlled or uncontrolled using standard cut-off values. All readings were written directly on the proforma during the examination to reduce recording errors. Data was analyzed with SPSS version 26. Mean and standard deviation were used for continuous variables, and percentages for categorical data. Pearson's correlation was applied to see the relationship between HbA1c and periodontal parameters (CPI, PPD, CAL). Then, multivariate linear regression was performed. Regression models were adjusted for important confounders reported in earlier research: age, gender, smoking status, diabetes duration, and oral hygiene habits. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 120 adults with Type 2 Diabetes Mellitus participated in the study. The mean age was 52.7±8.6 years, and slightly more male participants were included. The age distribution was almost similar in both glycemic groups. Most participants brushed once daily, and around one-fourth were smokers, which also reflects the general pattern of previous periodontal studies. Table 1 shows the basic characteristics. Periodontal measurements showed clear differences between the glycemic groups. Mean PPD and CAL were much higher in the poor glycemic control group, which indicates deeper pockets and more attachment loss. Table 2 presents these periodontal variables. HbA1c showed a moderate positive correlation with both PPD and CAL. This pattern has been reported consistently in previous studies on periodontal destruction among diabetic patients.

The correlation values from our study are shown in Table 3. Multivariate linear regression was used to check whether HbA1c remained a predictor of periodontal damage after controlling for age, sex, smoking, brushing habits, and diabetes duration. HbA1c stayed significant, showing that poor

Table 1: Baseline characteristics of study participants

Variables	Total (n=120)	Good Control HbA1c <7% (n=42)	Poor Control HbA1c ≥8% (n=78)
Age (years)	52.7 ± 8.6	51.9 ± 7.8	53.2 ± 9.0
Gender (Male)	58 (48.3%)	18 (42.8%)	40 (51.2%)
Smoking	28 (23.3%)	7 (16.6%)	21 (26.9%)
Duration of Diabetes (years)	8.1 ± 4.2	6.9 ± 3.8	8.8 ± 4.4
Brushing once daily	94 (78.3%)	29 (69.0%)	65 (83.3%)

Table 2: Comparison of periodontal parameters between glycemic groups

Periodontal variables	Good Control mean±SD	Poor Control mean±SD	p-value
PPD (mm)	3.5 ± 0.8	5.0 ± 1.1	<0.001
CAL (mm)	3.1 ± 0.9	4.7 ± 1.0	<0.001
CPI Score ≥ 3	38%	79%	<0.001

Table 3. Correlation of HbA1c with periodontal parameters

Variables	Correlation coefficient (r)	p-value
HbA1c vs PPD	0.41	<0.001
HbA1c vs CAL	0.43	<0.001
HbA1c vs CPI	0.39	<0.001

glycemic control independently contributed to periodontal tissue loss. This is consistent with several earlier cross-sectional studies. Table 4 shows the regression analysis. Figure 1 compares mean PPD and CAL between good and poor glycemic control groups, which clearly show worse periodontal measures in patients with poor glycemic control. This means that patients whose blood sugar levels are not well controlled have deeper periodontal pockets and more attachment loss.

Deeper pockets usually show more active gum inflammation, and higher CAL means more long-term tissue destruction. These results give a clear indication that periodontal disease intensity is higher in individuals with poorly controlled glycemia. The correlation analysis shows that higher HbA1c values are linked with worse periodontal outcomes. Even after adjustments, HbA1c still plays an important role in periodontal breakdown due to poor glycemic control. The current study's findings are similar to previous research, which shows an association between hyperglycemia and periodontal destruction. Inflammation due to diabetes accelerates periodontal damage and thus reinforces the importance of having periodontal care in diabetes management programs.

DISCUSSION

This study found a direct correlation between poor glycemic control and increased periodontal disease severity in Pakistani adults with T2DM, especially in patients with HbA1c 8% or above had deeper gum pockets, increased attachment loss, and higher CPI scores. These results are consistent with many previous studies. High blood sugar in type 2 diabetes causes AGEs products to build up in the gum tissues. These AGEs increase inflammation and slow down the healing of the gums. This leads to more pocket depth and attachment loss.[14]

Similarly, our results showed that higher HbA1c was moderately correlated with both PPD and CAL. This finding supports the bidirectional relationship between diabetes and periodontitis.[15]

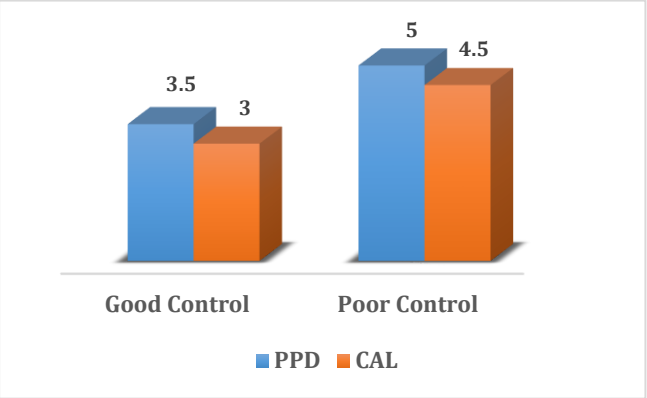
Several previous studies also reported similar findings. A study in India among 150 T2DM patients showed that those with poor glycemic control had significantly higher CAL and PPD compared to well-controlled diabetics.[16] Another study found that HbA1c levels were positively associated with periodontal destruction.[17] These studies suggest that glycemic control is an important predictor of periodontal disease severity. Our results are also similar to global research in this area. A meta-analysis was conducted in Saudi Arabia, which found that diabetics with poor glycemic control had significantly worse periodontal parameters than controlled diabetics or non-diabetic individuals.[18] Another study reported that poor glycemic control increases the risk of severe periodontitis by almost two times.[19]

Regression analysis in our study showed that HbA1c remained an independent predictor of CAL even after adjusting for age, gender, smoking, duration of diabetes, and oral hygiene. This indicates that hyperglycemia itself contributes directly to periodontal tissue breakdown, which has been confirmed in experimental studies.[20] Chronic inflammation caused by high blood sugar leads to cytokine release, neutrophil dysfunction, and increased oxidative stress in gums. These mechanisms explain why poor glycemic control increases tissue destruction.[21] Smoking is another important risk factor in periodontal disease. In our study, smokers had slightly higher CAL and PPD, but after regression, HbA1c remained the strongest predictor. This is similar to previous research showing that diabetes is a stronger determinant of periodontal severity than smoking alone, although smoking worsens the outcomes.[22] This study has

Table 4: Multivariate linear regression analysis predicting periodontal destruction

Predictor	β-coefficient	95% CI	p-value
HbA1c	0.37	0.19 – 0.52	<0.01
Age	0.11	−0.03–0.27	0.12
Smoking	0.18	0.06 – 0.31	0.03
Duration of diabetes	0.14	0.01 – 0.26	0.04
Brushing frequency	−0.09	−0.22–0.04	0.18

Figure 1: Periodontal measures by glycemic control



highlighted that in Pakistan, people with diabetes usually don't know much about oral health. They know about kidneys, eyes, and heart issues, but the link between diabetes and gum disease is largely ignored.[23] In our sample of participants, many people brushed only once a day but regular dental checkups were ignored altogether. These habits can easily make gum problems worse over time. If diabetes clinics start adding simple gum-care services, it might reduce the overall burden of disease and help patients feel better.[24] Some interventional studies have shown that when periodontitis is treated, blood sugar can improve a little.

A study by Nassar et al. (2025) noted that non-surgical gum cleaning caused a small but meaningful drop in HbA1c after three months.[25] It suggests a two-way benefit: better diabetes control helps the gums, and healthier gums can help with sugar levels too. Our results also show the need for regular gum screening in people with T2DM, especially in those who have poor glycemic control. Finding gum pockets or attachment loss early can prevent tooth loss and reduce inflammation in the whole body. Doctors in Pakistan should explain to diabetic patients why oral hygiene, checkups, and good sugar control are all connected to well-being. There are a few limitations in our study. It is cross-sectional, so we cannot claim a direct cause-and-effect; therefore, further investigations are recommended. Our sample also came from tertiary hospitals, so it might not fully represent the general population. Still, our findings agree with earlier studies from Pakistan and from other countries.

CONCLUSION

This study shows that poor glycemic control is strongly linked with more severe periodontal disease in Pakistani adults with Type 2 Diabetes Mellitus. Patients with HbA1c ≥8% had deeper gum pockets, higher attachment loss, and higher CPI scores compared to those with better sugar control. Regression analysis also showed that HbA1c is an independent predictor of periodontal tissue damage, even after adjusting for age, gender, smoking, diabetes duration, and hygiene habits. These findings highlight the need to include oral health awareness in diabetes programs. Regular gum checkups, patient education, and maintaining controlled blood sugar may lower gum complications and improve overall health outcomes for diabetic patients in Pakistan.

DECLARATIONS

Consent to participate: Written consent had been obtained from patients. All methods were performed following the relevant guidelines and regulations.

Availability of Data and Materials: Data will be made available upon request. The corresponding author will submit all dataset files.

Competing interests: None

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Authors' contributions: All authors had read and approved the final manuscript.

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