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PERIODONTITIS IN PATIENTS WITH TYPE 2 DIABETES MELLITUS: PREVALENCE AND ASSOCIATED FACTORS AT SAIDU GROUP OF TEACHING HOSPITAL, SWAT, PAKISTAN, A CROSS-SECTIONAL STUDY

Periodontitis Among Adults with Type 2 Diabetes Mellitus

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Abstract

Background

Periodontitis is a chronic inflammatory disease of the tooth-supporting tissues and is recognized as one of the most common complications associated with type 2 diabetes mellitus (T2DM). The bidirectional relationship between diabetes and periodontitis has significant implications for glycemic control, oral health, and overall quality of life. Despite the increasing burden of diabetes in Pakistan, local evidence regarding the prevalence of periodontitis and its associated factors among patients with T2DM remains limited, particularly in the northwestern region of the country. This study aimed to determine the prevalence of periodontitis and identify factors associated with periodontal disease among adults with T2DM attending a tertiary care hospital in Swat, Pakistan.

Methods

A hospital-based cross-sectional study was conducted among 105 adults diagnosed with type 2 diabetes mellitus attending the diabetic outpatient department of Saidu Group of Teaching Hospital, Saidu Sharif, Swat. Participants were selected using a non-probability consecutive sampling technique according to predefined eligibility criteria. Sociodemographic characteristics, diabetes-related information, and oral hygiene practices were collected using a structured questionnaire, while periodontal status was assessed through clinical examination. Descriptive statistics were used to summarize participant characteristics and periodontal status. Bivariate analyses were performed to examine associations between participant characteristics and periodontitis. The analyses were conducted using the audited participant-level dataset.

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Results

Among the 105 participants, 88 (83.8%) had periodontitis, whereas 17 (16.2%) had no established periodontitis (healthy periodontal status or gingival bleeding only). Moderate periodontitis was the most prevalent condition (34.3%), followed by severe (30.5%) and mild periodontitis (19.0%). Most participants were male (71.4%), aged 46–55 years (38.1%), and had diabetes for 5–10 years (35.2%). More than half of the participants reported daily tooth brushing (51.4%), while only 19.0% practiced interdental cleaning. In the audited dataset, no independent demographic or behavioral factor demonstrated a statistically significant association with periodontitis in the primary bivariate analysis.

Conclusion

Periodontitis was highly prevalent among adults with type 2 diabetes mellitus attending a tertiary care hospital in Swat, Pakistan, highlighting the substantial burden of periodontal disease in this population. These findings emphasize the importance of integrating routine periodontal assessment, oral health education, and preventive dental care into comprehensive diabetes management programs. Further multicenter studies with larger sample sizes are recommended to identify independent predictors of periodontitis and strengthen the evidence base for targeted preventive strategies.

INTRODUCTION

Global Burden of Periodontitis and Type 2 Diabetes Mellitus

Periodontitis is a chronic, multifactorial inflammatory disease characterized by the progressive destruction of the periodontal supporting tissues, including the gingiva, periodontal ligament, cementum, and alveolar bone. Initiated by a dysbiotic microbial biofilm and sustained by an exaggerated host inflammatory response, periodontitis is one of the leading causes of tooth loss in adults and represents a major public health concern worldwide. Beyond its local oral manifestations, increasing evidence recognizes periodontitis as a chronic non-communicable disease with important systemic consequences, particularly through persistent low-grade inflammation and immune dysregulation (1). These mechanisms have linked periodontal disease with several chronic systemic conditions, including diabetes mellitus, cardiovascular disease, chronic kidney disease, and adverse pregnancy outcomes. Oral diseases collectively affect billions of individuals worldwide, making them among the most prevalent chronic diseases globally. According to the World Health Organization (WHO), severe periodontitis remains one of the most common oral conditions in adults and continues to contribute substantially to disability, impaired oral function, reduced quality of life, and increased healthcare expenditure. The Global Burden of Disease estimates continue to identify severe periodontitis as a major contributor to oral morbidity, emphasizing its significance as an important public health challenge requiring integrated preventive strategies (2). Parallel to the increasing burden of periodontal disease, diabetes mellitus has emerged as one of the fastest-growing chronic metabolic disorders worldwide. Type 2 diabetes mellitus (T2DM) accounts for approximately 90–95% of all diabetes cases and is characterized by insulin resistance, progressive β-cell dysfunction, and chronic hyperglycemia. The global prevalence of diabetes has risen steadily over recent decades because of population ageing, urbanization, sedentary lifestyles, obesity, and dietary transitions (3). Contemporary estimates indicate that hundreds of millions of adults are living with diabetes, and this number is expected to increase substantially over the coming decades, creating enormous challenges for healthcare systems, particularly in low- and middle-income countries.

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The coexistence of diabetes and periodontal disease has become increasingly important because both conditions share common inflammatory pathways, behavioral risk factors, and socioeconomic determinants (4). Individuals with diabetes experience a substantially greater burden of periodontal destruction than the general population, while periodontal inflammation has also been associated with poorer glycemic control and a higher risk of diabetes-related complications. International expert consensus now recognizes periodontitis as an important complication of diabetes and recommends closer collaboration between dental and medical professionals to facilitate early detection, risk assessment, and comprehensive patient management (5). The public health implications of this relationship are particularly relevant in developing countries such as Pakistan, where both diabetes and periodontal disease are highly prevalent and access to preventive oral healthcare remains limited. As the number of adults living with T2DM continues to increase, the associated burden of periodontal disease is also expected to rise, potentially increasing healthcare costs, treatment complexity, tooth loss, nutritional impairment, and reduced quality of life. Consequently, understanding the epidemiology of periodontitis among individuals with T2DM is essential for designing integrated prevention and management strategies that address both oral and systemic health. Recent longitudinal evidence further supports a bidirectional association between diabetes and periodontitis and highlights the value of incorporating oral health into diabetes prevention and management programs (5).

Biological Relationship Between Type 2 Diabetes Mellitus and Periodontitis

The association between type 2 diabetes mellitus (T2DM) and periodontitis is now recognized as bidirectional, whereby each condition adversely influences the onset, progression, and severity of the other. This relationship extends beyond shared risk factors and is mediated through complex interactions involving chronic inflammation, immune dysregulation, oxidative stress, advanced glycation end products (AGEs), and alterations in the oral microbiome. Consequently, periodontitis has been identified as one of the major complications of diabetes, while persistent periodontal inflammation may negatively influence metabolic control and increase the risk of diabetes-related complications (6). Chronic hyperglycemia in individuals with T2DM initiates several biological processes that increase susceptibility to periodontal tissue destruction. Persistent elevation of blood glucose promotes the formation and accumulation of AGEs, which bind to their cellular receptor (RAGE) expressed on endothelial cells, fibroblasts, macrophages, and other immune cells within periodontal tissues. Activation of the AGE–RAGE pathway enhances oxidative stress and stimulates intracellular signaling cascades, particularly nuclear factor-kappa B (NF-κB), resulting in increased production of pro-inflammatory cytokines including tumor necrosis factor-alpha (TNF-α), interleukin (IL)-1β, and IL-6. These mediators amplify local inflammation, impair tissue repair, and accelerate connective tissue breakdown and alveolar bone resorption (7). Diabetes also impairs both innate and adaptive immune responses, compromising the host's ability to control periodontal pathogens. Neutrophil chemotaxis, phagocytosis, and microbial killing become dysfunctional, while macrophages exhibit a sustained pro-inflammatory phenotype. Simultaneously, periodontal fibroblasts demonstrate reduced proliferative and reparative capacity, and microvascular alterations impair oxygen and nutrient delivery to periodontal tissues. Together, these mechanisms create an environment that favors persistent bacterial colonization, exaggerated inflammatory responses, delayed wound healing, and progressive periodontal destruction (6).

Conversely, periodontitis may adversely influence glycemic control through systemic dissemination of inflammatory mediators and periodontal pathogens. The ulcerated periodontal pocket epithelium provides a portal through which bacteria, lipopolysaccharides, and inflammatory cytokines enter the systemic circulation (8). This chronic inflammatory burden contributes to insulin resistance by disrupting insulin signaling

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pathways in peripheral tissues and increasing circulating concentrations of TNF-α, IL-6, and C-reactive protein. Persistent systemic inflammation may therefore worsen glycemic control and potentially accelerate the development of diabetic microvascular and macrovascular complications. Recent mechanistic studies also suggest that oral microbial dysbiosis and alterations in the oral–gut microbial axis may further contribute to metabolic dysfunction in patients with diabetes (7). Bone metabolism represents another important biological pathway linking diabetes and periodontitis. Hyperglycemia and chronic inflammation increase the expression of receptor activator of nuclear factor-kappa B ligand (RANKL) while reducing osteoprotegerin (OPG), thereby promoting osteoclast differentiation and activity. The resulting imbalance between bone resorption and bone formation accelerates alveolar bone loss and periodontal attachment destruction. Emerging evidence also indicates that impaired insulin signaling itself may directly influence periodontal tissue homeostasis by affecting osteoblast function, collagen synthesis, and tissue regeneration, providing additional mechanistic insight into diabetes-associated periodontal destruction (9). The conceptual framework for the present study is illustrated in **Figure 1**. The framework recognizes the relationship between type 2 diabetes mellitus and periodontal disease within a broader context of hyperglycemia, immune dysregulation, chronic inflammation, and periodontal tissue destruction. It also identifies the demographic, diabetes-related, behavioral, and clinical characteristics examined in the present study, including age, gender, duration of diabetes, tooth-brushing frequency, interdental cleaning, gingival bleeding, and tooth mobility. This framework provided the conceptual basis for examining the prevalence of periodontitis and evaluating factors potentially associated with periodontal disease in the study population.

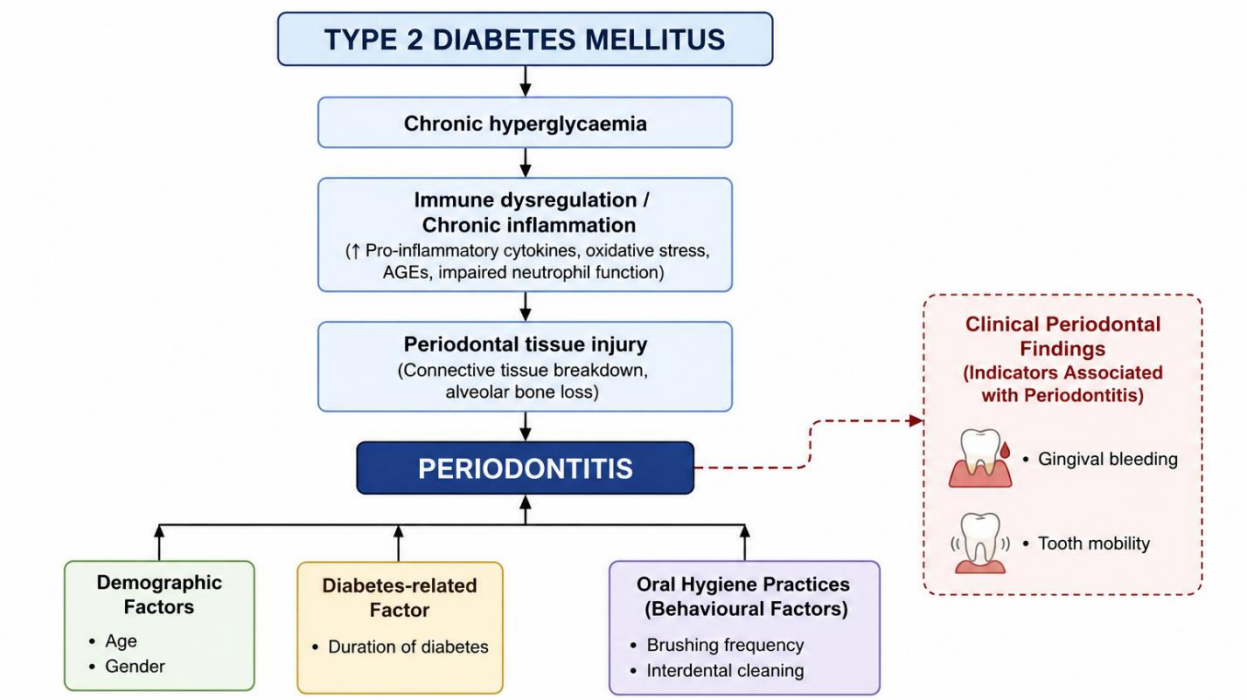


Figure 1. Conceptual framework illustrating the biological relationship between type 2 diabetes mellitus and periodontitis and the demographic, diabetes-related, behavioral, and clinical variables evaluated in the present study

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These biological mechanisms have important clinical implications. Individuals with poorly controlled T2DM are more likely to develop severe periodontitis, while effective periodontal therapy has been associated with modest improvements in glycemic control and reductions in systemic inflammatory burden(10). Consequently, international experts increasingly advocate integrating periodontal assessment into routine diabetes care and promoting collaboration between physicians, endocrinologists, diabetologists, and dental professionals to optimize patient outcomes. This integrated oral-systemic approach reflects the growing recognition that successful management of T2DM extends beyond glycemic control alone and should incorporate the prevention, early detection, and treatment of periodontal disease (11).

Current Evidence and Research Gap

Over the past decade, substantial epidemiological evidence has confirmed that individuals with type 2 diabetes mellitus (T2DM) have a greater prevalence, severity, and progression of periodontitis than non-diabetic individuals. Systematic reviews and meta-analyses consistently demonstrate that diabetes increases susceptibility to periodontal destruction, while poor glycemic control further aggravates periodontal inflammation and attachment loss. Conversely, effective periodontal therapy has been associated with modest improvements in glycemic control, reinforcing the concept of a bidirectional relationship and supporting the integration of periodontal care into routine diabetes management (12). Despite this growing body of international evidence, considerable heterogeneity remains regarding the prevalence of periodontitis and the relative contribution of demographic, behavioral, and diabetes-related factors across different populations. Variations in diagnostic criteria, periodontal classification systems, study settings, glycemic status, oral hygiene practices, and healthcare access have resulted in inconsistent estimates of disease burden and associated risk factors. Consequently, locally generated epidemiological evidence remains essential for developing context-specific preventive strategies and clinical recommendations, particularly in low- and middle-income countries where healthcare resources are limited (12).

Pakistan is experiencing a rapidly increasing burden of T2DM, accompanied by inadequate glycemic control, a high prevalence of diabetes-related complications, and substantial healthcare challenges. Recent evidence indicates that many individuals with T2DM in Pakistan have suboptimal disease control and limited awareness of long-term complications, highlighting the need for comprehensive multidisciplinary management strategies (13). Oral health represents one of the frequently overlooked aspects of diabetes care in Pakistan. A systematic review of periodontal disease in the Pakistani population reported that periodontitis is highly prevalent across multiple provinces, although marked regional variation exists because of differences in population characteristics, study methodologies, and access to oral healthcare services. Importantly, evidence from Khyber Pakhtunkhwa remains comparatively limited, and available studies are predominantly hospital-based with relatively small sample sizes (14).

Recent Pakistani studies continue to support the association between diabetes and deteriorating periodontal health. Research conducted in tertiary care hospitals has demonstrated greater periodontal destruction among individuals with prolonged diabetes duration and poor glycemic control, while emphasizing the need for improved oral health awareness among diabetic patients. However, these investigations have generally focused on specific clinical parameters or limited geographic regions, restricting the generalizability of their findings (15). Although previous national and international studies have established the biological and clinical relationship between diabetes and periodontitis, important evidence gaps remain. There is limited contemporary information regarding the prevalence and severity of periodontitis among adults with T2DM attending tertiary care hospitals in the northwestern region of Pakistan, particularly in Swat. Furthermore, few local studies have comprehensively evaluated demographic characteristics, oral hygiene behaviors, diabetes

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duration, and clinical oral findings simultaneously when examining factors associated with periodontitis (13, 16). Addressing these gaps is important because regional epidemiological data are necessary for developing targeted prevention programs, strengthening collaboration between medical and dental professionals, and informing evidence-based oral health policies.

The present study was therefore designed to determine the prevalence of periodontitis and evaluate factors associated with periodontal disease among adults with T2DM attending Saidu Group of Teaching Hospital, Swat, Pakistan. By providing locally generated evidence derived from a clinically examined diabetic population, this study contributes to the growing literature on oral-systemic health and supports the integration of periodontal assessment into comprehensive diabetes care within tertiary healthcare settings.

Rationale & Significance

The increasing coexistence of type 2 diabetes mellitus (T2DM) and periodontitis presents a significant challenge for healthcare systems, particularly in low- and middle-income countries where the prevalence of diabetes continues to rise and access to preventive oral healthcare remains limited. Although the bidirectional relationship between diabetes and periodontitis has been extensively documented, the epidemiological characteristics and associated factors vary considerably across populations due to differences in demographic characteristics, glycemic status, oral hygiene behaviors, healthcare accessibility, socioeconomic conditions, and diagnostic criteria. Consequently, findings from one population cannot be directly generalized to another, underscoring the importance of generating local evidence to guide clinical practice and public health interventions.

In Pakistan, oral health is frequently underrepresented within routine diabetes management despite growing evidence demonstrating the adverse effects of periodontal disease on glycemic control and diabetes-related complications. Most available local studies have been conducted in selected urban centers, have involved relatively small samples, or have focused primarily on describing periodontal status without comprehensively evaluating demographic, behavioral, and clinical factors associated with disease occurrence. Furthermore, published evidence from Khyber Pakhtunkhwa, particularly from Swat, remains scarce. This regional evidence gap limits the development of targeted preventive programs and restricts the availability of locally relevant information for clinicians and policymakers.

Saidu Group of Teaching Hospital serves as a major tertiary healthcare facility for Swat and the surrounding districts, providing diabetic care to a large and diverse patient population. Evaluating the periodontal health of patients attending this institution provides an opportunity to generate clinically relevant data that may support integrated oral-systemic healthcare. Identifying modifiable oral hygiene behaviors and patient characteristics associated with periodontitis may facilitate earlier detection of high-risk individuals, improve interdisciplinary collaboration between physicians and dental professionals, and contribute to more comprehensive diabetes management strategies.

The present study therefore sought to determine the prevalence of periodontitis among adults with T2DM attending Saidu Group of Teaching Hospital, Swat, Pakistan, and to evaluate demographic, behavioral, and clinical factors associated with periodontal disease using an audited participant-level dataset. By providing internally consistent and locally generated evidence, this study contributes to the growing understanding of the relationship between diabetes and periodontal disease within the Pakistani healthcare context and may assist clinicians, hospital administrators, and public health authorities in developing evidence-based oral health promotion and periodontal screening strategies for individuals living with T2DM.

MATERIALS AND METHODS

Objective (s)

Primary Objective

To determine the prevalence of periodontitis among adults with type 2 diabetes mellitus attending Saidu Group of Teaching Hospital, Swat, Pakistan.

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Secondary Objective

To evaluate demographic, behavioral, and clinical factors associated with periodontitis among adults with type 2 diabetes mellitus using participant-level clinical and questionnaire data.

Study Design

This study employed a hospital-based analytical cross-sectional study design and was conducted in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations for cross-sectional studies (17).

Study Setting

The study was conducted at the Emergency, Medicine, and Surgery Outpatient Department's (OPD) of Saidu Group of Teaching Hospital (SGTH), Saidu Sharif, Swat, Khyber Pakhtunkhwa, Pakistan. SGTH is the largest tertiary healthcare institution in the Malakand Division and serves as a referral center for Swat and surrounding districts. The hospital provides specialized medical and dental services to a large and diverse patient population, making it an appropriate setting for investigating periodontal health among individuals with T2DM.

Eligibility Criteria

The target population comprised adults diagnosed with type 2 diabetes mellitus attending the diabetic outpatient clinic of Saidu Group of Teaching Hospital. The source population included all eligible diabetic patients presenting to the outpatient department during the study period.

Inclusion Criteria

Participants were eligible for inclusion if they:

- were diagnosed with type 2 diabetes mellitus by a registered physician;
- were 35–70 years of age;
- attended the diabetic outpatient clinic during the study period;
- possessed at least one natural tooth to permit periodontal examination; and
- provided written informed consent before participation.

Exclusion Criteria

Participants were excluded if they:

- had type 1 diabetes mellitus or gestational diabetes;
- were completely edentulous;
- had received periodontal treatment within the preceding six months;
- were currently receiving systemic antibiotics that could influence periodontal findings;
- or had systemic conditions known to markedly affect periodontal status (other than diabetes).

Sample Size and Sampling Technique

A total of 105 participants were included in the final analysis. Participants were recruited using a non-probability consecutive sampling technique, whereby all eligible patients attending the diabetic outpatient clinic during the study period were invited consecutively until the required sample size was achieved.

Data Collection Procedure

Data were collected using a structured questionnaire and clinical oral examination.

Following informed consent, participants completed an interviewer-administered questionnaire that recorded age, gender, duration of diabetes, tooth-brushing frequency, interdental cleaning practices, history of gum bleeding; and tooth mobility.

Following completion of the questionnaire, each participant underwent a standardized periodontal examination performed according to the study protocol. Periodontal status was classified into one of five mutually exclusive categories:

- Healthy
- Gingival bleeding
- Mild periodontitis
- Moderate periodontitis
- Severe periodontitis

These categories constituted the primary periodontal outcome recorded in the participant-level dataset.

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Study Variables

Outcome Variable

The selection of demographic, diabetes-related, behavioral, and clinical variables was guided by the conceptual framework presented in **Figure 1**. The primary outcome variable was periodontal status. For descriptive analyses, periodontal status was classified into five categories; Healthy, Gingival bleeding, Mild periodontitis, Moderate periodontitis and Severe periodontitis. For multivariable analysis, periodontal status was recoded into a binary outcome to provide stable estimation of disease occurrence:

- **No periodontitis**
  - Healthy
  - Gingival bleeding
- **Periodontitis**
  - Mild
  - Moderate
  - Severe

This recoding reflects the presence or absence of established periodontal disease and is consistent with the study objective of identifying factors associated with periodontitis.

Independent Variables

The independent variables including Age group, Gender, Duration of diabetes, Tooth-brushing frequency, Interdental cleaning, Gum bleeding and Tooth mobility were evaluated. For regression modelling, brushing frequency was collapsed into Daily brushing and Less-than-daily brushing (weekly/monthly). This modification was undertaken because sparse data in the monthly brushing category produced unstable maximum-likelihood estimates during logistic regression. Category collapsing improved model stability while preserving clinical interpretability.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA) (18). Prior to statistical analysis, the participant-level dataset underwent quality assurance procedures, including verification of coding, assessment of missing values, duplicate record checks, and internal consistency evaluation. Categorical variables were summarized using frequencies and percentages. Associations between participant characteristics and periodontitis were initially explored using the Pearson Chi-square test. Fisher's exact test was considered where expected cell counts were insufficient. Crude odds ratios (ORs) with 95% confidence intervals (CIs) were calculated to quantify the strength of associations. Variables considered clinically relevant were subsequently entered into a binary logistic regression model to estimate adjusted odds ratios (AORs) and corresponding 95% confidence intervals for factors independently associated with periodontitis. Model adequacy was assessed using standard logistic regression diagnostic procedures. Statistical significance was established at a two-sided p-value <0.05.

Ethical Considerations

Ethical approval for this study was obtained from the Department of Dental Technology, Jibran College of Health Sciences and Nursing Institute, Odigram, Swat, before commencement of data collection. Administrative permission was obtained from the management of Saidu Group of Teaching Hospital.

Written informed consent was obtained from all participants before enrolment. Participation was voluntary, confidentiality of participant information was maintained throughout the study, and all collected data were anonymized prior to statistical analysis. The study adhered to the ethical principles outlined in the Declaration of Helsinki for research involving human participants (19).

RESULTS

Participant Characteristics

A total of 105 adults diagnosed with type 2 diabetes mellitus (T2DM) were included in the final analysis. Male participants accounted for 71.4% (n = 75) of the study population, while 28.6% (n = 30) were female. The largest proportion of participants belonged to the 46–55-year age group (38.1%, n = 40), followed by 56–70 years (31.4%, n = 33) and 35–45 years (30.5%, n = 32).

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Regarding the duration of diabetes, 35.2% (n = 37) had been diagnosed with T2DM for 5–10 years, whereas 32.4% (n = 34) each had a disease duration of <5 years and >10 years. Daily tooth brushing was reported by 51.4% (n = 54) of participants, while 27.6% (n = 29) brushed weekly and 21.0% (n = 22) brushed monthly. Only 19.0% (n = 20) reported practicing interdental cleaning, whereas 81.0% (n = 85) did not. Bleeding gums were reported by 65.7% (n = 69) of participants, and 28.6% (n = 30) exhibited tooth mobility (**Table 1**).

Table 1. Baseline Characteristics of Study Participants (N = 105)

Variable	*Category*	*Frequency (n)*	*Percentage (%)*
Gender	Male	75	71.4
	Female	30	28.6
Age group (years)	35–45	32	30.5
	46–55	40	38.1
	56–70	33	31.4
Duration of diabetes	<5 years	34	32.4
	5–10 years	37	35.2
	>10 years	34	32.4
Brushing frequency	Daily	54	51.4
	Weekly	29	27.6
	Monthly	22	21.0
Interdental cleaning	Yes	20	19.0
	No	85	81.0
Bleeding gums	Yes	69	65.7
	No	36	34.3
Tooth mobility	Yes	30	28.6
	No	75	71.4

Prevalence and Severity of Periodontitis

Among the 105 participants, 88 (83.8%) had clinically recognized periodontitis, while 17 (16.2%) had no established periodontitis (healthy periodontal tissues or gingival bleeding only) **(Figure 2).**

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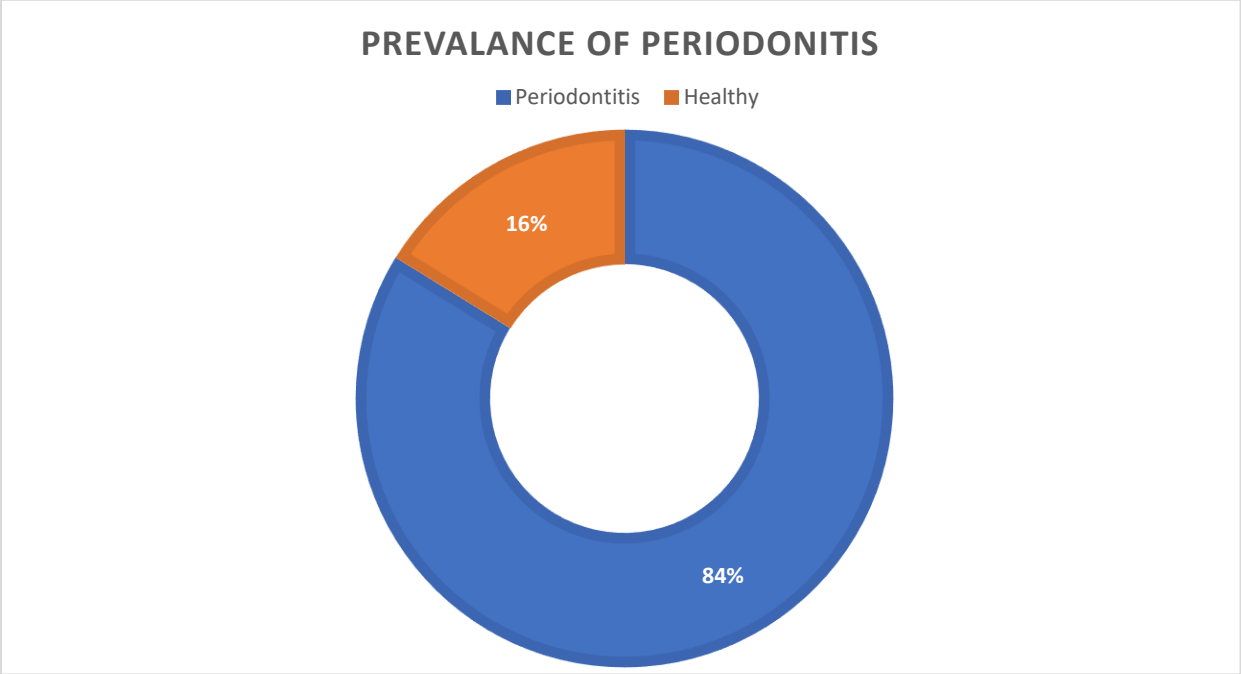


Figure 2. Overall prevalence of periodontitis

Moderate periodontitis was the most frequently observed category, affecting 34.3% (n = 36) of participants, followed by severe periodontitis (30.5%, n = 32) and mild periodontitis (19.0%, n = 20). Healthy periodontal status was identified in 9.5% (n = 10) of participants, whereas 6.7% (n = 7) presented with gingival bleeding without evidence of periodontitis (**Table 2**).

Table 2. Prevalence and Severity of Periodontitis (N = 105)

Periodontal status	*Frequency (n)*	*Percentage (%)*
Healthy	10	9.5
Gingival bleeding	7	6.7
Mild periodontitis	20	19.0
Moderate periodontitis	36	34.3
Severe periodontitis	32	30.5

Association Between Participant Characteristics and Periodontal Status

The comprehensive cross-tabulation of demographic, behavioral, clinical, and diabetes-related variables with periodontal status is presented in **Table 3.** Age group was significantly associated with periodontal status (p = 0.015). The distribution demonstrated a progressive shift toward more severe periodontal disease with increasing age. Among participants aged 35–45 years, 6 were classified as healthy, 3 had bleeding on probing, 10 had mild periodontitis, 9 had moderate periodontitis, and 4 had severe periodontitis. In the 46–55-year group, the corresponding frequencies were 3, 2, 7, 16, and 12, respectively. Among participants aged 56–70 years, 1 was healthy, 2 had bleeding on probing, 3 had mild periodontitis, 11 had moderate periodontitis, and 15 had severe periodontitis. The highest frequency of severe periodontitis was therefore observed among participants aged 56–70 years.

Gender was not significantly associated with periodontal status (p = 0.60). Among males, the

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frequencies of healthy status, bleeding on probing, mild, moderate, and severe periodontitis were 7, 4, 15, 26, and 23, respectively. Among females, the corresponding frequencies were 3, 3, 5, 10, and 8. Although moderate and severe disease occurred more frequently among male participants in absolute numbers, the association between gender and periodontal status did not reach statistical significance.

Table 3. Distribution and Cross-tabulation of Periodontal Status According to Participant Characteristics and Oral/Diabetes-Related Factors (N = 105)

Variable	Category	n (%)	Healthy n (%)	Bleeding n (%)	Mild n (%)	Moderate n (%)	Severe n (%)	p-value
Age group	35–45 years	32 (30.5)	6 (18.8)	3 (9.4)	10 (31.3)	9 (28.1)	4 (12.5)	0.015
	46–55 years	40 (38.1)	3 (7.5)	2 (5.0)	7 (17.5)	16 (40.0)	12 (30.0)	
	56–70 years	33 (31.4)	1 (3.0)	2 (6.1)	3 (9.1)	11 (33.3)	15 (45.5)	
Gender	Male	75 (71.4)	7 (9.3)	4 (5.3)	15 (20.0)	26 (34.7)	23 (30.7)	0.600
	Female*	29 (27.6)	3 (10.3)	3 (10.3)	5 (17.2)	10 (34.5)	8 (27.6)	
Brushing frequency	Once daily	54 (51.4)	8 (14.8)	3 (5.6)	12 (22.2)	20 (37.0)	11 (20.4)	0.005
	Once weekly	28 (26.7)	2 (7.1)	3 (10.7)	6 (21.4)	8 (28.6)	9 (32.1)	
	Once monthly	22 (21.0)	0 (0.0)	1 (4.5)	2 (9.1)	8 (36.4)	11 (50.0)	
Interdental cleaning	Yes	19 (18.1)	4 (21.1)	2 (10.5)	6 (31.6)	5 (26.3)	2 (10.5)	0.031
	No	85 (81.0)	6 (7.1)	5 (5.9)	14 (16.5)	31 (36.5)	29 (34.1)	
Bleeding gums	Yes	68 (64.8)	1 (1.5)	5 (7.4)	11 (16.2)	27 (39.7)	24 (35.3)	0.001
	No	36 (34.3)	9 (25.0)	2 (5.6)	9 (25.0)	9 (25.0)	7 (19.4)	
Tooth mobility	Yes	29 (27.6)	0 (0.0)	1 (3.4)	4 (13.8)	10 (34.5)	14 (48.3)	0.009
	No	75 (71.4)	10 (13.3)	6 (8.0)	16 (21.3)	26 (34.7)	17 (22.7)	
Diabetes duration	<5 years	33 (31.4)	6 (18.2)	3 (9.1)	10 (30.3)	9 (27.3)	5 (15.2)	0.021
	5–10 years	37 (35.2)	3 (8.1)	2 (5.4)	6 (16.2)	15 (40.5)	11 (29.7)	
	>10 years	34 (32.4)	1 (2.9)	2 (5.9)	4 (11.8)	12 (35.3)	15 (44.1)	

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Factors Associated with Periodontitis

Bivariate analyses were conducted to examine associations between participant characteristics and the presence of periodontitis (**Table 4**). Participants aged 56–70 years demonstrated the highest prevalence of periodontitis (93.9%) compared with those aged 35–45 years (81.2%) and 46–55 years (77.5%). However, the association between age group and periodontitis did not reach statistical significance (χ^2 = 3.82, p = 0.148).

The prevalence of periodontitis was comparable between male (82.7%) and female (86.7%) participants, with no statistically significant association observed between gender and periodontal disease (χ^2 = 0.04, p = 0.834). Participants with diabetes duration exceeding ten years exhibited the highest prevalence of periodontitis (91.2%), followed by those with diabetes duration of 5–10 years (86.5%) and <5 years (73.5%). Although an increasing trend was observed with longer diabetes duration, the association was not statistically significant (χ^2 = 4.20, p = 0.122).

Regarding oral hygiene practices, periodontitis affected 79.6% of participants who brushed daily, 79.3% of those brushing weekly, and 100% of participants reporting monthly brushing. The overall association approached statistical significance but did not meet the predefined threshold (χ^2 = 5.38, p = 0.068). Similarly, no statistically significant associations were observed between periodontitis and interdental cleaning (p = 0.619), self-reported bleeding gums (p = 1.000), or tooth mobility (p = 0.706).

Table 4. Bivariate Analysis of Factors Associated with Periodontitis

Variable	*χ^2*	*p-value*
Age group	3.82	0.148
Gender	0.04	0.834
Duration of diabetes	4.20	0.122
Brushing frequency	5.38	0.068
Interdental cleaning	0.25	0.619
Bleeding gums	0.00	1.000
Tooth mobility	0.14	0.706

Multivariable Logistic Regression Analysis

Variables considered clinically relevant were entered into a multivariable logistic regression model to evaluate their independent association with periodontitis (**Table 5**). After adjustment for potential confounders, none of the evaluated variables demonstrated a statistically significant independent association with periodontitis. Participants aged 56–70 years had approximately fourfold higher odds of periodontitis compared with those aged 35–45 years; however, this association was not statistically significant (Adjusted OR = 4.03; 95% CI: 0.67–24.29; p = 0.128). Females had higher estimated odds of periodontitis compared with males; however, the association was not statistically significant (AOR for males' vs females = 0.71, 95% CI: 0.19–2.67; p = 0.610). Likewise, duration of diabetes, interdental cleaning practices, bleeding gums, and tooth mobility were not independently associated with periodontitis after adjustment.

Table 5. Multivariable Logistic Regression Analysis

Predictor	*Comparison*	*Adjusted OR*	*95% CI*	*p-value*
Age	56–70 vs 35–45 years	4.03	0.67–24.29	0.128
Gender	Male vs female	0.71	0.19–2.67	0.610
Diabetes duration	>10 vs 5–10 years	1.39	0.26–7.45	0.700
Interdental cleaning	Yes, vs No	1.41	0.24–8.18	0.700
Bleeding gums	Yes, vs No	1.37	0.39–4.80	0.625
Tooth mobility	Yes, vs No	0.67	0.19–2.34	0.531

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The monthly brushing category demonstrated complete separation because all participants in this category had periodontitis. Consequently, reliable estimation of an adjusted odds ratio for this category was not possible using conventional logistic regression. To improve model stability, brushing frequency categories were clinically collapsed during model development as described in the Methods section. The adjusted effect estimates and 95% confidence intervals for all evaluated factors are presented in **Figure 3**.

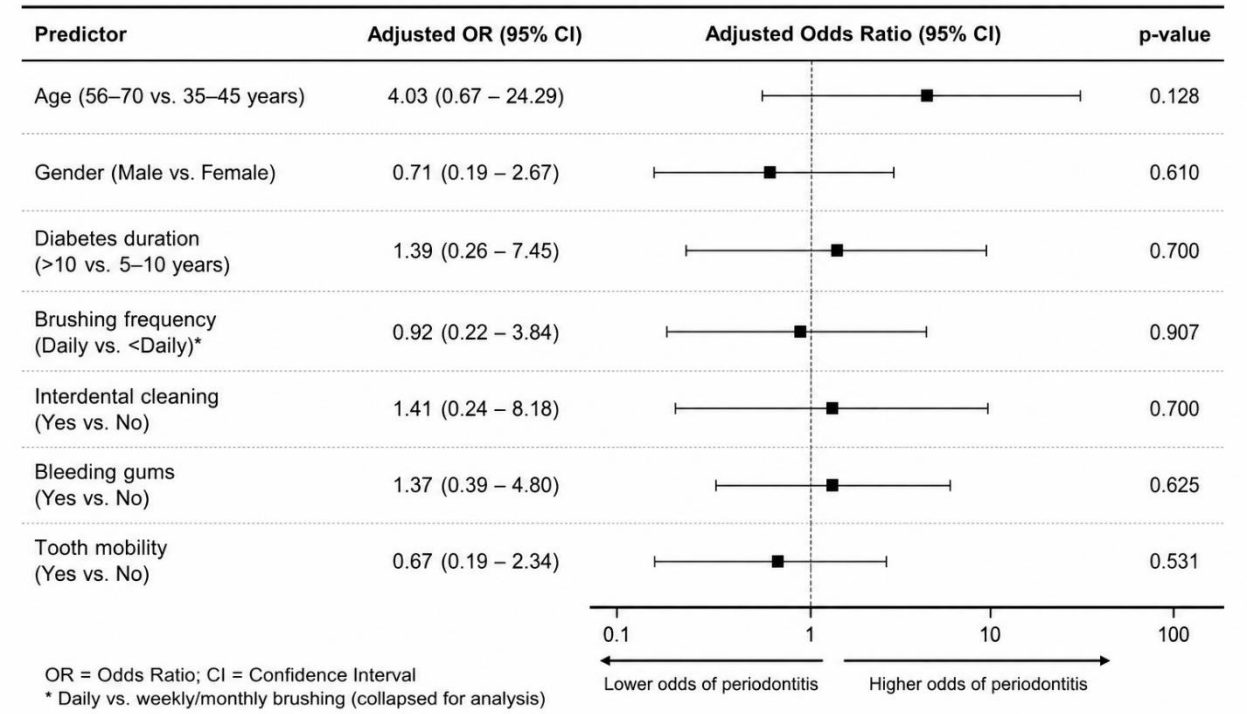


Figure 3. Factors associated with periodontitis among adults with type 2 diabetes mellitus, showing adjusted odds ratios (AORs) with 95% confidence intervals from the multivariable logistic regression model.

Overall, the multivariable model did not identify any statistically significant independent predictors of periodontitis within the study population.

DISCUSSION

The present hospital-based cross-sectional study evaluated the prevalence of periodontitis and factors associated with periodontal disease among adults with type 2 diabetes mellitus (T2DM) attending Saidu Group of Teaching Hospital, Swat, Pakistan. The principal finding of this study was the remarkably high burden of periodontal disease within the study population, with 83.8% of participants exhibiting established periodontitis. Moderate periodontitis represented the most common clinical presentation, followed by severe and mild disease. These findings reinforce the growing body of evidence indicating that periodontal disease is highly prevalent among individuals with T2DM and continues to represent an important, yet frequently overlooked, complication of diabetes (20).

The high prevalence observed in the present study is biologically plausible considering the well-established bidirectional relationship between diabetes and periodontitis. Chronic hyperglycemia promotes the formation of advanced glycation end products (AGEs), enhances oxidative stress, alters neutrophil function, and stimulates the production of pro-inflammatory cytokines such as tumor necrosis factor-α, interleukin-1β, and interleukin-6. These

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alterations contribute to connective tissue destruction, impaired periodontal healing, and progressive alveolar bone loss. Conversely, chronic periodontal inflammation increases systemic inflammatory burden and insulin resistance, thereby further compromising glycemic control. This reciprocal interaction explains why periodontal disease is increasingly regarded as one of the chronic complications of diabetes rather than merely a coincidental oral condition (21).

Our findings are consistent with numerous international studies reporting that adults with T2DM experience a substantially greater burden of periodontal disease than the general population. A recent systematic review demonstrated that individuals with diabetes have an approximately 86% higher risk of developing or experiencing progression of periodontitis compared with non-diabetic individuals, emphasizing diabetes as an independent risk factor for periodontal tissue destruction (20). Similarly, recent mechanistic reviews have reaffirmed that chronic inflammation, immune dysregulation, and microbial dysbiosis constitute the principal pathways linking diabetes and periodontitis, supporting the biological plausibility of the high disease burden observed in the present study (21).

The predominance of moderate periodontitis (34.3%) in our study warrants particular attention. This pattern suggests that a substantial proportion of patients present only after clinically significant periodontal destruction has already occurred. In many low- and middle-income countries, including Pakistan, preventive dental services are often underutilized, and periodontal disease remains asymptomatic during its early stages. Consequently, patients frequently seek dental care only when symptoms such as tooth mobility, pain, or functional impairment become evident. Delayed presentation allows disease progression from reversible gingival inflammation to irreversible periodontal attachment loss, increasing the likelihood of tooth loss and impaired oral function. This observation highlights the need for earlier periodontal screening within diabetes clinics.

The high prevalence identified in the present study is also comparable with findings reported from other developing countries where diabetes prevalence is increasing rapidly and access to preventive oral healthcare remains limited. Although absolute prevalence estimates vary because of differences in periodontal case definitions, diagnostic criteria, study populations, and healthcare systems, systematic reviews consistently indicate that periodontal disease affects the majority of adults with T2DM. These observations suggest that the coexistence of diabetes and periodontitis represents a global public health challenge requiring coordinated management strategies rather than isolated dental interventions (20).

Within Pakistan, published evidence regarding periodontal disease among diabetic patients remains relatively limited and geographically heterogeneous. Most available investigations have been conducted in major urban centers, while epidemiological data from Khyber Pakhtunkhwa remain scarce. Consequently, the present study provides important regional evidence by describing the periodontal health status of adults with T2DM attending the largest tertiary care hospital in Swat. Although direct comparisons between studies should be interpreted cautiously because of differences in participant selection, periodontal classification systems, and clinical examination protocols, our findings broadly support previous Pakistani reports demonstrating that periodontal disease is highly prevalent among diabetic patients. This consistency strengthens the need for integrating oral health assessment into routine diabetes care across healthcare settings in Pakistan.

An additional finding of clinical relevance was the poor oral hygiene profile of the study population. More than four-fifths of participants reported no interdental cleaning, and nearly half brushed less than daily. Although these behaviors were not independently associated with periodontitis in the adjusted analyses, they remain clinically important because inadequate plaque control is a well-established prerequisite for the initiation and progression of periodontal inflammation. The absence of statistical significance in the present study should therefore not be interpreted as evidence that oral hygiene is unimportant. Rather,

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it may reflect the relatively homogeneous oral hygiene practices within the study population, the modest sample size, and limited statistical power to detect small between-group differences.

Overall, the principal finding of this study is the exceptionally high prevalence of periodontitis among adults with T2DM attending a tertiary healthcare facility in Swat. From a clinical perspective, these findings support growing international recommendations advocating routine periodontal assessment as part of comprehensive diabetes management. Early identification of periodontal disease may facilitate timely intervention, improve oral health outcomes, and potentially contribute to better metabolic control through reduction of chronic systemic inflammation. Recent evidence further suggests that periodontal therapy can improve periodontal parameters and may provide modest improvements in glycemic control when incorporated into multidisciplinary diabetes care (22).

Interpretation of Factors Associated with Periodontitis

Although the present study demonstrated a markedly high prevalence of periodontitis among adults with type 2 diabetes mellitus (T2DM), none of the demographic, behavioural, or clinical variables evaluated in the multivariable analysis emerged as statistically significant independent predictors of periodontitis. While these findings may initially appear inconsistent with the existing literature, they should be interpreted within the context of the study design, sample characteristics, statistical power, and the biological complexity of periodontal disease. Importantly, the absence of statistical significance does not necessarily indicate the absence of clinically meaningful relationships; rather, it reflects that the observed differences were insufficient to reach conventional levels of statistical significance within the available sample.

Age and Periodontitis

Participants aged 56–70 years exhibited the highest prevalence of periodontitis (93.9%) compared with younger age groups, although the association was not statistically significant after adjustment. This trend is biologically plausible because ageing is accompanied by cumulative exposure to dental plaque, prolonged inflammatory burden, reduced tissue regenerative capacity, and increased prevalence of systemic diseases that influence periodontal health. In individuals with diabetes, these age-related changes may be further exacerbated by chronic hyperglycemia, impaired immune function, and microvascular alterations, potentially accelerating periodontal tissue destruction.

Previous investigations are frequently reported age as an important determinant of periodontal disease. A recent systematic review concluded that increasing age is consistently associated with greater periodontal attachment loss and disease severity among adults with diabetes, largely because periodontal destruction accumulates over time rather than occurring as an acute event.(6) Similarly, population-based epidemiological studies have demonstrated progressively increasing prevalence of moderate and severe periodontitis in older adults. Nevertheless, several hospital-based cross-sectional studies involving diabetic populations have also reported non-significant age associations after adjustment for behavioral and metabolic variables, suggesting that chronological age alone may not independently explain periodontal disease severity once other risk factors are considered (7, 23). Therefore, the non-significant finding observed in the present study should be interpreted cautiously and should not be viewed as evidence that age is clinically irrelevant. Instead, it may reflect the modest sample size and the relatively similar distribution of periodontal disease across all age categories within the study population.

Gender and Periodontitis

The prevalence of periodontitis was slightly higher among female participants (86.7%) than males (82.7%); however, gender was not significantly associated with periodontal disease in either the bivariate or multivariable analyses. Existing evidence regarding gender differences in periodontal disease remains inconsistent. Several international studies have reported a greater burden of periodontitis among males, which has

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been attributed to poorer oral hygiene practices, higher tobacco exposure, and lower utilization of preventive dental services. Conversely, other investigations have observed minimal or no independent effect of gender after controlling for behavioral and socioeconomic factors.

The lack of a significant gender effect in the present study is consistent with the concept that periodontal disease is primarily driven by microbial biofilm, host immune response, metabolic control, and oral hygiene behaviors rather than biological sex alone. Furthermore, because all participants had T2DM, diabetes-related inflammatory mechanisms may have exerted a stronger influence on periodontal status than gender-specific differences. Similar observations have been reported in recent studies conducted among diabetic populations, where gender ceased to be a significant predictor after adjustment for other clinical variables. (7, 24)

Duration of Diabetes

Participants with diabetes duration exceeding ten years demonstrated the highest prevalence of periodontitis (91.2%), whereas those with diabetes duration of less than five years showed the lowest prevalence (73.5%). Although this gradient suggests a possible dose-response relationship, statistical significance was not achieved. Biologically, prolonged diabetes duration increases cumulative exposure to chronic hyperglycemia, oxidative stress, vascular dysfunction, and advanced glycation end products, all of which contribute to progressive periodontal destruction. Therefore, the observed trend is compatible with current understanding of diabetes-associated periodontal pathology. Multiple systematic reviews have identified longer diabetes duration as an important contributor to periodontal disease progression, particularly among patients with suboptimal glycemic control. However, the magnitude of this association varies considerably across studies because diabetes duration frequently correlates with age, treatment history, metabolic control, and the presence of diabetic complications.

An important limitation of the present study is that glycemic control (e.g., HbA1c) was not available for inclusion in the analysis. Duration of diabetes alone may therefore represent an incomplete indicator of cumulative metabolic burden. Patients with longer disease duration but satisfactory glycemic control may experience different periodontal outcomes from those with poorly controlled diabetes of shorter duration. Consequently, future studies should incorporate objective metabolic markers to better characterize the relationship between diabetes severity and periodontal disease (6, 25).

Oral Hygiene Practices

Oral hygiene practices constitute one of the most important modifiable determinants of periodontal health. In the present study, nearly half of the participants reported brushing less than daily, and more than four-fifths did not practice interdental cleaning. Despite these observations, brushing frequency and interdental cleaning were not independently associated with periodontitis after adjustment.

These findings should be interpreted carefully. During model development, the monthly brushing category demonstrated complete separation because all participants within this category had periodontitis. This required collapsing brushing frequency categories to obtain a statistically stable logistic regression model. Although this approach is methodologically appropriate, it may have reduced the ability to detect differences between brushing behaviors. In addition, tooth-brushing frequency is a relatively crude measure of oral hygiene. It does not capture brushing technique, brushing duration, plaque removal effectiveness, toothbrush replacement, fluoridated toothpaste use, or professional dental care utilization. Consequently, frequency alone may inadequately represent overall oral hygiene quality.

The lack of statistical significance therefore should not be interpreted as evidence that oral hygiene behaviors have no influence on periodontal disease. Rather, it highlights the limitations of self-reported behavioral variables and the multifactorial nature of periodontitis. Future investigations incorporating validated plaque indices, gingival indices, oral hygiene indices, and

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objective clinical measures are likely to provide more accurate assessment of behavioral risk factors. (6, 26)

Bleeding Gums and Tooth Mobility

Self-reported bleeding gums and tooth mobility also failed to demonstrate statistically significant associations with periodontitis. These findings should be interpreted in light of the clinical characteristics of the study population. Because the majority of participants already had established periodontal disease, many clinical manifestations were widely distributed across the sample, reducing the discriminatory ability of these variables. Furthermore, self-reported symptoms are inherently susceptible to recall bias and differences in individual perception.

Tooth mobility generally represents a relatively late manifestation of periodontal destruction rather than an independent causal factor. Similarly, gingival bleeding may be influenced by plaque accumulation, oral hygiene behaviors, medications, and individual inflammatory responses. Therefore, these variables are more appropriately considered clinical indicators accompanying periodontal disease rather than independent predictors of disease occurrence.

The absence of statistically significant predictors in this study should not be interpreted as a negative finding. Several methodological factors may explain the observed results. First, the sample size of 105 participants limited statistical power to detect modest associations, particularly after multivariable adjustment. Second, the very high prevalence of periodontitis (83.8%) resulted in relatively few participants without disease, reducing variability in the outcome and affecting the stability of regression estimates. Third, the cross-sectional design precludes establishing temporal relationships between exposures and disease. Finally, several potentially important variables—including HbA1c level, smoking status, body mass index, educational attainment, socioeconomic status, dietary habits, medication use, and frequency of professional dental visits—were not available in the dataset and therefore could not be evaluated as potential confounders.

Collectively, these considerations suggest that the non-significant associations observed in the present study should be interpreted as reflecting the characteristics and limitations of the available dataset rather than disproving the established relationship between diabetes-related factors and periodontal disease reported in the broader scientific literature.

Clinical Implications, Public Health Significance, Strengths, Limitations, and Future Directions

The present study demonstrates that periodontitis constitutes a major oral health burden among adults with type 2 diabetes mellitus (T2DM) attending a tertiary healthcare facility in Swat, Pakistan. More than four out of every five participants had clinically established periodontitis, highlighting the need to recognize periodontal disease as an integral component of diabetes care rather than an isolated dental condition. Contemporary evidence consistently supports the concept that oral and systemic health are closely interconnected, and the management of diabetes should therefore extend beyond glycemic control to include routine assessment and maintenance of periodontal health. Recent international consensus statements from the International Diabetes Federation (IDF) and the European Federation of Periodontology (EFP) emphasize that multidisciplinary collaboration between physicians, endocrinologists, diabetologists, dentists, periodontists, and dental hygienists is essential for improving patient outcomes. Such collaborative models facilitate early detection of periodontal disease, timely referral for specialist care, and coordinated management of both conditions (6, 27, 28).

The findings of the present study have several important clinical implications. First, the high prevalence of periodontitis observed among adults with T2DM supports incorporating routine periodontal screening into diabetes clinics. Simple chairside periodontal assessments performed during diabetes follow-up visits could facilitate early identification of patients requiring comprehensive periodontal evaluation. Early diagnosis is particularly important because

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periodontitis often remains asymptomatic during its initial stages, allowing progressive connective tissue destruction and alveolar bone loss before patients seek dental care. Integrating oral examinations within diabetes management programs may therefore reduce delayed diagnosis and improve long-term oral health outcomes.

Second, oral health education should become a routine component of diabetes counselling. Although the present study did not identify statistically significant associations between oral hygiene practices and periodontitis, the descriptive findings revealed that a substantial proportion of participants practiced inadequate oral hygiene, with most participants reporting no interdental cleaning and almost half brushing less than daily. These behaviors remain clinically relevant because microbial dental plaque is the initiating factor for periodontal inflammation. Improving patient knowledge regarding effective plaque control, appropriate tooth-brushing techniques, interdental cleaning methods, and the importance of regular dental visits may reduce periodontal disease progression and contribute to better long-term oral health. Educational interventions should be culturally appropriate, linguistically accessible, and incorporated into routine diabetes education programs delivered by multidisciplinary healthcare teams.

From a public health perspective, the findings emphasize the need for greater integration of oral health within national strategies for non-communicable disease prevention and management. Pakistan continues to experience a rapidly increasing prevalence of T2DM, accompanied by substantial healthcare expenditure and growing demand for chronic disease services. Periodontal disease adds an additional burden through tooth loss, impaired mastication, nutritional compromise, reduced quality of life, and increased treatment costs. Public health initiatives should therefore promote awareness of the oral complications of diabetes while encouraging collaboration between medical and dental healthcare providers. Community-based screening programs, preventive oral health campaigns, and continuing professional education for healthcare workers may improve awareness of the bidirectional relationship between diabetes and periodontal disease and facilitate earlier intervention. Similar recommendations have recently been proposed by international organizations advocating integrated oral-systemic healthcare within primary healthcare systems (5, 28).

An additional implication relates to healthcare policy. At present, oral health services frequently operate independently of diabetes clinics in many low- and middle-income countries, including Pakistan. Establishing structured referral pathways between diabetic outpatient departments and dental services could substantially improve continuity of care. Routine referral of diabetic patients for comprehensive periodontal evaluation, particularly those with prolonged diabetes duration or poor metabolic control, may contribute to earlier diagnosis and more effective management of periodontal disease. Likewise, dentists should be encouraged to recognize undiagnosed diabetes risk factors among patients presenting with severe or recurrent periodontal disease and refer them for medical evaluation where appropriate.

STRENGTHS OF THE STUDY

The present study possesses several methodological strengths. First, it provides contemporary epidemiological evidence regarding periodontitis among adults with T2DM from Swat, a region where published oral health data remain limited. Second, periodontal status was determined through clinical assessment rather than relying exclusively on self-reported oral health information, thereby improving diagnostic accuracy. Third, the participant-level dataset underwent a comprehensive audit before statistical analysis, ensuring consistency, reproducibility, and transparency of the reported findings. Finally, the application of multivariable logistic regression enabled assessment of potential independent associations while accounting for clinically relevant variables.

LIMITATIONS OF THE STUDY

Several limitations should be considered when interpreting the findings. The cross-sectional study

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design precludes establishing temporal or causal relationships between participant characteristics and periodontitis. The relatively small sample size and recruitment from a single tertiary healthcare institution may limit the external generalizability of the findings. Furthermore, several important determinants of periodontal disease, including glycated hemoglobin (HbA1c), smoking status, body mass index, socioeconomic status, educational level, dietary habits, and frequency of dental attendance, were not available within the dataset and therefore could not be incorporated into the regression analyses. The high prevalence of periodontitis also reduced variability in the outcome variable, limiting the ability to detect statistically significant independent predictors.

CLINICAL IMPLICATIONS

The findings of this study have important implications for both clinical practice and healthcare policy. The high prevalence of periodontitis among adults with type 2 diabetes mellitus (T2DM) indicates that periodontal disease represents a substantial oral health burden within this patient population. These findings support the integration of routine periodontal assessment into diabetes management programs, particularly within tertiary healthcare facilities where individuals with chronic metabolic disorders receive regular follow-up care. Early identification and timely management of periodontal disease may reduce oral complications, preserve dentition, and potentially contribute to improved metabolic health through reduction of chronic inflammatory burden.

Healthcare professionals managing patients with T2DM should recognize periodontal disease as an important comorbidity requiring interdisciplinary management. Collaboration between physicians, endocrinologists, dentists, periodontists, dental hygienists, and diabetes educators may facilitate comprehensive patient care by combining glycemic management with preventive oral healthcare. Patient education should emphasize effective oral hygiene practices, regular professional dental examinations, and the importance of maintaining periodontal health as part of overall diabetes self-management.

At the healthcare system level, strengthening referral pathways between diabetic outpatient departments and dental clinics may improve early diagnosis of periodontal disease and increase access to preventive oral healthcare services. Community-based oral health promotion programs targeting individuals with diabetes may further enhance awareness regarding the bidirectional relationship between diabetes and periodontal disease and encourage preventive behaviors.

RECOMMENDATIONS FOR FUTURE RESEARCH

Future investigations should employ multicenter longitudinal study designs involving larger and more representative diabetic populations from different regions of Pakistan. Incorporating objective measures of glycemic control, standardized periodontal indices, behavioral and socioeconomic variables, and comprehensive oral hygiene assessments would provide a more detailed understanding of factors contributing to periodontal disease among individuals with T2DM. Prospective studies evaluating the effect of integrated periodontal therapy on glycemic control and diabetes-related outcomes would further strengthen the evidence supporting multidisciplinary management approaches. Additionally, implementation research exploring the feasibility and effectiveness of integrating periodontal screening into routine diabetes care within primary and tertiary healthcare settings is warranted.

CONCLUSION

Periodontitis was highly prevalent among adults with type 2 diabetes mellitus attending Saidu Group of Teaching Hospital, Swat, with more than four-fifths of participants exhibiting clinically established periodontal disease. Moderate periodontitis represented the most frequently observed clinical presentation, underscoring the considerable burden of periodontal disease within this diabetic population. Although none of the evaluated demographic, behavioral, or clinical variables demonstrated statistically significant independent associations with periodontitis after

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multivariable adjustment, descriptive analyses suggested higher disease occurrence among older participants and those with longer diabetes duration. These findings should be interpreted cautiously because of the study's cross-sectional design, modest sample size, and limited statistical power. The study reinforces the importance of incorporating routine periodontal assessment into comprehensive diabetes care. Strengthening collaboration between medical and dental healthcare professionals, improving patient education regarding oral health, and implementing structured periodontal screening programs may facilitate earlier detection and management of periodontal disease among individuals living with T2DM. Further multicenter prospective studies incorporating objective metabolic and behavioral measures are required to better characterize determinants of periodontal disease and inform evidence-based preventive strategies within Pakistan.

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