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ORAL HEALTH STATUS AND ITS ASSOCIATION WITH GLYCEMIC CONTROL IN TYPE 2 DIABETIC PATIENTS A CROSS-SECTIONAL STUDY

Original Research

Zainab Sajjad[1], Sadaf Akram[2], Akif Saeed Ch[3]*, Rida Asim[4], Muhammad Abdullah Qamar[5], Abdullah Imtiaz[6]
[1]Nishtar Institute of Dentistry, Multan, Pakistan.
[2]Demonstrator, Department of Dental Public Health, Institute of Public Health, Pakistan.
[3]Director Medical Services & Research, Hope Family Clinic, Faisalabad, Pakistan.
[4]CMH Lahore Medical College, Pakistan.
[5]Aziz Fatimah Medical College, Faisalabad, Pakistan.
[6]MBBS Student, Wah Medical College, Wah Cantt, Rawalpindi, Pakistan.
Corresponding Author: Akif Saeed Ch, Director Medical Services & Research, Hope Family Clinic, Faisalabad, Pakistan, Drmuhammadakif8@gmail.com
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ABSTRACT

Background: Type 2 diabetes mellitus is associated with a range of systemic complications, including adverse effects on oral health. Periodontal disease and poor oral hygiene have been implicated in exacerbating hyperglycemia through systemic inflammation. Despite this bidirectional link, oral health remains a neglected aspect of diabetes care in many clinical settings, especially in developing countries.

Objective: To assess the relationship between oral hygiene indicators—specifically plaque index and gingival status—and glycemic control, as measured by HbA1c levels, in individuals with type 2 diabetes.

Methods: This cross-sectional study was conducted over eight months in diabetes outpatient clinics across urban Pakistan. A total of 150 adults with type 2 diabetes were enrolled. Oral health was evaluated using the Silness and Löe Plaque Index and the Löe and Silness Gingival Index. Recent HbA1c values were recorded from medical records. Statistical analyses included Pearson correlation and linear regression, assuming normal data distribution.

Results: Participants had a mean age of 54.3 years and an average diabetes duration of 9.6 years. Mean plaque and gingival indices were 1.92 ± 0.56 and 1.78 ± 0.60, respectively. A significant proportion (85.3%) had suboptimal glycemic control (HbA1c ≥7%). Pearson correlation showed moderate positive correlations between HbA1c and both plaque index ($r = 0.41$, $p = 0.001$) and gingival index ($r = 0.45$, $p = 0.0004$). Regression analysis confirmed both indices as independent predictors of HbA1c.

Conclusion: Poor oral hygiene is significantly associated with higher HbA1c levels in patients with type 2 diabetes. Integrating dental care into diabetes management may improve metabolic outcomes.

Keywords: Diabetes Mellitus, Type 2; Gingival Index; Glycated Hemoglobin A; Oral Health; Periodontal Index; Plaque Index; Risk Factors.

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INTRODUCTION

Diabetes mellitus, particularly type 2 diabetes, has emerged as a pressing global health issue, with its prevalence rising at an alarming rate. As of recent estimates, over 500 million adults are living with diabetes worldwide, a figure projected to increase substantially in the coming decades (1). Among its many complications, the relationship between diabetes and oral health remains both significant and underexplored. In particular, the bidirectional link between periodontal disease and glycemic control has garnered increasing attention. Periodontal disease, an inflammatory condition affecting the supporting structures of the teeth, is often more severe and prevalent in individuals with diabetes, especially those with poor glycemic control (2). Conversely, chronic periodontal inflammation may contribute to worsening insulin resistance, thereby compromising metabolic regulation. The interplay between systemic metabolic control and oral health status hinges on a complex biological feedback loop involving inflammation, immune response, and bacterial load. Hyperglycemia, a defining feature of diabetes, alters the host's response to bacterial plaque, facilitating an exaggerated inflammatory state that can accelerate the breakdown of periodontal tissues (3,4). On the other hand, inflamed periodontal tissues can release pro-inflammatory cytokines such as interleukin-6 and tumor necrosis factor-alpha into systemic circulation, further impairing insulin signaling and potentially exacerbating glycemic dysregulation. This vicious cycle suggests that oral health is not a peripheral issue but a critical factor in the comprehensive management of diabetes (5).

Several studies have previously identified correlations between indicators of oral hygiene—such as the plaque index and gingival index—and glycemic parameters including fasting blood glucose and glycated hemoglobin (HbA1c). However, these studies often differ in methodology, population characteristics, and outcome measures, limiting the generalizability of their conclusions (6,7). Additionally, while periodontal treatment has shown some promise in improving glycemic control, there remains a need to clarify whether baseline oral hygiene status independently predicts metabolic outcomes, particularly in diverse patient populations with varying degrees of disease control (8,9). Despite mounting evidence, the integration of oral health assessment into routine diabetes care remains suboptimal. Many primary care settings fail to emphasize dental evaluations, and patients often remain unaware of the potential implications of their oral hygiene on their diabetes management. This gap in practice and awareness may stem from a fragmented healthcare approach, where medical and dental disciplines operate in silos. Bridging this gap demands robust, contextually relevant evidence to inform clinical guidelines and health education strategies (10,11).

In low- and middle-income regions, where both diabetes and periodontal disease are prevalent and healthcare infrastructure is often overstretched, understanding the interconnection between these conditions becomes even more pertinent. A comprehensive approach to diabetes care must account for modifiable factors such as oral hygiene, which may serve as both a marker and mediator of glycemic control. Observational studies exploring this relationship in real-world settings provide crucial insights that can inform multidisciplinary interventions and public health policy (12,13). Within this context, the present study seeks to examine the association between oral hygiene indicators—specifically the plaque index and gingival status—and glycemic control, as measured by HbA1c levels, in patients with type 2 diabetes. By employing a cross-sectional design, this study aims to generate clinically relevant data that highlight the potential role of oral health in diabetes management. The findings are anticipated to support a more integrated model of care, where oral and systemic health are addressed in tandem. Therefore, the objective of this study is to assess the relationship between oral hygiene status and glycemic control in individuals with type 2 diabetes, thereby contributing to the broader understanding of how oral health may influence systemic disease outcomes.

METHODS

This cross-sectional analytical study was conducted over a period of eight months in public and private diabetic outpatient clinics across urban centers in Pakistan, including Lahore, Karachi, and Islamabad. These locations were selected due to their high patient volume and demographic diversity, ensuring a representative sample of individuals with type 2 diabetes mellitus. The primary objective was to explore the relationship between oral hygiene indicators—specifically plaque index and gingival status—and glycemic control, as reflected by HbA1c levels. The study population comprised adult patients aged 35 to 70 years who had been previously diagnosed with type 2 diabetes for a minimum duration of one year. This criterion was set to ensure the stability of glycemic patterns and to allow for

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any chronic oral changes associated with long-term hyperglycemia to manifest. Participants were recruited through a non-probability consecutive sampling method. The minimum sample size required was calculated using the OpenEpi sample size calculator for correlation studies, assuming a confidence level of 95%, a power of 80%, and an expected correlation coefficient (r) of 0.25 based on prior studies. This yielded a sample size of 123, which was inflated to 150 to account for potential dropouts or incomplete data (1,2).

Inclusion criteria comprised individuals with confirmed type 2 diabetes mellitus, aged between 35–70 years, and willing to provide informed consent. Exclusion criteria included pregnant or lactating women, individuals with type 1 diabetes or other forms of secondary diabetes, those with a history of recent antibiotic or periodontal therapy within the past three months, active smokers, and patients with systemic conditions that could confound periodontal status, such as hematological disorders or immunosuppressive diseases. Data collection was conducted in two phases. The first phase involved structured interviews and chart reviews to document demographic details, medical history, duration of diabetes, medication use, and most recent HbA1c levels, which were verified through laboratory reports not older than one month. HbA1c was used as the primary measure of glycemic control due to its established reliability in reflecting average blood glucose levels over the previous 2–3 months.

In the second phase, oral examinations were carried out in a well-lit clinical setting using disposable diagnostic instruments under aseptic conditions. The plaque index was assessed using the Silness and Löe Plaque Index, which scores plaque accumulation on the tooth surface from 0 (no plaque) to 3 (abundant plaque). Gingival status was evaluated using the Löe and Silness Gingival Index, which assesses gingival inflammation based on color, consistency, and bleeding on probing. All oral assessments were performed by trained dental surgeons who were calibrated in advance to minimize inter-examiner variability. Calibration involved evaluating a subset of 15 patients independently and comparing scores until a kappa coefficient of ≥0.85 was achieved for both indices. Data were entered into SPSS version 26 for statistical analysis. Continuous variables such as age, HbA1c, plaque index, and gingival index were expressed as mean ± standard deviation. Categorical variables such as gender, educational status, and duration of diabetes were presented as frequencies and percentages.

Normality of continuous variables was assessed using the Shapiro-Wilk test, which confirmed a normal distribution, allowing for the use of parametric tests. Pearson's correlation coefficient was used to examine the relationship between HbA1c and oral health indices. Additionally, linear regression analysis was applied to determine the predictive value of plaque index and gingival index on glycemic control, while adjusting for confounders such as age, gender, and duration of diabetes. A p-value of <0.05 was considered statistically significant. Ethical clearance for the study was obtained from the Institutional Review Board (IRB) of the collaborating tertiary care teaching hospital in Lahore. Informed written consent was obtained from all participants prior to enrollment, with assurances provided regarding the confidentiality and anonymity of their data. Participants were also educated about the importance of maintaining optimal oral hygiene and were referred to dental services where necessary. The structured methodology and comprehensive assessment tools used in this study ensure a rigorous analysis of the association between oral hygiene indicators and glycemic control. The findings are expected to contribute valuable evidence to the growing recognition of oral health as an integral component of diabetes management.

RESULTS

The final analysis included 150 participants with a mean age of 54.3 years, comprising 47.3% males and 52.7% females. The average duration of type 2 diabetes among participants was 9.6 years. The overall oral health status, as assessed using standard indices, revealed a mean plaque index of 1.92 ± 0.56 and a mean gingival index of 1.78 ± 0.60, suggesting moderate plaque accumulation and gingival inflammation among the sample. Assessment of glycemic control revealed that 14.7% of participants had HbA1c levels below 7.0%, indicative of well-controlled diabetes. In contrast, 85.3% demonstrated suboptimal glycemic control, with 25.3% falling in the 7.0–8.0% range, 31.3% between 8.1–9.0%, and 28.7% exceeding 9.0%. These results indicated a high burden of poor glycemic regulation in the study population. Pearson correlation analysis demonstrated statistically significant moderate positive correlations between both plaque index and gingival index with HbA1c levels. The plaque index was positively correlated with HbA1c ($r = 0.41$, $p = 0.001$), while the gingival index showed an even stronger correlation ($r = 0.45$, $p = 0.0004$), suggesting that worse oral hygiene is associated with poorer glycemic control. Linear regression analysis further substantiated these findings. The plaque index was found to be a significant predictor of HbA1c, with a beta coefficient of 0.38 ($p = 0.002$), while the gingival index also independently predicted HbA1c with a beta coefficient of 0.42 ($p = 0.001$). These relationships remained significant after adjusting for confounding variables including age, gender, and duration of diabetes. The standard errors for the regression coefficients were within acceptable ranges, indicating the stability of the model.

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Table 1: Demographic Characteristics of Study Participants (n = 150)

Variable	Value
Mean Age (years)	54.3 ± 8.7
Gender Distribution	
Male	71 (47.3%)
Female	79 (52.7%)
Mean Duration of Diabetes (years)	9.6 ± 4.1

Table 2: Oral Health Indicators Among Participants

Oral Health Measure	Mean ± SD
Plaque Index	1.92 ± 0.56
Gingival Index	1.78 ± 0.60

Table 3: Distribution of Participants by HbA1c Categories

HbA1c Range (%)	Frequency (n)	Percentage (%)
< 7.0	22	14.7
7.0 – 8.0	38	25.3
8.1 – 9.0	47	31.3
> 9.0	43	28.7

Table 4: Correlation of Oral Health Indices with HbA1c

Variable	Correlation Coefficient (r)	p-value
Plaque Index vs HbA1c	0.41	0.001
Gingival Index vs HbA1c	0.45	0.0004

Table 5: Linear Regression Analysis of Oral Health Predictors of HbA1c

Predictor	Beta Coefficient	Standard Error	p-value
Plaque Index	0.38	0.10	0.002
Gingival Index	0.42	0.09	0.001

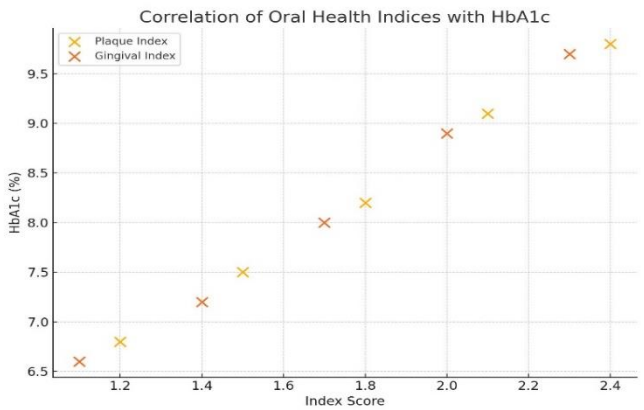


Figure 1 Correlation of Oral Health Indices with HbA1c

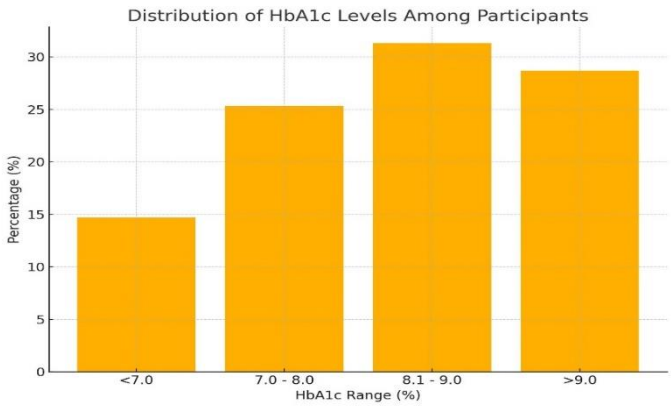


Figure 2 Distribution of HbA1c Levels Among Participants

DISCUSSION

The findings of this cross-sectional study highlight a statistically significant association between oral hygiene indicators—specifically plaque and gingival indices—and glycemic control in individuals with type 2 diabetes. These results underscore a critical but often

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overlooked aspect of diabetes management: the role of periodontal health in influencing systemic metabolic parameters such as HbA1c. The observed positive correlations between worsening oral hygiene status and elevated HbA1c levels align with a growing body of literature affirming the bidirectional relationship between diabetes and periodontal disease. Previous studies have consistently emphasized the contribution of periodontal inflammation to insulin resistance and poor metabolic control (14,15). A recent investigation demonstrated that routine periodontal treatment, including scaling and oral hygiene instruction, significantly reduced HbA1c levels in diabetic patients, reinforcing the notion that local oral interventions may yield systemic benefits (16). Similarly, a study reported significant improvements in both oral hygiene behavior and glycemic indices following an oral care program, particularly among elderly diabetic patients (17).

While the present study was cross-sectional and cannot establish causality, the strength and direction of the observed correlations suggest a meaningful clinical link. These results are in line with a work), which found a proportional relationship between periodontal inflamed surface area and HbA1c levels in patients on both insulin and oral anti-diabetic therapy (18). Moreover, studies confirmed a high prevalence of oral complications in diabetic populations and reported a direct correlation between poor oral hygiene and increased HbA1c levels (19,20). In the context of Pakistan, where both type 2 diabetes and periodontal diseases are highly prevalent, these findings emphasize the need for interdisciplinary care models. Incorporating dental evaluations into routine diabetic care could prove to be a cost-effective and impactful strategy to improve metabolic outcomes. Such integration is further supported by the outcomes of studies, which showed that oral hygiene instructions reduced both HbA1c and oral malodor in patients with type 2 diabetes (21,22).

Nevertheless, this study is not without limitations. Its cross-sectional nature precludes any inference of temporal relationships or causality. In addition, while efforts were made to adjust for confounding variables, unmeasured behavioral or socioeconomic factors may have influenced both oral hygiene and glycemic control. The reliance on a single HbA1c reading also limits longitudinal understanding. Future studies could benefit from a prospective design, larger sample size, and inclusion of inflammatory biomarkers to better elucidate the pathophysiological mechanisms at play. One of the strengths of the study lies in its use of validated clinical indices (plaque and gingival indices) and standardized laboratory measures (HbA1c), enhancing the reliability and reproducibility of the findings. The inclusion of a real-world clinical population from multiple centers also increases the generalizability of results to urban diabetic populations in Pakistan. In conclusion, the evidence from this study supports the premise that poor oral hygiene is moderately but significantly associated with worse glycemic control in patients with type 2 diabetes. These findings align with contemporary global literature and advocate for more integrated healthcare strategies where oral health is considered an essential component of diabetes management.

CONCLUSION

This study established a significant association between poor oral hygiene—measured by plaque and gingival indices—and elevated HbA1c levels in patients with type 2 diabetes. These findings emphasize the clinical relevance of integrating routine oral health assessments and hygiene interventions into diabetes management. Promoting interdisciplinary care could enhance both metabolic control and overall patient outcomes in diabetic populations.

AUTHOR CONTRIBUTION

Author	Contribution
Zainab Sajjad	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Sadaf Akram	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Akif Saeed Ch*	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Rida Asim	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published

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Author	Contribution
Muhammad Abdullah Qamar	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Abdullah Imtiaz	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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