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Comparative Assessment of Clinical Periodontal Parameters Among Diabetic Versus Non-Diabetic Males in Erbil City

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Abstract: Periodontal disease is an inflammation considered one of the main causes of tooth loss. Chronic type is depicted by the gradual breakdown of the tissues surrounding the tooth. Multiple factors increase the risk of periodontitis, including poor oral hygiene, smoking, stress, diabetes, genetic factors, and certain medications. Elevated blood sugar levels that affect the immune system lead to periodontal inflammation, suggesting a bidirectional relationship. The severity of periodontitis is increased by Type 2 diabetes, and glycemic control might be adversely affected by chronic periodontitis with compromised immune responses and vascular changes. Current research aimed to compare periodontitis among diabetic and non-diabetic patients, evaluating diabetes duration, brushing status, and clinical parameters. A clinical comparative study included 60 male patients aged 35 to 70 years, divided into two groups: 30 (Diabetic with periodontitis) and 30 (non-diabetic with periodontitis). Data collected at the Faculty of Dentistry, Tishk International University, Erbil. Results showed that all clinical parameters differed significantly between the diabetic and non-diabetic groups. In addition, the latter group showed that all parameters were higher in the non-brushing group than in the brushing group, with significant differences. In conclusion, maintaining glycemic control and proper oral hygiene helps reduce the incidence of periodontal disease.

Keywords: Periodontal Disease; Periodontitis; Diabetes; Periodontal Parameters; Oral Hygiene

1. Introduction

Periodontal disease is regarded as one of the key causes of tooth loss; the most common periodontal findings are tooth mobility and furcation involvement. Chronic periodontitis is a chronic inflammatory disease of the tissues supporting the tooth, characterized by the gradual breakdown of the tissues surrounding the tooth, such as the alveolar bone, periodontal ligament, gingiva, and cementum, and, if untreated, can lead to tooth loss [1].

Periodontitis is an infection-driven disease that causes inflammation of the periodontal structures and eventually leads to irreversible attachment loss around the tooth. Biofilms play a significant role in the onset and severity of periodontitis; although periodontitis is typically noticed in adults, young individuals can also experience its harmful outcomes [2].

Bacteria cause most oral cavity diseases, including periodontal diseases. However, caries and periodontal diseases are not purely bacterial diseases, because bacteria are not the only cause of the disease; they are considered endogenous infections that depend on multiple preconditions, such as the

presence of a certain habitat, external conditions that affect and promote the flora, and changes in the host defense system. [3]

Multiple factors can increase the risk of periodontitis in each individual, including poor oral hygiene, smoking, genetic factors, stress, certain medications, and diabetes. Many studies have indicated that diabetic individuals, particularly those who have deprived glycemic control, are at high risk of rising periodontitis, it has been proven that elevated blood sugar can impair immune system and prevent its proper function thus promoting inflammation, therefore it leads to destruction of tissues supporting the teeth, periodontitis may vice versa affect blood glucose regulation, so a common relationship is suggested [4,5].

Type 2 diabetes mellitus and chronic periodontitis have a significant impact on global health; a bidirectional relationship exists between chronic periodontitis and Type 2 diabetes mellitus, whereby the risk and severity of periodontitis are increased by Type 2 diabetes mellitus. In contrast, chronic periodontitis may affect glycemic control, compromised immune responses, and vascular changes that are associated with hyperglycemia, made the persons with Type 2 diabetes mellitus more susceptible to periodontal diseases. Understanding this relationship is important for developing proper treatment approaches that include both metabolic and oral health [6].

Although the connection between periodontal disease and diabetes has been well documented, the extent to which disease severity is influenced by the period of diabetes, the level of glycemic control, and individual oral hygiene practices remains insufficiently clarified. A deeper understanding of these modifying factors is essential for enhancing preventive strategies, enabling earlier diagnosis, and optimizing clinical management to improve overall patient outcomes. This study aims to compare the prevalence and severity of periodontitis between diabetic and non-diabetic patients and to investigate the effects of diabetes duration and oral hygiene behaviors on periodontal health.

The objectives were:

1. To determine the prevalence of periodontitis among diabetic and non-diabetic patients (DP, NDP).
2. To compare the periodontal clinical parameters such as plaque index (PI), gingival index (GI), clinical attachment loss (CAL), and probing depth (PD) between the two groups (DP and NDP).
3. To evaluate the influence of the period of diabetes on periodontal condition (less than 5 years, 6-10 years, and more than 10 years).
4. To examine the relationship between brushing status (brushing or not brushing) and periodontal health, as determined by clinical parameters (PI, GI, PD, and CAL) in both groups (DP and NDP).

2. Literature Review

2.1 Periodontal Disease and Its Impact on Diabetes

Periodontitis, sharing the same risk factors, can have an impact on diabetes, especially in type 2, by affecting glycemic control. With poor glycemic control (HbA1c > 9.0%, 75 mmol/mol), there is a strong association with periodontitis, suggesting that it may compromise glycemic control. According to previous studies that included more than 22,000 patients with type 2 diabetes was found that their incidence was more significant and greater in patients with periodontal disease than in patients without periodontal disease [7].

A cohort study in 2025 has shown that diabetic individuals with severe periodontitis have an increased risk of cardiovascular complications and diabetic nephropathy compared to individuals with no periodontitis [8].

Recent evidence suggests that periodontitis in non-diabetic individuals is believed to have an undesirable influence on HbA1c levels. A meta-analysis compared the mean difference in HbA1c levels between non-diabetic individuals with and without periodontitis and found a mean difference of 0.16% [9].

2.2 Association Between Diabetes and Periodontitis

Diabetes mellitus and periodontitis are common, chronic diseases. It is commonly assumed that the inter-connection between diabetes mellitus and periodontitis is a two-way association, i.e., the presence of one condition tends to enhance the severity and consequences of the other, and vice versa. Diabetes affects one in 10 adults, and periodontal disease affects four in 10 adults in the USA [4].

Deficiencies in insulin action, secretion, or both can result in hyperglycemia, a hallmark of diabetes mellitus, a group of metabolic disorders. The number of cases worldwide was estimated to be 371 million, which might increase to 643 million in 2030, and 83 million. As a result, diabetes is a main global public health concern [10]. The autoimmune process that damages the β cells in the pancreas, which secrete insulin, causes type 1 diabetes; this results in insufficient insulin production.

Combining insulin resistance with reduced insulin secretion results in type 2 diabetes, which is more prevalent—adults with type 2 diabetes account for ninety to ninety-five percent of all cases of the disease. Diabetes mellitus is linked to various difficulties such as osteoporosis, cancer, retinopathy, neuropathy, nephropathy, bunions, and cardiovascular disease. It has been acknowledged for the past 20 years that one of the "classic" consequences of diabetes is periodontal disease [11]. Epidemiological investigations have demonstrated that the risk of periodontitis is higher in people with diabetes than in individuals with no diabetes. Diabetes has been clearly proven to be a major risk factor for periodontal disease. In the US National Health and Nutrition Examination Survey III, for instance, after adjusting for age, ethnicity, education, and sex, adults with poorly controlled diabetes and higher levels of HbA1c had a significantly higher prevalence of severe periodontitis than those with better glycemic control [12].

2.3 Periodontal Parameters (Plaque Index, Gingival Index, Pocket Depth, and Clinical Attachment Loss)

The clinical parameters used to determine periodontitis are PI, GI, PD, and CAL. The plaque index is a clinical tool utilized to calculate the thickness or amount of dental plaque on the teeth, especially near the gingival margin. It helps assess oral hygiene status and risk of periodontal disease. One of the most commonly used versions is the Silness and Löe plaque index, which grades each tooth from 0 to 3 based on the amount of visible plaque already used in current research [13].

A study carried out by Sreenivasan in 2016 provided very reliable and clear findings; however, he administered the Quigley-Hein index, which ranges from 0-5. Regarding anterior teeth, plaque scores of 1-3 were the most common, occurring on 27–34% of evaluated surfaces; score 4 was observed on approximately 5.5%, and score 5 on only 0.08% of anterior surfaces. In contrast, the most frequent score for the posterior teeth was 3, observed on 49% of evaluated surfaces. Score 4 was present on 20% of posterior sites—more frequently than scores 1 and 2, which appeared on 11–17% of surfaces.

Only a small fraction—less than 2%—of back surfaces recorded a score of 5. In addition, it notes that a gingival index score of 0 is more commonly observed in anterior teeth than in posterior teeth, with approximate percentages of 9% and 3%, respectively. Moreover, score 2 accounts for similar

distributions in anterior teeth (72%) and posterior teeth (64%). On the other hand, score 2 for the gingival index was more prominent in posterior teeth by 32% compared to anterior teeth by 17% [14].

For clinical attachment loss and pocket depth, an article reported higher grades in both measures in patients with diabetes compared with healthy patients. [15] Furthermore, in a study, the mean periodontal pocket depth was significantly greater in diabetic patients (3.70 ± 1.28 mm) than in the control group (1.42 ± 0.94 mm), with a statistically significant difference between the two groups ($p = 0.015$). A strong positive correlation was determined between diabetes and pocket depth ($rs = 0.788$) [16].

Adversely, a few researchers have observed that pocket depth and clinical attachment loss do not vary significantly between diabetic and non-diabetic patients. For instance, in 2012, a study measured pocket depth and clinical attachment loss in 72 diabetic patients and compared these values with those obtained from 39 non-diabetic patients. The results suggested that the mean pocket depth among people with diabetes was 2.53mm ± 0.61, which was similar to that of non-diabetics, 2.51 mm ± 0.46 [17].

3. Methodology

3.1 Setting and Time of Study

The study was conducted at Tishk International University Faculty of Dentistry (diagnostic and periodontics department), covering the period from October 20, 2024, to February 12, 2025.

3.2 Ethical Considerations

Before the study began, all applicants were fully informed about the research, and written agreement was obtained and signed by each volunteer prior to the procedure.

3.3 Study Design and Sample Groups

A clinical comparative study was undertaken involving 60 male patients, aged 35 to 70 years. The patients were separated into two groups: 30 male patients (Diabetic with periodontitis) and the same number of non-diabetic patients (periodontitis). The second main condition was that participants must have at least 20 teeth present.

The inclusion criteria for diabetic patients were (controlled or uncontrolled), and the duration categories were between (less than 5 years, 6-10 years, more than 10 years). The patients are generally healthy except for diabetes in the diabetic group.

Participants following such criteria were excluded from the study: participants who had a history of systemic diseases (e.g., high blood pressure, coronary heart disease, and cancer), who had taken medication (immunosuppressive agents, antibiotics, and nonsteroidal) for the last 6 months, vitamin supplementation, smoking history, and periodontal treatment was carried out within the 3 months prior to the baseline examination.

3.4 Data Collection

After assessing each patient to determine whether he might be indicated for this study, data were collected for each patient. Data that might serve the aims and objectives of the current study were obtained using a questionnaire administered to pretest patients as part of a pilot study to assess potential outcomes and patient responses.

Data concerning age, gender, diabetic status (diabetic and non-diabetic), diabetic control, duration of diabetes, and patients' oral hygiene, assessed by toothbrushing. Figure 1 indicates the main study structure.

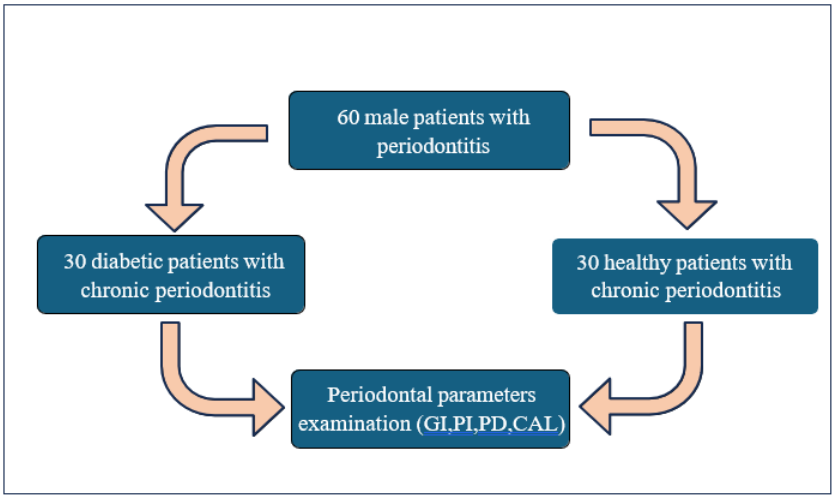

Figure 1: Study design of the data collection showing patient grouping and parameters. Patients involved underwent a full-mouth periodontal checkup by three examiners using standardized criteria for clinical periodontal parameters (Gingival index GI, Plaque index PI, Pocket depth PD, and Clinical attachment loss CAL), measured with William's periodontal probe.

3.5 Instruments Used

The instruments and tools used are itemized in Table 1.

Table 1: List of used instruments

Instruments	Company	Country
William's periodontal probe	Hu-Friedy	Chicago
Dental mirrors	labkhandziba	Iran
Disposable gloves	One plus	Malesia
Disposable masks	Shagul med	Chine
Face shield	muryobao	Spanish

3.6 Methods

3.6.1 Clinical Periodontal Examination

Clinical periodontal examination, including assessment of periodontal parameters (PI, GI, PD, CAL), was performed for each patient in both groups using the same criteria.

3.6.1.1 Plaque Index (PI)

For classifying the amount of plaque on the Midbuccal, Distobuccal, Mesiobuccal, and Midlingual. Utilized scores developed by Leo and Silness with a gentle application of a dental probe near the Gingival margin [18]. The scores range from 0 to 3, as clarified in Table 2.

Table 2: Standards of plaque index (PI)

Score	Criteria

0	No dental plaque in the gingival region
1	A film of dental plaque sticking to the free gingival margin and tooth closest area. Plaque may only be identified by flowing a probe around the tooth surface.
2	Moderate accumulation of soft deposits within the gingival pocket, on the gingival The naked eye can observe the margin and/or neighboring tooth surface.
3	Loads of soft matter within the gingival pocket and/or on the gingival margin and the neighboring tooth surface

3.6.1.2 Gingival Index (GI)

For the clinical evaluation of gingival inflammation severity, the study employed the scoring system (0-3) introduced by Loe and Silness [19]. The Gingiva around each tooth was examined gently by inserting William's probe and then recording the response (bleeding, non-bleeding and redness) on four surfaces (Midbuccal, Distobuccal, Mesiobuccal and Midlingual). The label conditions of each score are explained in Table 3.

Table 3: Standards used for measuring the gingival index

Score	Gingival Status	Criteria
0	**Normal Gingiva**	Biological coral pink gingival with no e/o inflammation
1	**Mild Inflammation**	Small color shifts, minor Edema. No bleeding on probing
2	**Moderate Inflammation**	Redness, Edema and glazing. Bleeding upon probing
3	**Severe Inflammation**	Obvious redness and Edema/Ulceration/tendency to bleed naturally

3.6.1.3 Periodontal Pocket Depth (PD)

The distance from the margin of the gingiva to the base of the pocket was obtained by gentle placement of William's Probe in the sulcus and parallel to the long axis of the tooth on four different sites (Midbuccal, Distobuccal, Mesiobuccal, and Midlingual) [17].

3.6.1.4 Clinical Attachment Loss (CAL)

To record the reflection of the position of the attachment of the gingiva to the tooth and identify the extent of attachment loss, William's Probe was utilized. Results were obtained by gently inserting William's Probe, parallel to the long axis of each tooth, on four surfaces of each tooth, and recording the distance from the base of the pocket to the gingival margin. The severity of cases is illustrated in Table 4 [17].

The Centers for Disease Control and Prevention (CDC) and the American Academy of Periodontology (APA) recently introduced a new case definition for periodontitis, primarily for population-based surveillance and epidemiologic studies, based on classifications derived from probing depth and clinical attachment level measurements.

Table 4: Criteria for diagnosing periodontitis for CAL, PD combined

Severity	Range
Severe Periodontitis	Presence of two or more interproximal sites with clinical attachment loss of 6 mm or more, not on a similar tooth. At least one interproximal site with a probing depth of 5 mm or greater.
Moderate Periodontitis	Presence of two or more interproximal sites with clinical attachment loss of 4 mm or greater, arising on at least two different teeth. Alternatively, two or more interproximal sites with a probing depth of 5 mm or greater, not on same tooth.
Slight Periodontitis	Existence of ≥ 2 interproximal sites with ≥ 3 mm clinical attachment loss on at least two different teeth. Alternatively, presence of probing depth (PD) of ≥4 mm at two or more interproximal sites, not on a similar tooth. Or one site PD≥5mm.

3.7 Statistical Analysis

Data assessment was done using SPSS version 27.0. An independent-samples t-test was used to compare means between two independent groups, with normality and homogeneity of variance assessed prior to analysis. For comparisons involving more than two independent Groups, a one-way analysis of variance (ANOVA) was conducted to determine whether significant differences existed among group means. When ANOVA yielded significant results, post hoc tests were carried out to identify specific group differences while accounting for multiple comparisons. A significance level of $p < 0.05$ was applied to the analysis to ensure the reliability and Validity of the findings.

4. Results

Sixty patients were included in the study. Their overall mean age was 48.77±8.51 years, with a range of 34 years (minimum 35, maximum 69). They were of two groups: Diabetic Periodontitis DP and Non-Diabetic Periodontitis NDP, Figure 2

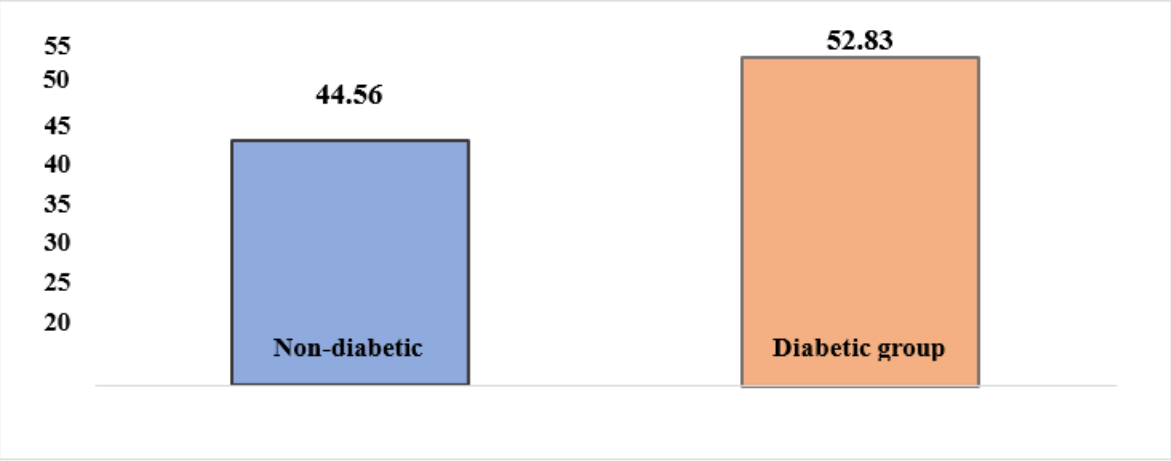

Figure 2: Samples' age means in years shows that the mean age for diabetic periodontitis (52.83) was more than the non-diabetic periodontitis (44.56), (P= 0.000) *obtained by paired samples t-test, and the mean difference is significant at the 0.05 level.

4.1 Clinical Parameters in Diabetic and Non-Diabetic Periodontitis Groups

The findings presented in Table 5 show that all clinical periodontal parameters (PI, GI, PD, and CAL) had higher mean values in the diabetic periodontitis (DP) group than in the non-diabetic periodontitis (NDP) group.

For PI, GI, PD, and CAL, the mean values in the Diabetic Periodontitis patients group were 1.94±0.38, 1.85±0.38, 2.5±0.28, 4.1±0.79, respectively; however, for Non-Diabetic Periodontitis patients group the mean value for PI, GI, PD, and CAL were 1.17±0.43, 0.91±0.51, 1.38±0.28, 2.33±0.64, respectively, with a very high significant difference between both groups (DP and NDP).

Table 5: Clinical parameters in Diabetic and Non-Diabetic Periodontitis groups

Clinical Parameters	Diabetic Status	N.	Mean	±SD	P Value	Decision
PI	**Diabetic**	30	1.94±	0.38	0.00	VHS
	Non-Diabetic	30	1.17±	0.43	0.00	VHS
GI	**Diabetic**	30	1.85±	0.39	0.00	VHS
	Non-Diabetic	30	0.91±	0.51	0.00	VHS
PD	**Diabetic**	30	2.50±	0.28	0.00	VHS
	Non-Diabetic	30	1.38±	0.28	0.00	VHS
CAL	**Diabetic**	30	4.10±	0.79	0.00	VHS
	Non-Diabetic	30	2.33±	0.64	0.00	VHS

*. Based on an independent-samples t-test, the mean difference is significant at the 0.05 level.

4.2 The Effect of Brushing Statues on Clinical Parameters in Non-Diabetic Periodontitis and Diabetic Periodontitis Groups

Obtained results are shown in both Tables 6 and 7. Table 6 indicates that in the non-diabetic group, the mean value of all clinical parameters for the non-brushing group, PI, GI, PD, and CAL (1.48±0.24, 1.25±0.29, 1.53±0.28, 2.81±0.43) were higher compared to the brushing group (0.89±0.36, 0.61±0.48, 1.26±0.23,1.90±0.47) with a significant difference between all clinical parameters in both groups (brushing and non- brushing).

Table 6: Brushing status effect on clinical parameters of the NDP non-diabetic group

Diabetic statues	Clinical parameters	Brushing statues	N	Mean ± SD	P value
Non-Diabetic patients	**PI**	Brushing	16	0.89±0.36	0.00
		Non-Brushing	14	1.48±0.24	0.00
	GI	Brushing	16	0.61±0.48	0.00
		Non-Brushing	14	1.25±0.29	0.00
	PD	Brushing	16	1.26±0.23	0.008
		Non-Brushing	14	1.53±0.28	0.01
	CAL	Brushing	16	1.9±0.47	0.00
		Non-Brushing	14	2.81±0.43	0.00

*. Based on an independent-samples t-test, the mean difference is significant at the 0.05 level.

Table 7: Brushing status effect on clinical parameters of the DP diabetic group

Diabetic statues	Clinical parameters	Brushing statues	N	Mean ± SD	P value
Diabetic patients	PI	Brushing	8	1.62±0.35	0.00
		Non-Brushing	22	2.06±0.33	0.01
	GI	Brushing	8	1.56±0.11	0.01
		Non-Brushing	22	1.96±0.41	0.00
	PD	Brushing	8	2.41±0.43	0.20
		Non-Brushing	22	2.54±0.21	0.40
	CAL	Brushing	8	4.01±0.84	0.70
		Non-Brushing	22	4.13±0.79	0.70

*. Based on an independent-samples t-test, the mean difference is significant at the 0.05 level.

While in the diabetic group Table 7; the mean value of all clinical parameters for non-brushing group PI, GI, PD, and CAL (2.06±0.33, 1.96±0.41, 2.54±0.21, 4.13±0.79) were higher compared to brushing group (1.62±0.35, 1.56±0.11, 2.41±0.43, 4.01±0.84) with non-significant difference between all the clinical parameter in both groups (brushing and non-brushing), except for significant difference in PI and GI in both brushing and non-brushing groups.

4.3 The Influence of Diabetic Durations on Clinical Parameters in the Diabetic Periodontitis Group

Table 7 shows that all clinical parameters (PI, GI, PD, and CAL) increase with increasing diabetic duration, and the highest mean value is seen in the patient group that had diabetes for >10 years, with significant differences in both clinical parameters, GI (P value=0.005), and CAL (P value=0.01). And a non-significant difference in both PI (P value=0.06) and PD (P value=0.3). For GI, patients with diabetes duration >10 years had significantly higher mean values than both the <5 years group (mean difference = -0.6005, P value = 0.004) and the 6–10 years group (mean difference = -0.14, P value = 0.41, not significant). Similarly, the 6–10 years group had a significantly higher mean value than the <5 years group (mean difference = -0.45, P-value = 0.004).

Table 8: The influence of diabetic durations (<5 years, 6-10 years, and <10 years) on clinical parameters in the diabetic periodontitis patient group:

Clinical parameters		Sum of Squares	Df	Mean Square	F	P value
PI	Between Groups	0.829	2	0.414	3.135	0.06
	Within Groups	3.57	27	0.132		
	Total	4.399	29			
GI	Between Groups	1.494	2	0.747	6.557	0.005
	Within Groups	3.077	27	0.114		
	Total	4.572	29			
PD	Between Groups	0.172	2	0.086	1.066	0.358
	Within Groups	2.182	27	0.081		
	Total	2.355	29			
CAL	Between Groups	4.941	2	2.47	4.998	0.014
	Within Groups	13.346	27	0.494		
	Total	18.287	29			

Regarding CAL, a significantly greater mean value was observed in the >10 years group compared to the <5 years group (mean difference = -1.2535, P-value = 0.004). The difference between the <5 years and 6–10 years groups approached significance (mean difference = - 0.6022, P value = 0.056), while no significant difference was found between the 6–10 years and >10 years groups (mean difference = - 0.65, P value = 0.08).

These findings show that the longer the duration of diabetes, particularly more than 10 years, the more severe the periodontitis is.

Table 9: The influence of diabetic durations (<5 years, 6-10 years, and <10 years) on GI and CAL clinical parameters in the diabetic periodontitis patient group

Dependent Variable	**Group (year)**		**Mean Difference**	**P Value**
GI	**< 5 Years**	**6 -10 Years**	-.45956*	0.004
		> 10 Years	-.60050*	0.004
	6 -10 Years	**< 5 Years**	.45956*	0.004
		> 10 Years	-0.14094	0.419
	> 10 Years	**< 5 Years**	.60050*	0.004
		6 -10 Years	0.14094	0.419
CAL	**< 5 Years**	**6 -10 Years**	-0.60221	0.056
		> 10 Years	-1.25350*	0.004
	6 -10 Years	**< 5 Years**	0.60221	0.056
		> 10 Years	-0.65129	0.08
	> 10 Years	**< 5 Years**	1.25350*	0.004
		6 -10 Years	0.65129	0.08

*. By ANOVA, the mean difference is significant at the 0.05 level.

5. Discussion

5.1 Comparison Between Healthy Group and Diabetic Type 2 Group Regarding Clinical Periodontal Parameters (PI, GI, PD, CAL)

In the present study, all clinical periodontal parameters (PI, GI, PD, and CAL) exhibited higher mean values in the diabetic type 2 diabetes group compared to the healthy group, with a highly significant difference between the two groups (DP and NDP), as presented in Table 5.

Regarding PI and GI, the higher mean value in the DP group compared to the NDP group, with a significant difference between both groups, is due to several potential causes like impaired immune function, which includes neutrophil dysfunction, increased creation of pro-inflammatory mediators (IL-1B, TNF-a) and advanced glycation end-product in diabetic individuals reduce plaque control and increase the susceptibility for periodontal inflammation [20].

Several cross-sectional studies support the current finding that patients with T2DM have significantly higher PI and GI than non-diabetic individuals [21,22]. A disagreeing study with current finding had showed no significant difference in PI and GI between DP and NDP; the most probable cause for that is promoted oral hygiene measures among samples and better glycemic control by the type 2 diabetic individuals, as it is proven that proper care for oral hygiene and glycemic control in diabetic patients can protect the patients from periodontal diseases [23].

Parameter analysis of PD and CAL in the current study showed higher mean values in the DP group compared to the NDP group, with a highly significant difference between the groups, consistent with previous findings. The possible causes include impaired immune responses in diabetic patients and reduced neutrophil function, such as chemotaxis and phagocytosis, which weaken the immune system's ability to fight periodontal pathogens, thus leading to chronic inflammation [24,25].

Additionally changes in sub-gingival microflora caused by higher glucose level in crevicular fluid of diabetic patients leads to having more pathogen sub-gingival biofilm [26], and poor glycemic control which consistently in many studies it is marked that there is a strong correlation between high Hba1c and more severe periodontitis [27], all of these factors allow deeper and more bacterial invasion and deeper pocket formation and attachments loss in each individual [28].

The result of the present study agrees with the result of a study done by Mirzaei et al. (2021) that investigated 11 cross-sectional studies involving 38,896 participants, which showed that chronic hyperglycemia in diabetes leads to increased oxidative stress and the development of advanced glycation end products (AGEs), which in turn elevate pro-inflammatory cytokines like IL-1β and TNF-α. These inflammatory mediators impair immune cell function and accelerate tissue breakdown in the periodontium, resulting in deeper periodontal pockets and greater CAL [29].

However, some studies disagreed with these findings, including a 2020 meta-analysis, which reported that in several of the included studies, the differences in periodontal parameters between individuals with type 2 diabetes and those without were not statistically meaningful [30].

Likewise, a randomized controlled trial published in 2023 found no clear association between baseline HbA1c levels and PD and CAL among patients with type 2 diabetes. Additionally, when levels of glycemic control categorized diabetic participants, the periodontal outcomes, such as PD and CAL, remained consistent [31]. Altogether, these outcomes imply that periodontal status does not consistently vary with diabetic status or severity.

5.2 The Effect of Brushing Status on Clinical Parameters in Diabetic and Non-Diabetic Periodontitis Groups

The result showed that in the NDP, the mean value of all clinical parameters for the Non-Brushing Group, PI, GI, PD, and CAL, were higher compared to the brushing group, with significant differences between all clinical parameters in both groups (brushing and non-brushing), which has been presented in Table 6.

The high mean values of PI and GI in the NDP group of Non-Brushers are due to a lack of regular toothbrushing, which allows plaque to accumulate and mature on the tooth surface [32,33]. These bacteria release toxins that cause inflammation, redness, edema, and bleeding of the gingiva. Over time, this chronic inflammation can damage the periodontium, even in systemically healthy individuals [34].

A randomized trial supports our result, showing that delaying brushing frequency to every 48-72 hours led to significantly higher PI scores, and that elevated levels correlated with increased gingival inflammation (GI) and bleeding on probing (BOP) [35]. Another study disagrees with our finding and shows no significant difference in PI and GI among non-brushers when baseline hygiene habits are good, suggesting that the absence of brushing alone may not drive PI and GI differences unless coupled with poor technique or infrequent cleaning [36].

Regarding the high mean value of PD and CAL in non-brushers of the NDP group is due to failing to brush regularly, which leads to unchecked plaque biofilm maturation, which promotes colonization by

harmful bacteria (P. gingivalis, T. forsythia) that release toxins and enzymes that degrade connective tissues, resulting in significantly greater PD and CAL compared to those who brush consistently [33,34].

Current results are consistent with a German cohort study, which shows that poor oral hygiene is strongly associated with higher mean PD and CAL, independent of factors such as age, smoking, and socioeconomic status [37].

In the diabetic group DP, the mean values of all clinical parameters for the non-brushing group PI, GI, PD, and CAL were higher than in the brushing group, with significant differences in PI and GI and non-significant differences in PD and CAL in both brushing and non-brushing groups.

The significantly high mean value of PI and GI values in diabetic non-brushers is caused by behavioral patterns that ignore oral hygiene, a microbial shift that favors disease-causing bacteria, a weakened immune response that is unable to control biofilm-induced inflammation, and irregular brushing, which not only permits plaque to accumulate but also works in concert with salivary glucose to create a nutrient-rich environment for bacteria. In non-brushers with diabetic periodontitis, all of these factors lead to noticeably greater PI and GI [38].

The findings of this study were consistent with those of a 2020 study, which found that diabetic patients with poor oral hygiene exhibited significantly higher plaque and gingival indices than those who maintained regular brushing habits. Our findings are contradicted by another study, which found that PI levels in diabetic teenagers did not significantly change with brushing frequency. This suggests that mechanisms other than brushing, such as systemic or salivary changes, contribute to plaque buildup [39].

Regarding CAL and PD, although the differences are not statistically significant, non- brusher showed slightly higher mean values. Study findings are supported by a cross-sectional study of 4,477 adults with type 2 diabetes, which found that, despite differences in brushing habits, toothbrushing frequency was not significantly associated with PD. This suggests that other factors may outweigh the effects of brushing [40]. However, a study that contradicts our findings found that people with diabetes who brush only once a day, not at night, had worse periodontal outcomes than those who brush twice a day. This difference was statistically significant, with night brushing showing PD 2.32 ± 0.52 mm vs. 2.16 ± 0.43 mm and CAL 2.61 ± 0.73 mm vs. 2.44 ± 0.65 mm [41].

5.3 The Influence of Diabetic Durations (<5 years, 6-10 years, and <10 years) on Clinical Parameters in Diabetic Periodontitis Patient Group

The results of Table 3 showed that all clinical parameters were affected by the duration of diabetes; however, PI and PD did not show a significant difference with the increasing duration. On the other hand, GI and CAL were significantly affected. Regarding PI, the lack of a significant difference may be due to patients becoming self-conscious and shy about their oral health, which prompts them to brush their teeth before entering the clinic for dental and periodontal check-ups.

A study supporting our claim examined 126 patients with type 2 diabetes and found no significant difference in PI between those with shorter and those with longer diabetes duration [42].

However, another study reported that as the duration of diabetes increased, PI increased significantly. Examining type 2 diabetic patients, it has been stated that it is caused by the complication of diabetes, which is reduced salivary flow, which promotes plaque retention [21].

Regarding the current study's PD indicating a non-significant increase with diabetic duration, which was due to several causes, longer duration may cause persistent hyperglycemia, resulting in lower-

grade chronic inflammation that contributes to slower periodontal breakdown; however, change may not reach statistical significance due to individual variation, glycemic control and improved diabetic care and awareness over time, or sample size limitation [43].

A longitudinal observation stated agreement with our result. It showed that deep periodontal pockets were common among diabetic patients, but again, PD did not show a significant difference between duration-of-exposure groups [44]. A cross-sectional study was contrary to our results, which showed that longer diabetic duration was associated with slightly deeper pockets, with a non-significant difference. This could be due to overlap with glycemic control, as patients with longer disease duration maintained good HbA1c levels, thereby reducing the measurable effect of duration alone [45].

The CAL level raised a huge concern, particularly since it is a critical indicator of irreversible periodontal ligament support loss and the severity of periodontitis. This CAL increase with longer diabetic duration is a combination of several factors that reduce the capacity for periodontal healing and increase the risk of infection, as indicated by CAL being the most sensitive and strongly time-associated indicator in this analysis [46].

A study that agrees with our finding found that with increasing diabetic duration, GI and CAL were significantly increased. For instance, it was shown that regular dental care is required for diabetic patients, since diabetic duration is directly proportional to increases in GI and CAL, with a highly significant correlation between them. It has been reported that clinical attachment loss can increase even in a stable periodontal pocket depth [31].

On the other hand, a study contradicted our result and reported the opposite, finding that GI and CAL were not significantly related to diabetic duration [47].

6. Conclusions

The present study achieved the following findings:

1. All periodontal clinical parameters (PI, GI, PD, CAL) mean values were higher in the periodontitis diabetic type 2 group than the periodontitis healthy group, with a very significant difference.
2. Considering the effect of brushing results obtained from periodontitis of the NDP healthy group who brush their teeth daily compared to those who do not, there is more severe periodontitis in the higher mean values of the periodontal clinical parameters (PI, GI, PD, and CAL) in non-brushing patients compared to the brushing patients, with a very significant difference. Same as in the periodontitis of the DP diabetic type 2 group, the non-brushing patients have higher mean values of the periodontal clinical parameters (PI, GI, PD, and CAL) with a significant difference in the parameters PD and CAL only, and non- significant difference in PI and GI.
3. Longer diabetic duration found to be leading to more severe periodontitis, with diabetic patient group with >10 years history of the disease having higher mean values of the periodontal clinical parameters (PI, GI, PD and CAL) than patients with 6-10 years and <5 years history of the disease, with a significant difference of GI and CAL, and non-significant difference of PI and PD.

7. Recommendations

Based on the present study's findings, the current study suggests the following recommendations for future studies:

1. Extended and more detailed studies are required to see whether the promotion of oral hygiene can equalize the severity of periodontitis in diabetic patients to that of healthy patients.

2. Further experiments are required to explore the long-term consequences of glycemic control on the severity of periodontitis and whether preventive strategies can reverse its effects.

Author's Contribution

The authors approve that all named individuals have read and accepted the final manuscript. Each author contributed equally and substantively to the study's conception, layout, data analysis, and manuscript organization. All authors agree on the order of names as presented and accept full responsibility for the integrity and originality of the work.

Conflict of Interest

There is no conflict of interest for this paper.

Use of AI tool Declaration

The authors declare that no AI tools were used in any part of the preparation of this manuscript.

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