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Original Research Article

Impact of Xerostomia on Oral Microbiome and Mucosal Integrity

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ABSTRACT

Background: Xerostomia diminishes oral mucosal protection by saliva, and may also alter the oral microbial balance and integrity of oral mucosa; the relationship between xerostomia and dysbiosis and oral mucosal health is not fully understood.

Objective: To determine the correlation between xerostomia, changes in the oral microbiome, and changes in the integrity of the oral mucosa.

Methods: This is an analytical cross sectional study that was carried out in the department of oral medicine and oral and maxillofacial surgery of tertiary care dental hospital in Pakistan between December 2025 and May 2026. Patients with xerostomia (n = 50) and age and sex-matched controls (n = 50) were enrolled using consecutive sampling. Salivary flow rates, clinical mucosal examination and microbiological profiles were evaluated and compared between the groups.

Results: Mean age was 48.6 ± 12.4 years and ages and sex distributions were comparable between groups. Salivary flow was markedly lower in the xerostomia group (0.18 ± 0.07 vs 0.43 ± 0.11 mL/min, $p < 0.001$). Erythema (54.0% vs 16.0%), fissuring (42.0% vs 10.0%), and ulceration (28.0% vs 6.0%) were more frequent among patients with xerostomia. Candida species were detected in 36.0% of patients versus 10.0% of controls, and overall microbiome alteration occurred in 74.0% versus 28.0% (OR 7.32, 95% CI 3.03 to 17.71, $p < 0.001$).

Conclusion: There was a significant relationship between xerostomia and the alteration of oral microorganisms and damage to the oral mucosa. It is essential to maintain the function and microbial balance of the salivary organs and early clinical diagnosis could be helpful in avoiding the occurrence of mucosal complications.

Keywords: *Xerostomia; Oral microbiome; Dysbiosis; Oral mucosa; Salivary flow; Candida*.

INTRODUCTION

The clinical condition of xerostomia is the subjective perception of a dry mouth, sometimes with diminished flow of saliva. In addition to discomfort, salivation dysfunction can negatively impact oral homeostasis due to the functions of saliva including hydration, lubrication, antimicrobial activity, buffering, mechanical clearance, and the effect on oral microbial

communities. Dry mouth can thus lead to changes in the oral microbial ecosystem and to a higher vulnerability of the mucosa, which can be seen as a consequence of the age-related changes in salivary function[1]. Clinical studies have also demonstrated that xerostomia is correlated with alterations in the oral microbial flora, indicating that the diminished salivary volume affects the relationship between the host and the indigenous flora[2]. Oral health is dependent on saliva which regulates oral pH, remineralizes, lubricates, and provides innate immune mechanisms.

As well, as secretions decrease, these protective mechanisms are compromised and dental caries, oral irritation, halitosis, opportunistic infections and problems eating and speaking are increased[3]. Oral environment alterations can also influence the fungi community. In the postmenopausal women, xerostomia has been associated with changes in the oral mycobiome and inflammatory status, which suggests that salivary dysfunction may affect many other microbial communities in the oral ecosystem[4]. Oral microbiome refers to the bacteria, fungi, viruses and other microorganisms that interact with epithelial tissues, saliva and immune systems of the host. A healthy community is in dynamic equilibrium and dysbiosis can be associated with inflammation and tissue injury. The low flow of saliva can enhance microbial changes in abundance and community structure[5] as saliva is a significant environmental determinant of microbial composition.

There is also evidence that xerosomia may affect the growth of microorganisms, thereby favoring colonization by microorganisms related to caries, periodontal disease, mucosal infection and other complications[6]. The connection between microbial dysbiosis and xerostomia is especially significant if there is a decrease in salivation. Radiotherapy to the head and neck area can lead to long-term problems with dry mouth, and microbiome research has shown shifts in microbial composition and function in Radiation Therapy (RT) patients with symptoms of oral dryness[7]. In head and neck cancer, the interaction between oral microorganisms and salivary metabolites also suggests that alterations of the biochemical environment can have an impact on the behavior of microorganisms and disease processes[8]. The results indicate that the integrity of the mucosa and stability of the microorganisms are related outcomes of salivary dysfunction.

Another model in which this relationship can be studied is in the case of autoimmune disease. Xerostomia is a hallmark of Sjögren's syndrome, and there are significant changes in the oral microbiome in this condition. Xerostomia treatment studies have found that altering the nature of saliva may impact oral microbial characteristics, suggesting that both symptomology and microbial ecology may be impacted by treatment[9]. This significance is supported by evidence that xerostomia can negatively impact dental treatment outcomes, leading to challenges with maintaining oral health and greater risks of complications during dental care[10]. The effects of diminished saliva function can be far-reaching. Experimental data from a sialoadenectomy mouse model demonstrate that the loss of saliva may impact the integrity of the intestinal barrier and composition of the microbiome, revealing a wider involvement of the salivary function in host-microbiome interactions[11].

Enzyme-based mouthwashes are also being studied at the oral level for their wound healing and xerostomia management activity, as well as to restore protective salivary functions, rather than simply for their anti-dry effect[12]. These methods could potentially help to prevent damage to the mucosal surfaces that are exposed to mechanical, chemical and microbial stresses. Salivary impairment and microbial alteration can also be evaluated in a clinical context of radioiodine therapy. Xerostomia, which is often accompanied by alterations in the oral microbiota, can be a side effect of radioiodine therapy for differentiated thyroid cancer, and such salivary decrease may have ecological effects[13]. Changes in the oral microbiome have been reported in other inflammatory conditions, such as ulcerative colitis, where dental disease and changes in the oral microbiome highlight the link between oral microbial communities and inflammatory pathways[14].

Moisture alone may not restore biological functions of natural saliva. Therefore, the physicochemical properties, microbial compatibility, safety and tissue

support are important factors to be considered in the development of artificial saliva. These considerations have been highlighted in recent evaluation of novel formulations of artificial saliva, highlighting the complexity of replacing salivary function[15]. The oral-gut axis is also gaining focus as evidence of communication between the two microbiomes has further increased interest in the topic, suggesting a possible connection between oral microbial changes and systemic and gastrointestinal processes[16]. Salivary components of mucosal integrity are closely related. MUC5B is crucial for lubrication, microbial aggregation and protection of oral tissues and is relevant to the barrier environment in cases of changes in salivary quantity or quality[17].

Inflammatory bowel disease has also been shown to be associated with dysbiosis of both the oral and fecal microbial communities, further suggesting that oral microbial imbalances may be part of broader microbial and inflammatory networks[18]. Although there is growing evidence that xerostomia is associated with changes in the oral microbiome, many questions remain unanswered about the effects of decreased salivary protection on simultaneously changing oral microbiome composition and the integrity of the oral mucosa. Much of the existing literature centers on diseases, treatment-induced xerostomia, or specific microbial groups, and the interplay of xerostomia and dysbiosis with mucosal health is only partially understood. These changes need to be investigated to understand xerostomia and management. This can help with the strategies of maintaining the microbial balance, maintaining the oral mucosa and enhancing the health of the oral cavity.

Objective: To evaluate the correlation between xerostomia, changes in the composition of the oral microbiome, and the integrity of the oral mucosa, and to see if clinically visible changes of the oral mucosa can be correlated with a reduction in salivary function.

MATERIALS AND METHODS

Study Design: Analytical cross-sectional study.

Study Setting: Department of Oral Medicine and Oral & Maxillofacial Surgery, a tertiary care dental hospital in Pakistan.

Study Duration: 6 months (December 2025 to May 2026).

Sample Size: A total of 100 participants were included, comprising 50 patients with clinically diagnosed xerostomia and 50 age- and sex-matched individuals without xerostomia as controls.

Sample Technique: Consecutive sampling technique was used.

Inclusion criteria: The study included the participants from dental outpatient department who were 18 years and above during the study period. The xerostomia group included patients who had experienced persistent oral dryness and also had clinical signs that indicated salivary function was decreased. The participants in the control group had no significant symptoms of oral dryness and normal salivary function. Informed consent was obtained from all participants.

Exclusion criteria: Any patient with an active oral malignancy, severe systemic disease, acute oral infections, prior major surgery on the salivary glands, or the inability to provide an adequate oral sample were excluded. Patients not willing to participate and pregnant women were also excluded.

METHODS

Demographic data, medical history, medications, symptoms of xerostomia, and oral clinical data were recorded on a structured proforma. The standardized symptom-based assessment along with unstimulated salivary flow measurement were used to assess xerostomia. The clinical assessment of oral mucosal integrity included the presence of erythema, ulceration, fissuring, atrophy, dryness and other mucosal abnormalities. Oral samples were taken by standardized sterile methods from the oral cavity and sent for microbiological analysis in a suitable way. Conventional microbiological methods were used, and when applicable, molecular methods for microbial identification and characterization. The relative abundance of selected bacterial and fungal species was determined among participants with and without xerostomia. Statistically, associations between salivary flow, microbiome changes, and mucosal changes were determined. Means and

standard deviations were used for continuous variables; frequencies and percentages were used for categorical variables. Comparative and correlation tests were used, and a p value < 0.05 was set as statistically significant.

RESULTS

100 participants were analysed, of which 50 were patients with xerostomia and 50 controls. The mean age of the sample was 48.6 ± 12.4 years (49 males, 51 females). The groups were comparable for age (49.2 ± 12.7 vs 48.0 ± 12.1 years, p = 0.630) and sex distribution (p = 0.841), indicating that the groups were well matched. The mean unstimulated salivary flow rate was significantly reduced in the xerostomia group compared to controls (0.18 ± 0.07 mL/min vs 0.43 ± 0.11 mL/min, respectively, p < 0.001). Forty-three (86.0%) of patients with xerostomia and 6 (12.0%) of controls reported clinical oral dryness (p < 0.001).

Demographic and clinical characteristics are summarised in Table 1.

Variable	Xerostomia (n = 50)	Control (n = 50)	p value
Mean age (years)	49.2 ± 12.7	48.0 ± 12.1	0.630
Male, n (%)	24 (48.0)	25 (50.0)	0.841
Female, n (%)	26 (52.0)	25 (50.0)	0.841
Salivary flow (mL/min)	0.18 ± 0.07	0.43 ± 0.11	<0.001
Clinical oral dryness, n (%)	43 (86.0)	6 (12.0)	<0.001
Mucosal erythema, n (%)	27 (54.0)	8 (16.0)	<0.001
Fissured mucosa, n (%)	21 (42.0)	5 (10.0)	<0.001
Oral ulceration, n (%)	14 (28.0)	3 (6.0)	0.003

Table 1: Demographic and Clinical Characteristics of Study Participants

Note. Independent-samples t test for continuous and chi-square test for categorical variables. Values are mean ± SD or n (%).

The xerostomia group had significantly higher rates of oral mucosal abnormalities. Erythema was identified in 27 (54.0%) patients, fissuring in 21 (42.0%), and ulceration in 14 (28.0%), compared with 16.0%, 10.0%, and 6.0% of controls, respectively (all p < 0.01). Patients with xerostomia were at about six times the risk of each abnormality, suggesting that there was a definite correlation between decreased salivary function and decreased mucosal condition. Oral dryness had the highest discriminatory power between groups (OR 45.05, 95% CI 14.00 to 144.95); however, the large interval may be due to the low number of dry controls (Figure 1).

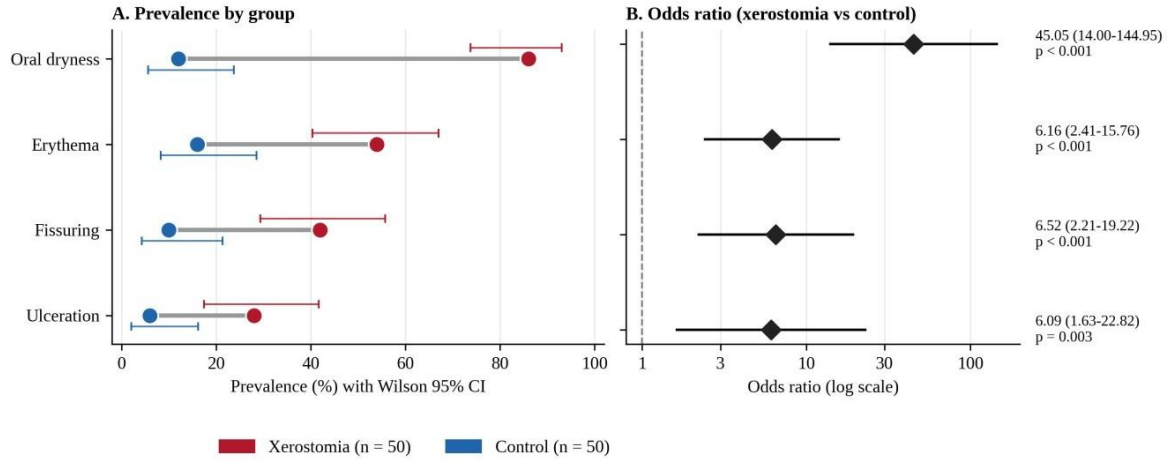


Figure 1: Oral mucosal abnormalities by study group. (A) Prevalence with Wilson 95% confidence intervals. (B) Odds ratios (xerostomia versus control) with 95% confidence intervals on a logarithmic scale; chi-square p values shown.

Participants with xerostomia had more microbial alteration in microbiological analysis. Candida species were detected in 18 (36.0%) patients compared with 5 (10.0%) controls (p = 0.002), and increased cariogenic bacteria were found in 29 (58.0%) versus 12 (24.0%) (p < 0.001). The incidence of opportunistic bacterial growth also occurred more often (46.0% vs 18.0%, p = 0.003). Candida colonisation was over

three times higher in the xerostomia group and more than half of these patients had an overgrowth of cariogenic Candida (Table2).

Microbiological finding	Xerostomia (n = 50)	Control (n = 50)	OR (95% CI)	p value
Candida spp., n (%)	18 (36.0)	5 (10.0)	5.06 (1.70 to 15.05)	0.002
Increased cariogenic bacteria, n (%)	29 (58.0)	12 (24.0)	4.37 (1.85 to 10.32)	<0.001
Opportunistic bacterial growth, n (%)	23 (46.0)	9 (18.0)	3.88 (1.56 to 9.65)	0.003
Overall microbiome alteration, n (%)	37 (74.0)	14 (28.0)	7.32 (3.03 to 17.71)	<0.001

Table 2: Oral Microbiological Findings Among Study Participants

Note. OR = odds ratio; CI = confidence interval. Chi-square test.

Overall microbiome alteration was identified in 37 (74.0%) participants with xerostomia and 14 (28.0%) controls (OR 7.32, 95% CI 3.03 to 17.71, p < 0.001). The absolute difference in prevalence ranged from 26 to 46 percentage points and all differences were statistically significant. In this way, almost three out of four patients with xerostomia had some type of microbial disturbance, while less than three out of ten controls had (Figure 2).

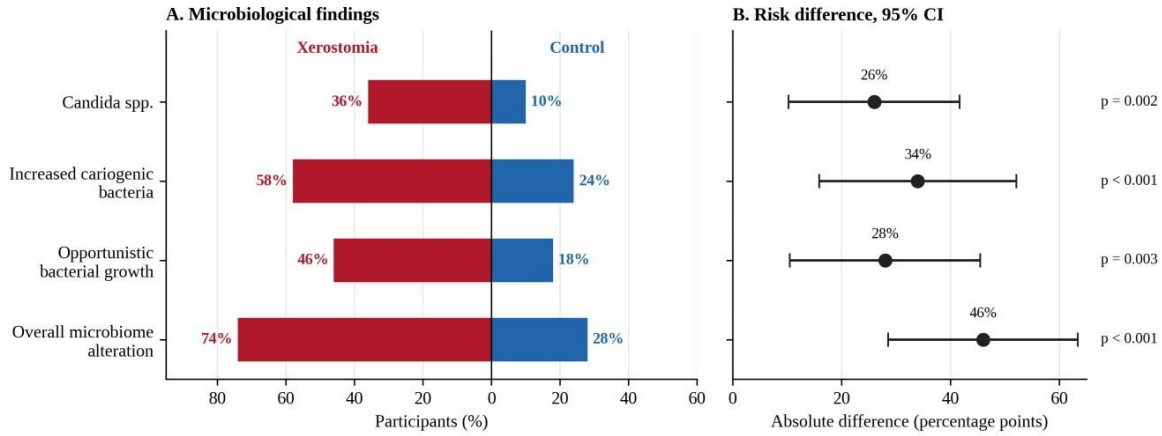


Figure 2: Microbiological findings by study group. (A) Percentage of participants with each finding in the two groups. (B) Absolute risk difference (percentage points) with 95% confidence intervals; chi-square p values shown.

Salivary flow was also correlated with the mucosal health. Those with lower salivary flow also had more abnormalities of the mouth lining and changes in their microbial communities, and mean salivary flow was lowest for participants who had microbiome alteration and clinical disease. There was only a small overlap between the salivary flow distributions of the two groups (Cohen's d = 2.71). The results were similar when measured clinically, microbiologically and in saliva. In general, a decrease in saliva production was correlated with concurrent disruption of the oral microbial environment and mucosal integrity (Figure 3).

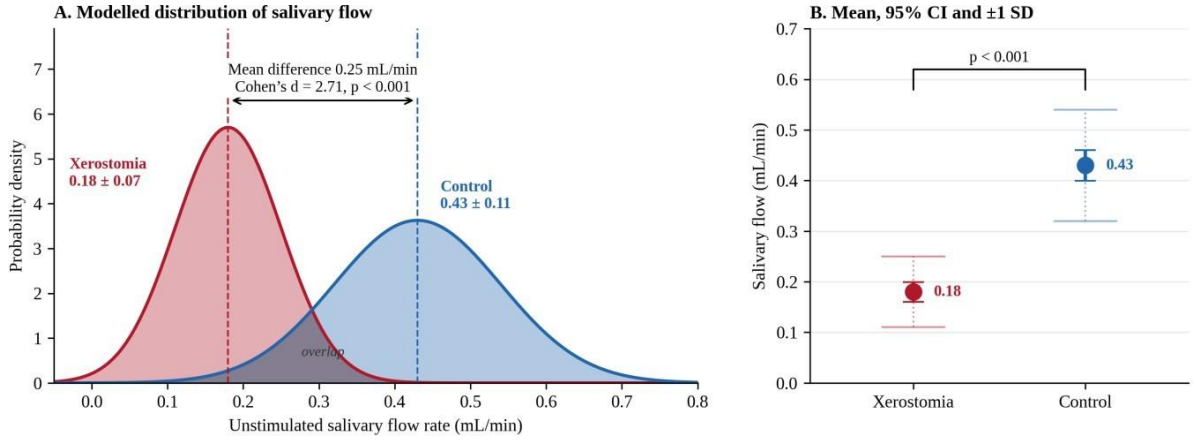


Figure 3: Salivary flow in relation to xerostomia status. (A) Normal density curves modelled from the group means and standard deviations; shaded grey area indicates overlap. (B) Group means with 95% confidence intervals (thick caps) and ±1 SD (thin caps).

DISCUSSION

The present study showed that there were significant associations between xerostomia, decreased salivary flow, and changes in the oral microbiome and impaired oral integrity. The unstimulated salivary flow was significantly lower in participants who complained of xerostomia than in controls and the percentage of participants who experienced oral dryness, erythema, fissuring and ulceration was higher. The results of this study corroborate the belief that saliva is not a mere lubricant but a critical part of the oral ecological system that helps to maintain salivation, microbial balance, epithelial protection and oral homeostasis[1]. The observed differences in microbial communities are in line with previous evidence that showed the changes in the oral microbiota of xerostomic patients[2]. The clinical findings are explained by a decrease in salivary flow in the xerostomia group. Saliva performs normal functions such as mechanical cleansing, buffering, antimicrobial defense, lubrication and maintenance of oral pH.

As secretion declines, these protective mechanisms are impaired, and allow microorganisms to survive and lead to mucosal irritation and dental disease[3]. In addition to bacterial changes, fungal changes may occur. Several components of the microbial ecosystem may be affected by xerostomia, with previous studies showing associations between xerostomia, inflammation, and alterations in the oral mycobiome[4]. The increased frequency of overall microbiome alteration in xerostomia participants further emphasizes ecological importance of saliva. The oral microbiome is in a dynamic balance with the host tissues and disruption of the environmental conditions can lead to dysbiosis. Decreased salivary flow can alter nutrient levels, oxygenation, pH, clearance of microbes, and surface colonization, which can increase the survival potential of microbes that can tolerate the changes in nutrients and other factors[5].

Similar observations have been made in the past about the increase in microbial growth and the changes in the oral microbial community in xerostomic patients[6]. Persistent dryness would have direct clinical implications on the integrity of the epithelium, as observed in this study, and hence on the mucosal abnormalities. The xerostomia group had significantly higher rates of erythema, fissuring and ulceration than the control group. Similar changes occur in those treated with radiotherapy for head and neck cancers, with oral dryness linked to alterations in the microbiome[7]. Research in head and neck cancer has also pointed to a relationship between the oral microbes and salivary metabolites, revealing that the salivary environment can affect microbial and tissue responses[8].

The present findings also have implications for patients with systemic diseases that involve salivary gland involvement. The oral microbiome is one area of interest in which disturbances are associated with impaired salivary secretion, such as Sjogren's syndrome. There is evidence that xerostomia treatment alters

oral microbial characteristics, which may result in a change in microbial ecology as well as symptoms[9]. In addition, there is an emerging body of systemic evidence that xerostomia can negatively affect dental treatment outcomes because it increases the risk of caries, oral complications, discomfort and poor oral hygiene[10]. The relationship between salivary dysfunction and microbial changes may extend beyond oral cavity. Experimental studies have shown that salivary reduction may have an impact on intestinal integrity and microbiome composition, indicating that saliva has a role in a wider host-microbiome communication[11].

This helps to maintain the biological significance of saliva. This led to an interest in therapeutic interventions going beyond symptom management. The use of enzyme-based mouthwashes and other salivary substitutes for their xerostomia management and their ability to support oral wound healing and protection of the oral mucosa is under investigation[12]. The results of this study are further confirmed by treatment-associated xerostomia. Patients with differentiated thyroid cancers who have been treated with radioiodine can experience salivary dysfunction with notable alterations in oral microbiota[13]. The results of this study indicate that the changes seen in the microbes is not only specific to the disease but can be generalized as a result of the altered environment in the saliva. Inflammatory diseases like UC have also been associated with oral microbiome disruption, with oral issues and microbial changes potentially influencing systemic inflammatory responses[14].

The findings also reveal that it is not enough to replace the moisture, but also to recreate the biological functions of natural saliva. The physicochemical properties, microbial characteristics, safety, and the role in supporting oral tissues are increasingly assessed to evaluate the formulation of artificial saliva[15]. The concept of the oral-gut axis further underscores the potential impact of changes in oral microbial communities on oral and non-oral disease. Bidirectional interaction between oral and intestinal microbial ecosystems indicates that the oral dysbiosis could be involved in systemic inflammatory and metabolic processes[16]. Salivary components like MUC5B, involved in lubrication, microbial aggregation and epithelial defense, also play a role in mucosal protection. Mucosal surfaces are therefore more susceptible to microbial and mechanical damage, thus exacerbating the effects of decreased salivary volume, and the reduction or alteration of some of the salivary protective components may have an effect.

The effects of decreased salivary volume may be compounded by the reduction or alteration of some of the salivary protective components, making mucosal surfaces more susceptible to microbial and mechanical damage. The concurrent salivary and fecal microbiome dysbiosis in inflammatory bowel disease further highlights the significance of the oral-gut microbiome communication and illustrates how oral microbial disturbances can be a part of larger systemic disease processes[18]. In general, the results suggest that xerostomia is not a mere subjective symptom, but rather a condition with both microbial and mucosal consequences. In the present study, reduced salivary flow was linked to increased microbiological changes and mucosal abnormalities. The findings provide evidence to support early identification of xerostomia, objective assessment of salivary function, assessment of oral mucous health and consideration of changes in the oral microbial flora during clinical management. Studying other longitudinal cohorts with detailed sequencing, quantitative salivary analysis, inflammatory markers and standardized mucosal scoring could help to elucidate the temporal relationship between salivary dysfunction, microbiome dysbiosis and loss of mucosal integrity.

CONCLUSION

The current research determined that there was significant alterations in the oral microbiome and compromised mucosal integrity associated with xerostomia. Oral dryness, erythema, fissuring and ulceration were more common in participants who had reduced salivary flow than in those who did not have xerostomia. Microbiological assessment also revealed higher frequencies of overall alteration of the microbiome (increased detection of Candida species, cariogenic bacteria and opportunistic microorganisms) among the xerostomia participants. The results

suggest that saliva is crucial for achieving a microbial balance and for protecting oral mucosal surfaces. Therefore, xerostomia is more than just a subjective oral dryness and should be treated as a clinically important condition. Early diagnosis and objective evaluation of salivary function, periodic assessment of mucosal integrity and appropriate interventions with salivary protection restoration or substitution could be helpful in minimizing microbial dysbiosis and mucosal complications. Longitudinal and molecular studies are suggested to further elucidate the mechanism(s) between salivary dysfunction, microbiome changes, and mucosal injury.

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