

The relationship between xerostomia and periodontal status in patients with cardiovascular diseases and type 2 diabetes

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Abstract

Aim: The aim of this cross-sectional study was to examine the correlation between patients' subjective perception of xerostomia and their periodontal status and to examine the potential association of this correlation with cardiometabolic disorders.

Methodology: A total of 147 patients (40 systemically healthy, 33 with cardiovascular disease [CVD], 40 with type 2 diabetes, and 34 with cardiometabolic disease [CVD + diabetes]) who came to Necmettin Erbakan University, Faculty of Dentistry, Department of Periodontology for periodontal treatment and agreed to participate were included in the study. Sociodemographic information, tooth brushing frequency, systemic disease status, and clinical periodontal parameters (plaque index [PI], gingival index [GI], bleeding on probing [BOP], and mean pocket depths) were recorded. Patients were asked to complete an 11-item subjective xerostomia inventory questionnaire.

Results: In the findings of our study, there was no statistically significant correlation between xerostomia total score and mean pocket depths, PI, GI, and BOP ($p>0.05$). There was no statistically significant difference between the mean values of xerostomia total score according to systemic disease groups ($p=0.654$). There is a statistically significant difference between the mean values of xerostomia total score according to periodontal status groups ($p=0.002$). The mean xerostomia total score was 20.19 in periodontally healthy patients, 24.42 in gingivitis patients, and 22.73 in periodontitis patients.

Conclusion: Although the results suggest that subjective dry mouth findings are associated with gingivitis, they do not affect pocket depth and do not increase susceptibility to periodontitis. Clinicians should emphasize the risk of gingivitis in patients with dry mouth and the importance of prevention.

Keywords: Cardiometabolic diseases, gingivitis, periodontal status, xerostomia, type 2 diabetes

Introduction

Saliva is an essential bodily fluid that plays a crucial role in protecting the teeth and oral tissues. It accomplishes this through its cleansing, lubricating, and antimicrobial properties (1, 2). Patients often fail to recognize the significance of a medical condition until it is absent. In the absence of the fluid known as saliva, basic activities like eating and speaking become challenging. Xerostomia is characterized as a subjective sensation of having a dry mouth and is frequently linked to a reduced rate of saliva production (hyposalivation) (3). Nevertheless, some people experience a sensation of dryness in their mouth despite having a normal rate of saliva production. Hence, the presence of xerostomia does not always indicate a decrease in the functioning of the salivary glands (4). Xerostomia has been linked to many variables, including the use of over 400 medications, psychological conditions such as stress and anxiety, salivary gland disorders such as Sjögren's syndrome, and radiotherapy targeting the head and neck region (2). Xerostomia is a prevalent issue in society. Epidemiological research indicates that the prevalence ranges from 0.9% to 64.8% (5). Xerostomia is more prevalent in those aged 60 and above, primarily because of cardiometabolic disorders, which encompass systemic chronic conditions such as hypertension and type 2 diabetes mellitus (T2DM), as well as the medications employed in treating these diseases.

Periodontitis is a severe chronic infection and immune reactive disease that damages the tissues and bone supporting teeth, potentially leading to tooth loss if untreated. Periodontitis is induced by subgingival biofilm. Even routine daily activities, such as maintaining oral hygiene habits, can cause oral microbiota to enter the bloodstream and cause bacteremia. In the presence of periodontitis, these bacteremia attacks are more frequent, last longer, and consist of more virulent bacterial species (6). The direct effect of periodontal pathogens on atheroma formation suggests that bacteremia is a possible mechanism linking periodontitis and CVD. Oral bacteria also mediate the tissue damage that characterizes the clinical features of periodontitis by triggering a local inflammatory response. The release of pro-inflammatory cytokines into the bloodstream causes systemic inflammation. In this way, systemic inflammation increases CVD risk and contributes to poor beta cell function and insulin resistance, thereby increasing the risk of T2DM.

Cardiometabolic disease encompasses a range of conditions and begins with insulin resistance, which is evident from an early age, and then advances to the clinically recognized high-risk states of metabolic syndrome and prediabetes. Eventually, cardiometabolic disease leads to the development of T2DM and CVD (7). Researchers report a higher occurrence of xerostomia in individuals with diabetes, which can be caused either directly by hyperglycemia or indirectly by drugs used to manage T2DM and associated cardiovascular problems, including hypertension (8). Xerostomia has many effects on oral health and can have a negative impact on quality

of life. This negative impact has received less attention than the impacts of periodontal disease.

Multiple surveys are employed to evaluate symptoms of dry mouth, including various scales measuring quality of life and specific tools such as the Xerostomia Questionnaire and the Xerostomia Inventory (XI) (2). The XI is a dependable tool that accurately measures many symptoms and effects of xerostomia. It utilizes suitable language and is based on the firsthand experiences of those suffering from xerostomia. Additionally, it is straightforward to administer (2, 9).

Therefore, we aimed to assess the impact of xerostomia on cardiometabolic diseases and different periodontal conditions using the XI questionnaire.

Materials and Methods

This cross-sectional study included 147 patients who came to Necmettin Erbakan University, Faculty of Dentistry, Department of Periodontology for periodontal treatment.

The protocol for this study was approved by the Necmettin Erbakan University Faculty of Dentistry's Non-Interventional Scientific Research Ethics Committee (2023/349) for studies involving human subjects. The study was conducted according to the criteria specified by the Helsinki Declaration. All the selected patients gave their informed consent to participate in this study.

The inclusion criteria for the study included being over 18 years of age and not having any disease other than diabetes or CVD that may affect periodontal status.

The exclusion criteria were as follows:

- Pregnancy or breastfeeding,
- Having undergone chemotherapy or radiotherapy, and
- Individuals who smoke more than 10 cigarettes a day.

Participants were categorized into four groups based on their general systemic health state and three groups based on their periodontal status.

The systemic status groups were as follows:

- Systemically healthy
- Cardiovascular disease (CVD)
- Type 2 diabetes mellitus (T2DM)
- Cardiometabolic disease (CVD + T2DM)

The periodontal status groups were as follows:

- Periodontally healthy (42)
- Gingivitis (57)
- Periodontitis (48)

Clinical periodontal parameters, such as bleeding on probing (BOP), gingival index (GI), probing pocket depth (PPD), and plaque index (PI), were measured and recorded (10). The measurements were conducted by the same clinician (Ö.Ö.), who was unaware of the research groups. To assess the reliability of the clinician's assessments, a group of ten individuals who were not otherwise involved in the study, received periodontal measurements. The measurements were subsequently replicated after a span of two days. The physician exhibited a measurement consistency above 90% between the two measurements. The examiner evaluated the consistency of PPD measurements at six tooth locations for each subject over two distinct sessions. The intra-class correlation coefficient for PPD measures was 0.91 ± 0.02 between the baseline and two-day follow-up measurements.

Study participants were requested to complete the XI questionnaire (Table 1). Participants were asked to choose one of five responses to the following statements regarding the previous four weeks: very often (scoring 5), fairly often (scoring 4), occasionally (scoring 3), hardly ever (scoring 2), and never (scoring 1) (9).

Table 1. The Xerostomia Inventory

Questionnaire
1. I sip liquids to aid in swallowing food
2. My mouth feels dry when eating a meal
3. I get up at night to drink
4. My mouth feels dry
5. I have difficulty in eating dry foods
6. I suck sweets or cough lozenges to relieve dry mouth
7. I have difficulty in swallowing certain foods
8. The skin of my face feels dry
9. My eyes feel dry
10. My lips feel dry
11. The inside of my nose feels dry

Response options: never (scoring 1), hardly ever (scoring 2), occasionally (scoring 3), fairly often (scoring 4) and very often (scoring 5).

Statistical analysis

Analyses were performed by using SPSS software (IBM SPSS Statistics version 23.0, IBM Inc., Armonk, NY, USA).

Compliance with the normal distribution was assessed using the skewness and kurtosis coefficients (± 3). The one-way analysis of variance test was employed to compare data that follows a normal distribution across groups consisting of three or more. The Kruskal-Wallis H test was employed to compare non-normally distributed data across groups consisting of three or more observations. Spearman's rho correlation coefficient was employed to assess the association between continuous

variables that deviated from a normal distribution. The Pearson correlation coefficient was employed to assess the association between continuous variables that conform to a normal distribution. The Fisher Freeman Halton test and Pearson chi-square test were employed to evaluate categorical data, while multiple comparisons were assessed using the Bonferroni corrected Z test. The two-way analysis of variance was employed to analyze data that followed a normal distribution based on systemic state and periodontal status. Additionally, the Bonferroni correction was utilized to conduct multiple comparisons. The analysis results are reported in the form of frequency (%) for categorical variables, mean $\pm$ standard deviation, and median (minimum-maximum) for quantitative variables. The significance threshold was set at $p < 0.050$.

Results

The study comprised 147 people: 40 who were systemically healthy, 40 with T2DM, 34 with cardiometabolic disease, and 33 with CVD. In terms of categorization based on their periodontal condition, 42 patients were found to be periodontally healthy, 57 had gingivitis, and 48 were diagnosed with periodontitis.

Table 2 presents a comparison of age, gender, educational status, and tooth brushing practices according to systemic status. Individuals were divided into four groups according to their ages: 18-35, 36-50, 51-60, and 61 and over. A statistically significant connection was found between systemic status and age groups ($p < 0.001$). Among persons aged 61 and above, there is no discernible difference between those who have diabetes, cardiovascular, and cardiometabolic diseases. However, there is a statistically significant decrease in the number of systemically healthy individuals. There is a statistically significant relationship between systemic status and tooth brushing frequency ($p = 0.001$). It has been observed that individuals who do not brush their teeth have less systemic health than all other diseases. There is a statistically significant connection between systemic status and educational status ($p < 0.001$). The number of systemically healthy university graduates is statistically significantly higher than university graduates with other systemic diseases. There is no statistically significant relationship between systemic status and gender ($p = 0.076$).

Table 3 shows the comparison data between clinical periodontal parameters and systemic disease groups. There is no statistically significant difference between the mean PPD median values according to systemic status ($p = 0.596$). There is no statistically significant difference between the distributions of clinical periodontal parameters according to systemic status ($p > 0.050$).

Table 4 presents an analysis of the correlation between the total score for xerostomia and periodontal clinical parameters. There is no statistically significant

relationship between xerostomia total score and periodontal clinical parameters ($p>0.050$).

Table 5 shows a comparison of the total score of xerostomia according to systemic status and periodontal status. The mean values of the xerostomia total score according to systemic status groups do not differ statistically significantly ($p=0.654$). The interaction between the systemic group and periodontal status does not show a statistically significant difference in the mean values of the xerostomia total score ($p=0.146$).

Table 6 Descriptive statistics of micro-shear values by systemic status and periodontal status

Table 6 presents descriptive statistics of micro-shear values according to systemic status and periodontal status. The mean values of the xerostomia total score differ statistically significantly ($p=0.002$) depending on the periodontal status groups. The average xerostomia total scores for periodontal health, gingivitis, and periodontitis groups were 20.19, 24.42, and 22.73, respectively. It was observed that the subjective xerostomia total score in the gingivitis group was statistically significantly higher than in the other periodontal status groups ($p<0.5$).

Table 2. Comparison of demographic categorical parameters by systemic status

	T2DM	CVD	Systemic Status CMD	Systemically Healthy	Test Statistical	<i>p</i> *
Age (years)						
18-35	5 (12.5) ^{ab}	8 (24.2) ^b	0 (0) ^a	27 (67.5) ^c	65.549	<0.001
36-50	13 (32.5)	4 (12.1)	8 (23.5)	10 (25)		
51-60	14 (35) ^a	11 (33.3) ^a	10 (29.4) ^{ab}	3 (7.5) ^b		
61 and over	8 (20) ^a	10 (30.3) ^a	16 (47.1) ^a	0 (0) ^b		
Gender						
Male	18 (45)	16 (48.5)	7 (20.6)	17 (42.5)	6.863	0.076
Female	22 (55)	17 (51.5)	27 (79.4)	23 (57.5)		
Education Status						
Primary school	15 (37.5) ^a	15 (45.5) ^{ab}	25 (73.5) ^b	7 (17.5) ^a	32.687	<0.001
High school	19 (47.5)	8 (24.2)	7 (20.6)	15 (37.5)		
University	6 (15) ^a	10 (30.3) ^{ab}	2 (5.9) ^a	18 (45) ^b		
Teeth Brushing Frequency						
Non-brushing	8 (20) ^{ab}	7 (21.2) ^{ab}	13 (38.2) ^b	2 (5) ^a	21.792	0.001
1 time per day	25 (62.5)	15 (45.5)	14 (41.2)	17 (42.5)		
2 or more per day	7 (17.5) ^a	11 (33.3) ^{ab}	7 (20.6) ^a	21 (52.5) ^b		

*Pearson chi-square test; a-c: There is no difference between groups with the same letter. T2DM: Type 2 Diabetes Mellitus. CVD: Cardiovascular Disease. CMD: Cardiometabolic Disease.

Table 3. Comparison of periodontal clinical parameters according to systemic status

	Systemic Status				Test Statistical	p
	T2DM	CVD	CMD	Systemically Healthy		
PPD (mm)	2.78 ± 0.76	2.91 ± 1.01	2.59 ± 0.63	2.76 ± 0.66	1.89	0.596**
	2.59 (1.46 - 4.71)	2.59 (1.57 - 6.5)	2.55 (1.63 - 4.35)	2.64 (1.89 - 4.63)		
PI	1.9 ± 0.6	1.86 ± 0.66	1.91 ± 0.55	1.67 ± 0.55	1.444	0.233*
	2 (1 - 3)	2 (1 - 3)	2 (1 - 3)	1.63 (0.67 - 3)		
GI	1.76 ± 0.47	1.63 ± 0.56	1.61 ± 0.52	1.7 ± 0.45	0.709	0.548*
	1.71 (1 - 3)	1.57 (0 - 3)	1.65 (0 - 2.67)	1.65 (1 - 2.59)		
BOP (%)	57.37 ± 37.69	57 ± 36.78	52.24 ± 41.51	37.76 ± 34.97	2.304	0.079*
	60 (0 - 100)	57.14 (0 - 100)	49.32 (0 - 100)	35.88 (0 - 100)		

T2DM: Type 2 Diabetes Mellitus. CVD: Cardiovascular Disease. CMD: Cardiometabolic Disease. PPD: Probing Pocket Depth. PI: Plaque Index. GI: Gingival Index. BoP: Bleeding on Probing. *One-Way Analysis of Variance test; **Kruskal Wallis H test; Mean ± Standard Deviation; Median (Minimum-Maximum)

Table 4. Examining the relationship between xerostomia total score and periodontal clinical parameters

	Xerostomia Total Score	
	r	p
PPD (mm)	-0.045*	0.588
PI	0.026**	0.754
GI	0.071**	0.394
BOP (%)	0.135**	0.103

PPD: Probing Pocket Depth. PI: Plaque Index. GI: Gingival Index. BoP: Bleeding on Probing. *Spearman's rho correlation coefficient; **Pearson correlation coefficient

Table 5. Comparison of xerostomia total score according to systemic status and periodontal status

	F	p	partial η^2
Systemic status	0.540	0.654	0.012
Periodontal status	6.780	0.002	0.091
Systemic status * Periodontal status	1.620	0.146	0.067

F: Two-Way Analysis of Variance Test Statistics; η^2 : Eta Squared; $R^2=15.51\%$; Adjusted $R^2=8.63\%$

Table 6. Descriptive statistics of micro-shear values by systemic status and periodontal status

	Periodontal Status			Total
	Periodontally Healthy	Gingivitis	Periodontitis	
Systemic status				
T2DM	21.44 $\pm$ 3.43	24.25 $\pm$ 4.42	22.87 $\pm$ 4.31	23.1 $\pm$ 4.22
CVD	17.57 $\pm$ 6.40	25.36 $\pm$ 7.24	25 $\pm$ 8.03	23.55 $\pm$ 7.89
CMD	22.00 $\pm$ 5.66	22.60 $\pm$ 5.42	19 $\pm$ 5.21	21.56 $\pm$ 5.48
Systemically healthy	19.33 $\pm$ 5.19	25.73 $\pm$ 5.82	22.1 $\pm$ 6.49	22.43 $\pm$ 6.28
Total	20.19 $\pm$ 5.29 ^b	24.42 $\pm$ 5.65 ^a	22.73 $\pm$ 6.4 ^{ab}	22.66 $\pm$ 6.02

T2DM: Type 2 Diabetes Mellitus. CVD: Cardiovascular Disease. CMD: Cardiometabolic Disease. Mean $\pm$ standard deviation; a-b: There is no difference between groups with the same letter.

Discussion

Saliva helps in the remineralization of teeth, aids in the transportation of digestive enzymes, and assists in speech, chewing, and swallowing (2). Xerostomia is a subjective feeling of dry mouth typically caused by decreased saliva production. In our study, we aimed to evaluate the effect of xerostomia on cardiometabolic diseases and different periodontal conditions by using the Xerostomia Inventory (XI) questionnaire to measure subjective dry mouth. This study is the first to examine the relationship between periodontal status and xerostomia in individuals with cardiometabolic disease.

Results of a study conducted by Mizutani et al. investigating the gingival condition of xerostomia in young adults revealed that xerostomia is associated with dental plaque accumulation and is therefore indirectly associated with %BOP in young adults (9). In their study, the Xerostomia Inventory questionnaire was used. Results showed no relationship between the total xerostomia score in the questionnaire results and the number of teeth with periodontal pockets of 4 mm or more. It has also been stated that xerostomia has a statistically significant relationship with dental plaque accumulation, and this condition is associated with increased bleeding on probing. Hirotsu and colleagues conducted a study to examine the relationship between xerostomia and periodontitis. In this study, the relationship between stimulated salivary flow in elderly individuals and the number of teeth with deep periodontal pockets in the mouth was examined. The results showed that deep periodontal pockets were statistically significantly associated with lower salivary flow in individuals aged 76 years and older (11). In our study, no relationship was found between xerostomia

total score and clinical periodontal parameters in any age group. In our study, plaque index was not found to be related to xerostomia total score, and accordingly, the percentage of bleeding on probing did not show any statistically significant difference.

Upon analyzing the Xerostomia Inventory questions individually based on different periodontal status groups, it was found that there was a significant statistical difference only in Question 7. Periodontally healthy patients more frequently selected the "never" option when asked about their difficulty in swallowing various foods, compared to the other groups with different periodontal statuses. There was no significant difference in the responses to this question between those with gingivitis and periodontitis.

Despite regular saliva production, some people have dry mouths. Field et al. found that the risk of having xerostomia increased by 1.24 times for every 10 years of age, regardless of medication use and age (12). The authors of the study also found that the prevalence of dry mouth was nearly four times higher in individuals who were taking medication (28%) compared to those who were not taking any medication (7.5%) (12).

Cardiometabolic disease is characterized by the simultaneous presence of two or more disorders. The prevalence of cardiometabolic disease among those aged 60 years and older is 4.7% (13). It is clear in the literature that the main risk factors for cardiometabolic diseases occur in the intensely interrelated physical, biological, social, and economic domains. Studies have shown that low socioeconomic level, low education level, and high age are associated with the risk of cardiometabolic disease (14-16). The demographic data of the population in our study is also compatible with the literature. In the present study, the incidence of cardiometabolic disease is higher in people with low education levels, people

aged 61 and over, and individuals who do not brush their teeth.

Numerous research studies have been conducted to examine the connections between periodontitis and cardiovascular diseases such as ischemic stroke and coronary heart disease (17-19). The risk of CVD has been shown to be moderately increased in patients with periodontitis (19). In Stage IV, the most severe stage of periodontitis, tooth loss occurs. In a study using periodontal tooth loss as a marker, it was observed that each tooth loss increased the risk of CVD (20). Another study showed that the number of missing teeth was a positive predictor of CVD-related hospitalizations (21). However, there is ongoing uncertainty in the literature about whether the incidence or rate of progression of periodontitis is higher in individuals with CVD. Scientific research suggests a bidirectional relationship between T2DM and periodontitis. In addition to T2DM, research has demonstrated a correlation between glycemic management and periodontitis (22). Periodontitis-induced systemic inflammation in the host elevates the susceptibility to CVD and impairs beta cell function and insulin resistance, thereby increasing the risk of developing T2DM. Therefore, the relationship between cardiometabolic diseases (CMD) was examined by using clinical periodontal parameters and creating different periodontal status groups. The current study showed no statistically significant link between CMD and other systemic statuses in terms of mean PPD, PI, GI, and BOP% values.

Xerostomia is a significant oral health problem linked to cardiovascular and metabolic conditions (23). Xerostomia can have an impact on cardiometabolic health, potentially leading to a higher likelihood of tooth loss as a result of the decreased ability of saliva to neutralize acids. Tooth loss is linked to longer chewing duration, worse chewing ability, and malnourishment (24). Studies evaluated the impact of xerostomia on the quality of life and systemic health of patients (25-27). The outcomes indicated that the sensation of dry mouth is a potentially incapacitating condition that can significantly impact oral health-related quality of life (26, 27). However, in our study, no statistical differences were found to support this hypothesis as a result of the analysis in which systemic and periodontal status were evaluated together. When the total score for xerostomia was assessed separately from the systemic state and categorized based on periodontal status groups, it was found that those in the gingivitis group had the highest level of xerostomia. Furthermore, numerically, the most xerostomic systemic condition group among periodontal healthy individuals was found to be those with cardiometabolic disease.

Limitations of our study include the cross-sectional study design and the fact that some daily habits (such as tea and coffee consumption) that may affect dry mouth were not questioned. The use of subjective questionnaire data by not measuring saliva flow rate is among the limitations of the study. It is necessary to carry out studies with larger populations in order to assess and categorize the stages of cardiometabolic disease.

Conclusion

The presence of subjective xerostomia and clinical periodontal parameters does not appear to be associated with any specific age group, provided that proper oral hygiene is maintained. It is important to note that gingivitis patients may have a stronger impression of xerostomia, regardless of their systemic status.

Disclosures

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Ethical Approval: Ethics committee approval was received for this study from the Necmettin Erbakan University Faculty of Dentistry's Non-Interventional Scientific Research Ethics Committee, in accordance with the World Medical Association Declaration of Helsinki, with the approval number: 2023-349.

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