

Oral Health In Diabetic Smokers: Assessing Dental Parameters And Implications

Diyabetik Sigara İçenlerde Ağız Sağlığı: Dental Parametrelerin Değerlendirilmesi ve Sonuçları

ABSTRACT

Objective: Diabetes mellitus and tobacco smoking are well-recognized risk factors for oral diseases; however, their individual and combined effects on dental and periodontal parameters remain incompletely understood. This study aimed to evaluate the impact of diabetes and smoking on caries experience, periodontal status, implant presence, and peri-implantitis prevalence in a large patient cohort.

Materials and Method: This retrospective cross-sectional study included 945 adult patients whose panoramic radiographs and clinical records were retrieved from institutional archives. Patients were categorized according to diabetes status and smoking habits. Oral health parameters, including DMFT index, periodontal status, implant presence, and peri-implantitis, were assessed radiographically. Group comparisons were performed using chi-square and Kruskal–Wallis tests, with statistical significance set at $p < 0.05$.

Results: Diabetic non-smokers exhibited significantly higher DMFT scores compared with other groups, whereas non-diabetic smokers demonstrated the lowest values. Advanced periodontitis (Stage III–IV) was more prevalent among diabetic patients, particularly non-smokers. Smoking was significantly associated with increased periodontal disease severity; however, no significant association was observed between smoking or diabetes status and peri-implantitis prevalence.

Conclusion: Within the limitations of this radiographic study, diabetes appeared to exert a stronger influence on overall oral health deterioration than smoking alone. While smoking was associated with increased periodontal disease severity, no clear association with radiographic peri-implant bone loss was observed. These findings highlight the importance of individualized preventive strategies for patients with metabolic risk factors.

Key Words: Diabetes Mellitus, Smoking, Oral Health, Periodontal Diseases, Peri-Implantitis, DMF Index.

ÖZ

Amaç: Diyabet mellitus ve tütün kullanımı, ağız hastalıkları için iyi bilinen risk faktörleridir; ancak bu faktörlerin dental ve periodontal parametreler üzerindeki bireysel ve birleşik etkileri tam olarak aydınlatılamamıştır. Bu çalışmanın amacı, geniş bir hasta kohortunda diyabet ve sigara kullanımının çürük deneyimi, periodontal durum, implant varlığı ve peri-implantitis prevalansı üzerindeki etkisini değerlendirmektir.

Gereç ve Yöntemler: Bu retrospektif kesitsel çalışmaya, panoramik radyografileri ve klinik kayıtları kurumsal arşivlerden elde edilen 945 yetişkin hasta dahil edilmiştir. Hastalar diyabet durumuna ve sigara kullanım alışkanlıklarına göre sınıflandırılmıştır. DMFT indeksi, periodontal durum, implant varlığı ve peri-implantitis gibi ağız sağlığı parametreleri radyografik olarak değerlendirilmiştir. Gruplar arası karşılaştırmalar ki-kare ve Kruskal–Wallis testleri kullanılarak yapılmış, istatistiksel anlamlılık düzeyi $p < 0,05$ olarak kabul edilmiştir.

Bulgular: Diyabetik sigara içmeyen bireylerde DMFT skorları diğer gruplara kıyasla anlamlı derecede daha yüksek bulunurken, diyabetik olmayan sigara içenlerde en düşük değerler saptanmıştır. İleri periodontitis (Evre III–IV), özellikle sigara içmeyen diyabetik hastalarda daha yaygın olarak gözlenmiştir. Sigara kullanımı, periodontal hastalık şiddetinde artış ile anlamlı düzeyde ilişkili bulunmuş; ancak sigara veya diyabet durumu ile peri-implantitis prevalansı arasında anlamlı bir ilişki saptanmamıştır.

Sonuç: Bu radyografik çalışmanın sınırlılıkları dahilinde, diyabetin tek başına sigara kullanımına kıyasla genel ağız sağlığındaki bozulma üzerinde daha güçlü bir etkiye sahip olduğu görülmektedir. Sigara kullanımı periodontal hastalık şiddetinde artış ile ilişkili bulunurken, radyografik peri-implant kemik kaybı ile net bir ilişki gösterilememiştir. Bu bulgular, metabolik risk faktörlerine sahip hastalarda bireyselleştirilmiş koruyucu stratejilerin önemini vurgulamaktadır.

Anahtar Kelimeler: Diabetes Mellitus, Sigara Kullanımı, Ağız Sağlığı, Periodontal Hastalıklar, Peri-İmplantitis, DMF İndeksi.

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INTRODUCTION

Oral health is increasingly recognized not only as a component of individual well-being but also as a valuable indicator of systemic health. Emerging evidence has revealed significant associations between poor oral health and various systemic conditions, including cardiovascular disease, diabetes, and chronic inflammatory disorders (1). Among these conditions, diabetes mellitus is particularly relevant due to its bi-directional relationship with oral health. Chronic hyperglycemia alters immune responses, impairs wound healing, and increases susceptibility to periodontal disease. Despite these well-established effects, many individuals with diabetes remain unaware of the oral manifestations of their condition, while the reciprocal influence of periodontal inflammation on glycemic control is often overlooked (1, 2). Tobacco smoking, another major modifiable risk factor, also exerts profound effects on oral health. It is strongly associated with periodontitis, halitosis, reduced healing capacity, and deeper periodontal pockets, largely due to its impact on the immune function and oral microbial ecology (3, 4). Although both diabetes and smoking are independently linked to adverse oral health outcomes, the interaction between these two factors—particularly regarding implant-related conditions—remains insufficiently understood (5). Inflammatory periodontal diseases represent one of the most prevalent chronic inflammatory conditions worldwide, affecting up to 90% of the global population (6). Periodontitis is mediated by a complex interplay between microbial dysbiosis and host immune responses, ultimately leading to the destruction of tooth-supporting tissues. The pathophysiology involves the activation of host-derived proteinases, degradation of marginal periodontal ligament fibers, apical migration of the junctional epithelium, and expansion of bacterial biofilm along the root surface. While biofilm accumulation initiates gingival inflammation, the transition to periodontitis depends on ecological shifts in the microbiome that promote the growth of pathogenic bacterial species. These shifts are fueled by inflammation-derived nutrients and tissue breakdown products. Simultaneously, anti-bacterial defense mechanisms attempt to contain microbial threats within the gingival sulcus. This dynamic interaction between microbial factors and host responses underscores the multifactorial nature of periodontitis initiation and progression (7). Peri-implantitis is a plaque-associated inflammatory condition characterized by progressive bone loss around dental implants. Similar to periodontitis affecting natural teeth, peri-implantitis develops as a result of a dysregulated host response to bacterial biofilm and is influenced by both local and systemic risk factors. Given the increasing use of dental implants in clinical practice, the evaluation of

peri-implant tissue health has become an integral component of comprehensive oral health assessment, particularly in patients with systemic conditions that may alter inflammatory responses (8, 9). Radiographic imaging plays a central role in the diagnosis and management of oral diseases. Among available modalities, panoramic radiography has become a routine and indispensable tool in dental practice due to its broad field of view, cost-effectiveness, and relatively low radiation exposure (10). This rotational technique provides a single tomographic image capturing the dentition, alveolar bone, and maxillofacial structures in a curved plane (11). In periodontology, panoramic radiographs offer valuable diagnostic insights, particularly in assessing alveolar bone loss, staging and grading of periodontitis, and identifying anatomical risk factors that may influence disease progression (12). Similarly, in cariology, panoramic imaging supports the assessment of overall caries experience at the population level and facilitates the calculation of indices such as DMFT, particularly in retrospective studies where standardized clinical examinations are not available. The DMFT index quantifies lifetime caries experience by recording the number of decayed (D), missing (M), and filled (F) teeth, and allows standardized comparisons of dental health status across different populations (13). Understanding the combined effects of diabetes and smoking is essential for improving targeted dental care in high-risk populations. Therefore, the present study aimed to assess oral health indicators—including DMFT scores, periodontal status, presence of dental implants, and peri-implantitis prevalence—in a large cohort of patients with varying glycemic control and smoking habits. By evaluating these parameters, we sought to clarify the relative and combined contributions of these risk factors to oral health deterioration.

MATERIAL AND METHODS

Study Design and Population

This retrospective cross-sectional study was conducted at Istanbul Okan University, Faculty of Dentistry, Department of DentoMaxillofacial Radiology, using archived panoramic radiographs and patient records. A total of 945 individuals, aged between 18 and 93 years, who received dental care between 2021 and 2023, were included in the study. Given the retrospective design of the study, no a priori power analysis was performed. Ethical approval was obtained from the Institutional Ethical Committee (decision number: 172/3).

Data Collection

Demographic variables (age and sex), dental parameters (DMFT index), periodontal status, and implant-related findings were recorded. Systemic health data, including diabetes mellitus categorized as controlled or uncontrolled according to HbA1c levels documented in the medical history) and smoking status (including daily cigarette consumption), were also retrieved from patient records.

Panoramic radiographs were evaluated by an experienced dentomaxillofacial radiologist. Periodontal health was classified according to staging criteria derived from clinical and radiographic findings, as documented in the electronic health records. The presence of dental implants and signs of peri-implantitis —such as radiographic bone loss and clinical signs noted in the records — were documented. Patients with incomplete records or low-quality images were excluded.

Panoramic radiographs were acquired and processed using Romexis imaging software (v4.6.1.R, Planmeca, Helsinki, Finland). All images were archived within the hospital's Picture Archiving and Communication System (PACS), enabling efficient retrieval for analysis. Patient management and administrative operations were supported by the Nucleus hospital patient automation system (v9.40.19, Monad Software and Consultancy, Turkey), which streamlined the clinical workflow. The integration of these digital systems facilitated comprehensive dental examinations and contributed valuable data for the present study.

The panoramic radiographs from the patients who met the inclusion criteria were examined. Initial evaluations were conducted by a fifth-year dental student serving as an intern dentist. In cases where interpretation was challenging, a senior dentomaxillofacial radiologist with over ten years of experience provided additional analysis. Inclusion criteria required patients to be 18 years of age or older and to have a well-documented systemic medical history available in the institutional clinical records. Eligible individuals were either systemically healthy or diagnosed with diabetes mellitus. All included patients were required to have panoramic radiographs archived in the clinical automation system. Radiographs had to be of sufficient diagnostic quality, free of artifacts, and allow clear visualization of key dental and alveolar structures necessary for assessment.

Exclusion criteria included patients with major systemic comorbidities other than diabetes, particularly conditions known to affect bone metabolism or periodontal status. Additional exclusion criteria comprised patients undergoing oncotherapy, those with specific bone-related diseases, or radiographs showing significant pathologies, poor image quality, or technical errors that impeded assessment. Individuals under 18 years of age and users of electronic cigarettes were also excluded. Radiographs compromised by factors such as malocclusion-related

distortion or insufficient clarity due to physical disabilities were likewise excluded. Ultimately, 945 patients who fulfilled these rigorous criteria were included in the study, ensuring a reliable foundation for comprehensive dental evaluation and generating robust insights into dental health parameters.

Clinical and Radiographic Parameters

Patients were categorized into four groups based on their medical history: diabetic smokers, diabetic non-smokers, non-diabetic non-smokers, and non-diabetic smokers. Diabetic patients were further stratified into two subgroups: controlled and uncontrolled—based on their HbA1c levels. An HbA1c cutoff value above 6.1% is recommended as optimal in most studies (14). In this study, patients with HbA1c levels exceeding 6.5% were classified as uncontrolled diabetics.

Smokers were categorized into four subgroups based on daily cigarette consumption: 1–5, 6–10, 11–20, and more than 20 cigarettes per day. All relevant information were retrieved from patient records and clinical documentation stored in the hospital automation system.

Panoramic radiographs were used to calculate the DMFT index. The number of remaining teeth, root-filled teeth, and the DMFT score were assessed based on radiographic evaluation. The index comprises three components: D (Decayed teeth with untreated caries), M (missing teeth due to caries), and F (filled teeth restored due to caries). Each patient's dental health was evaluated by summing these components, enabling a comprehensive analysis of dental status across groups (Figure 1).



Figure 1. Panoramic radiograph of a diabetic heavy smoker with multiple dental implants.

This image shows a panoramic view of a 61-year-old male patient diagnosed with type 2 diabetes mellitus (HbA1c: 6.8%) and a history of smoking more than 20 cigarettes per day. The patient presented with a DMFT score of 28, indicating extensive dental damage and restorative history. Multiple maxillary implants are visible, and evidence of advanced alveolar bone loss is observed around several

mandibular teeth. This case exemplifies the cumulative impact of poorly controlled diabetes and heavy smoking on periodontal and peri-implant bone structures.

Periodontal status was evaluated primarily based on radiographic bone loss observed on panoramic radiographs. Since standardized clinical periodontal measurements (e.g., probing depth, bleeding on probing) were not consistently available in this retrospective dataset, the periodontal condition was categorized radiographically as early-stage periodontitis (corresponding approximately to mild–moderate bone loss) and advanced-stage periodontitis (corresponding to more severe bone loss patterns) rather than applying the full 2017 clinical staging system (7). The number of implants was determined through radiographic examination. Radiographic bone loss exceeding 1.5 mm around implants was considered radiographically suggestive of peri-implantitis, in line with previous radiographic studies (15). The measurements were conducted using Romexis imaging software. The patients were categorized into three groups: those with no implants, those with implants without radiographic signs of peri-implantitis, and those with implants showing radiographic findings suggestive of peri-implantitis.

Statistical Analysis

Data analysis was performed using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics (mean, standard deviation, frequency, percentage) were used to summarize the data. Comparisons among groups were evaluated using the Chi-square test for categorical variables and the Kruskal-Wallis test for comparing non-normally distributed continuous variables among independent groups. Correlations between smoking intensity and oral health parameters were analyzed using Spearman's rank correlation coefficient. A p-value < 0.05 was considered statistically significant.

RESULTS

A total of 945 participants were included in the study, of whom 53.9% being female (n = 509) and 46.1% male (n = 436). The majority of individuals did not have diabetes (67.4%, n = 637), while 31.5% had well-controlled diabetes and 1.1% had poorly controlled diabetes. In terms of smoking status, 43.9% of participants were smokers. Among these, the most common daily consumption range was 11–20 cigarettes (23.1%, n = 218). Regarding implant status, 70.4% (n = 665), of participants did not have implants, and 6.7% (n = 63) had implants with PI (Table 1).

In terms of periodontal status, 47.4% (n = 448) of participants were diagnosed with advanced-stage periodontitis, indicating a high prevalence of advanced periodontal disease. Normality testing indicated that the age variable showed no major deviations (Z skewness = 1.135, Z kurtosis = -3.382). However, DMFT scores, implant numbers, and peri-implantitis counts displayed non-normal distributions (Z skewness ranging from 4.633 to 84.026; Z kurtosis -3.778 to 375.213), supporting the use of non-parametric tests. A statistically significant difference in DMFT scores was observed among the groups (Kruskal-Wallis test, p = 0.001). The diabetic non-smoker group had the highest DMFT (16.76 ± 7.13), while the non-diabetic smoker group exhibited the lowest (10.82 ± 6.82) (Table 2). These findings suggest that diabetes may be associated with greater caries experience, whereas smoking alone may not elevate DMFT to the same extent. Smoking status showed a significant gender-based difference (Chi-square test, p = 0.001). The most common group among females was non-smoking non-diabetics (19.8%), while non-diabetic smokers constituted the largest group among males (21.4%), indicating a gender-specific smoking distribution (Table 3). Daily smoking levels were reported as follows: 1-5 cigarettes (5.3%, n = 50) 6-10 (10.4%, n = 98), 11-20 (23.1%, n = 218), and >20 (5.3%, n = 50). Periodontitis prevalence varied significantly among groups (Chi-square test, p = 0.001). Early-stage disease (stage I–II) was more frequent in smokers without diabetes (11.1%), whereas advanced-stage periodontitis (stage III–IV) was most common among non-smoking diabetics (16.2%). There was no significant difference between genders regarding periodontitis prevalence (p = 0.489). No gender-related differences were observed in implant presence or peri-implantitis prevalence. Implant presence differed among the study groups, with a lower proportion of implants observed in patients with diabetes (Table 4). Most participants with implants but without a radiographic peri-implantitis sign belonged to the non-diabetic non-smoker group. Similarly, among patients presenting with both implants and peri-implantitis, the largest proportion was also observed in this group (Table 4). Smoking status was not associated with implant presence or peri-implantitis prevalence. In contrast, periodontitis severity varied according to smoking status, with higher proportions of advanced periodontitis observed among smokers. Across all periodontitis stages, the highest percentage of smokers were those consuming 11–20 cigarettes per day (Table 5).

Table 1. Distribution of demographic and clinical variables across the study population.

Variable	n	%	
Gender	Female	509	53.9
	Male	436	46.1
Diabetes Mellitus	No	637	67.4
	Well controlled DM	298	31.5
	Poorly controlled DM	10	1.1
Smoking status	No	530	56.1
	Yes	415	43.9
Smoking amount (per day)	1-5	49	11.80
	6-10	98	23.61
	11-20	218	52.53
	>20	50	12.05
Implant	no implant	665	70.4
	implant without PI	217	23.0
	implant with PI	63	6.7
Periodontitis	No	214	22.6
	Early-stage periodontitis	283	29.9
	Advanced-stage periodontitis	448	47.4

Table 2. Comparison of DMFT scores across diabetic and smoking subgroups.

	n (%)	DMFT Mean ± Std
Diabetes, non-smoker ^a	234 (24.76%)	16.76±7.13
Diabetes, smoker ^{ab}	74 (7.83%)	15.43±7.56
Non-diabetes, non-smoker ^b	296 (31.32%)	12.94±6.81
Non-diabetes, smoker ^c	341 (36.08%)	10.82±6.82

*Kruskal–Wallis test followed by post-hoc multiple comparison analysis.

Groups sharing the same superscript letter (a, b, c) are not significantly different from each other (p < 0.05).

Table 3. Distribution of gender and cigarette consumption according to diabetes and smoking status.

n (%)	Gender		Cigarette consumption amount per day				Total
	Female	Male	1-5	6-10	11-20	>20	
Non-diabetes, smoker	139 (14.7%)	202 (21.4%)	44 (4.7%)	87 (9.2%)	173 (18.3%)	37 (3.9%)	341 (36.1%)
Diabetes, smoker	25 (2.6%)	49 (5.2%)	6 (0.6%)	11 (1.2%)	44 (4.7%)	13 (1.4%)	74 (7.8%)
Non-diabetes, non-smoker	187 (19.8%)	109 (11.5%)	n/a				296 (31.3%)
Diabetes, non-smoker	158 (16.7%)	76 (8.0%)	n/a				234 (24.8%)
Total	509 (53.9%)	436 (46.1%)	50 (5.3%)	98 (10.4%)	218 (23.1%)	50 (5.3%)	945 (100.0%)

*n/a indicates non-applicable categories for non-smoker groups.

Table 4. Distribution of gender and cigarette consumption according to diabetes and smoking status.

n (%)	Periodontitis			Peri-implantitis (PI)		
	No	Early-stage periodontitis	Advanced-stage periodontitis	Implant without PI	Implant with PI	Patients with implants
Diabetes, non-smoker^a	20 (2.1%)	61 (6.5%)	153 (16.2%)	32 (3.4%)	8 (0.8%)	40 (4.2%)
Non-diabetes, smoker^a	113 (12.0%)	105 (11.1%)	123 (13.0%)	75 (7.9%)	25 (2.6%)	100 (10.6%)
Non-diabetes, non-smoker^b	76 (8.0%)	99 (10.5%)	121 (12.8%)	108 (11.4%)	28 (3.0%)	136 (14.4%)
Diabetes, smoker^b	5 (0.5%)	18 (1.9%)	51 (5.4%)	2 (0.2%)	2 (0.2%)	4 (0.4%)
Total	214 (22.6%)	283 (29.9%)	448 (47.4%)	217 (23.0%)	63 (6.7%)	280 (29.6%)

¹Group comparisons for periodontitis stage and implant presence were performed using the Chi-square test. Different superscript letters indicate statistically significant differences between groups (Chi-square test, $p < 0.05$).

²Peri-implantitis distribution was analyzed using the Chi-square test; no statistically significant association was observed between peri-implantitis and diabetes or smoking status ($p > 0.05$).

Table 5. Relationship between smoking intensity and implant status, peri-implantitis, and periodontitis.

		Cigarette consumption amount per day, n (%)				Total
		1-5 ^a	6-10 ^{ab}	11-20 ^b	>20 ^c	
Implant	No	36 (8.7%)	69 (16.6%)	167 (40.2%)	39 (9.4%)	311 (74.9%)
	Yes	14 (3.4%)	29 (7.0%)	50 (12.0%)	11 (2.7%)	104 (25.1%)
Peri-implantitis	Implant without PI	10 (2.4%)	22 (5.3%)	37 (8.9%)	8 (1.9%)	77 (18.6%)
	Implant with PI	4 (1.0%)	7 (1.7%)	13 (3.1%)	3 (0.7%)	27 (6.5%)
Periodontitis	No	20 (4.8%)	35 (8.4%)	52 (12.5%)	11 (2.7%)	118 (28.4%)
	Early-stage periodontitis	15 (3.6%)	28 (6.7%)	69 (16.6%)	11 (2.7%)	123 (29.6%)
	Advanced-stage periodontitis	15 (3.6%)	35 (8.4%)	96 (23.1%)	28 (6.7%)	174 (41.9%)
Total		50 (12.0%)	98 (23.6%)	217 (52.3%)	50 (12.0%)	415 (100.0%)

*Chi-square test. Different superscript letters indicate statistically significant differences between groups (Chi-square test, $p < 0.05$).

DISCUSSION

The present study investigated the relationship between diabetes, smoking, and key oral health parameters including DMFT, periodontitis severity, implants presence, and peri-implantitis, in a large patient population. Oral health not only reflects individual well-being but also serves as a sentinel indicator of systemic conditions. Oral health is increasingly recognized as an integral component of systemic health, with diabetes and smoking representing two major risk factors that exert independent and overlapping effects through inflammatory and immunological pathways. While both

conditions have been individually associated with adverse periodontal and dental outcomes, their combined influence on specific oral health indicators remains insufficiently characterized. By evaluating these parameters concurrently, the present study aimed to clarify how diabetes and smoking, alone and in combination, shape oral disease patterns in routine clinical settings. In the present cohort, periodontitis severity differed across diabetes and smoking subgroups, with distinct patterns observed for local and systemic risk factors. Smokers without diabetes more frequently presented with mild to moderate periodontitis, whereas individuals with diabetes—particularly non-smokers—showed a higher prevalence of advanced periodontal stages. This

finding supports the concept that smoking primarily contributes to periodontal tissue breakdown through local toxic and vascular effects, while diabetes promotes progression to more severe disease through systemic mechanisms such as impaired immune response, microvascular dysfunction, and delayed wound healing. Recent evidence further suggests that glycemic dysregulation may attenuate periodontal recovery even after smoking cessation, underscoring the dominant role of diabetes in modulating periodontal outcomes in affected individuals (16). In line with this, contemporary observational and review studies continue to emphasize the multifactorial interplay between smoking, periodontal disease, and systemic conditions, highlighting diabetes as a key modifier of host susceptibility and disease progression (17). Together, these findings reinforce the need to consider both behavioral and metabolic factors when interpreting periodontal disease patterns and planning preventive strategies. Consistent with existing literature, smoking emerged as a significant determinant of periodontal health, demonstrating a substantial influence on disease severity (18, 19). However, no significant association was found between smoking or diabetes status and peri-implantitis prevalence, suggesting that the mechanisms underlying peri-implant tissue breakdown may differ from those of periodontal disease and involve additional risk factors (20). The lack of significance in peri-implantitis outcomes may also reflect the relatively small sample size of the affected group (6.7%), limiting the statistical power of these analyses. Although a synergistic effect of smoking and diabetes might be anticipated, especially in relation to implant complications, our data did not support a compounded risk for peri-implantitis in patients with both conditions. This aligns with the conclusions of recent reviews, such as that by Sun (21), which emphasize that prevention and management strategies should prioritize patient-level factors—including systemic conditions and behavioral habits—over mechanical or implant-related characteristics. Sun further stresses the importance of risk profiling and tailored maintenance protocols in at-risk patients, echoing our findings that diabetic status may be a more prominent determinant than smoking for certain outcomes. Moreover, a recent comparative study by Hussain et al. (22) indicates that peri-implantitis development is more heavily influenced by patient-related factors (such as oral hygiene and systemic disease) than by implant surface topography. This supports our observation that implant presence and peri-implantitis prevalence did not significantly differ according to smoking status, but rather showed variation in systemic health groups—especially among non-diabetic, non-smoking individuals with implants. Interestingly, our study observed that the majority of participants with implants—both with and without peri-implantitis—were from the non-smoking, non-diabetic group. This could

imply a potential protective effect of avoiding systemic risk factors on implant longevity. Conversely, smokers and diabetic individuals were less likely to have implants, possibly due to contraindications for surgical placement or previous implant failure. These findings reinforce the importance of comprehensive preoperative evaluation and risk management strategies in medically compromised patients. The DMFT scores further support the dominant impact of diabetes on oral health. Diabetic, non-smokers exhibited the highest mean DMFT scores, whereas non-diabetic smokers showed the lowest values, suggesting that metabolic dysregulation may exert a stronger influence on caries experience than smoking alone. While smoking is a well-established risk factor for tooth loss, diabetes has been consistently associated with increased DMFT scores and a higher risk of periodontal and apical pathology through its effects on salivary function, immune response, and tissue repair (23, 24). Our findings are consistent with current preventive models that identify peri-implant mucositis as a key intervention stage to prevent progression to peri-implantitis. Previous evidence indicates that systemic and local factors—including diabetes, periodontitis, obesity, smoking, and alcohol use—contribute to peri-implant tissue inflammation, although their relative impact varies across populations (25, 26). In the present study, the lack of a significant association between smoking and peri-implantitis may reflect the multifactorial nature of disease progression as well as the limited number of peri-implantitis cases. Analysis of smoking behavior across the cohort revealed that the most common level of consumption was 11–20 cigarettes per day, irrespective of oral health condition. This finding implies a potential “threshold effect” where moderate-to-heavy smoking contributes consistently to oral health risk but may not correlate linearly with disease stage or implant outcomes. In line with this, no significant differences in smoking prevalence were observed between individuals with and without periodontitis or peri-implantitis, although the predominance of the 11–20 cigarette category across all groups indicates that dose–response relationships merit further investigation in larger cohorts. Previous literature has emphasized the partially overlapping yet distinct risk profiles of periodontitis and peri-implantitis. Darby highlighted that smoking is a well-established risk factor for periodontitis, whereas its association with peri-implant disease appears more variable and is frequently modulated by host- and site-related factors (3). Consistent with this framework, smoking in the present study was significantly associated with periodontitis severity but not with peri-implantitis prevalence, underscoring the multifactorial nature of

peri-implant inflammatory processes. Evidence from recent umbrella reviews further supports this complexity, identifying smoking and a history of periodontitis as suggestive—but not definitive—risk factors for peri-implantitis, alongside additional variables such as diabetes mellitus, hyperglycemia, implant location, lack of maintenance therapy, and insufficient keratinized mucosa (27). Although a synergistic effect of smoking and diabetes might be anticipated, especially in relation to implant-related complications, our findings did not demonstrate an increased peri-implantitis risk in patients presenting with both conditions. This observation aligns with the conclusions of the 2017 World Workshop on the Classification of Peri-Implant Diseases, which reported insufficient evidence to confirm smoking as an independent risk factor for peri-implantitis (20). Collectively, these findings highlight the need for future studies with larger sample sizes and more detailed risk stratification to better elucidate the interplay between systemic conditions, behavioral factors, and peri-implant disease development. Moreover, behavioral studies such as those by Eliasson (28) and Solberg et al. (29) have emphasized the broader health implications of smoking among diabetic patients, including impaired glycemic control, increased depressive symptoms, and poor adherence to medical advice. These psychosocial and behavioral variables may further complicate oral health management in diabetic smokers and underline the critical importance of interdisciplinary intervention strategies. Smoking cessation support tailored to diabetic patients should be a clinical priority and integrated into both dental and medical care frameworks. Limitations of this study include its retrospective and cross-sectional design, which limits causal inference. Furthermore, the relatively low representation of poorly controlled diabetic patients and individuals with peri-implantitis may have constrained our ability to detect more nuanced associations. Another important limitation relates to the imaging methodology. Periodontal status and DMFT scores were partly assessed using panoramic radiography, which is inherently limited in detecting early periodontal changes and may underestimate initial bone loss when compared with periapical radiography or CBCT imaging. Consequently, early-stage periodontal pathology may not have been fully captured. Moreover, key clinical periodontal parameters such as probing depth and bleeding on probing could not be measured directly due to the retrospective nature of the study; however, available clinical notes recorded by dentists were reviewed for most patients to support radiographic interpretation. Finally, relevant confounding factors—including socioeconomic status, diet, oral hygiene practices, and access to dental care—could not be systematically evaluated and may have influenced the observed associations.

Despite these limitations, the study holds several strengths. The inclusion of nearly 1,000 patients with well-documented systemic histories and radiographic records enhances the robustness of the findings. Stratification by smoking intensity and diabetic control level allowed for detailed subgroup comparisons, and the use of standardized indices (DMFT, periodontal staging, and radiographic criteria for peri-implantitis) lends reliability to our clinical assessments.

CONCLUSION

In conclusion, our study underscores the complex interplay between diabetes, smoking, and oral health. While both factors independently impact periodontal status, diabetes appears to exert a more pronounced influence on caries experience and disease severity. Smoking, although significantly associated with periodontitis, did not emerge as a clear risk factor for peri-implantitis in our cohort. These insights emphasize the importance of personalized prevention strategies, such as integrating meticulous periodontal care into the management protocols for diabetic patients. In addition, targeted smoking cessation programs should be incorporated to further reduce oral health complications in this high-risk population. Further longitudinal research integrating standardized clinical periodontal measurements and multidisciplinary evaluation is warranted to unravel the multifactorial nature of oral health risks in vulnerable groups.

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