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Review

Alterations of the oral microbiota and oral clinical findings in dry mouth

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ABSTRACT

Background: A large variety of microorganisms colonize the oral cavity. Imbalances in the microbial ecosystem, likely caused by changes in the oral environment, can lead to oral diseases. One change that exacerbates the oral environment is dry mouth, characterized by hyposalivation and/or hyperevaporation of saliva, which may be caused by adverse drug effects, radiotherapy for head and neck cancer, and systemic disease.

Highlight: In this review, we discuss the findings of studies reporting relationships between hyposalivation, clinical findings, and the oral microbiota, by using culture analysis and molecular biological analyses. The results of these studies indicate that hyposalivation contributes not only to fluctuations in the number of certain microorganisms, but also influences the composition of the microbiota (the microbial ecosystem) in the oral cavity. These results were reflected by clinical indices, such as the number of decayed, missing, or filled teeth, and the prevalence rate of candidiasis in the patients studied.

Conclusion: In order to treat the various dry mouth-associated health concerns, an understanding of the qualitative alterations of the oral microbiota occurring in dry mouth and appropriate prophylaxis of oral disease are required.

Contents

1. Introduction

More than 700 bacterial species have been identified in the oral cavity [1,2], which coexist or antagonize each other to form a complex microbial ecosystem [3]. The microbial ecosystem is normally stable; however, imbalance caused by various factors, including changes in the oral environment and lack of an immune response, can lead to oral diseases such as dental caries, chronic periodontitis, and oral candidiasis [4–6]. Decreased saliva secretion, or hyposalivation, represents one such change that may occur in the oral environment.

Xerostomia is a clinical condition caused by dry oral mucosa, or a reduction or absence of salivary flow, and the estimated worldwide prevalence of xerostomia among elderly individuals (over 65 years old) is approximately 30% [7]. There have been reports that

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more than 400 drugs, including antihypertensive drugs, antiallergic drugs, and psychotropic drugs, induce dry mouth as an adverse reaction [8]. Further, it has been reported that xerostomia is caused by radiotherapy for head and neck cancer, Sjogren's syndrome, poor glycemic control in diabetes, or obesity [9–12]. Thus, a precise understanding of the qualitative alterations of the oral microbiota caused by dry mouth, and appropriate oral care should help to prevent caries and candidiasis, and, consequently, the prophylaxis of oral diseases will contribute to improve the quality of life (QOL) in the elderly.

This review discusses hyposalivation, clinical findings, and qualitative alterations of the oral microbiota based on results from culturing and molecular biological analyses of the oral microbiota, in order to prevent oral diseases caused by dry mouth.

2. Oral clinical findings in hyposalivation

There have been several reports on the relationship between hyposalivation, caries, and periodontal diseases. The results of a questionnaire and clinical examination of oral status in 600 Hungarians aged 18–92 (mean 48 ± 16) years showed that the number of decayed, missing, and filled teeth (DMFT) (mean 27 ± 6 and 21 ± 8, respectively), plaque index (PlI) (mean 0.78 ± 0.57 and 0.61 ± 0.55, respectively), and gingival bleeding (Ainamo-Bay, mean 0.5 ± 0.38 and 0.26 ± 0.31, respectively) were significantly greater in the group with a resting saliva volume < 0.1 ml/min (the reference value) compared with the group with a resting saliva volume ≥ 0.1 ml/min [13]. A study assessing oral health as a function of nutritional status (assessed by the Mini Nutritional Assessment [MNA]) in 612 elderly Thai individuals showed that the prevalence of caries and periodontal disease was greater in the group with hyposalivation, compared to that in the control group [14]. Further, the number of remaining teeth and the MNA scores were lower in the group with hyposalivation than in the control group. Hyposalivation in denture-wearing subjects and edentulous subjects was associated with taste disorder, dysphonia, and/or anorexia, which also suggested that these symptoms might be associated with a decrease in the MNA scores. Leung et al. studied the oral status of 26 patients with primary Sjogren's syndrome aged 33–74 (mean 51 ± 14) years, 25 patients with secondary Sjogren's syndrome aged 27–66 (mean 43 ± 11) years, and 29 control subjects aged 27–75 (mean 44 ± 11) years in China, and reported that pH and buffering capacity of saliva were lower in the primary Sjogren's syndrome group than in the other two groups, and that saliva secretion was negatively correlated with the number of caries in the primary Sjogren's syndrome group ($r^2 = -0.511$, $p < 0.05$) [15]. However, there were no significant differences in the Community Periodontal Index (CPI) or attachment loss between the groups. As described above, there have been many reports on the positive association between hyposalivation and the caries index. However, there have also been several previous reports on associations between hyposalivation and indices of periodontal disease, including those on hyposalivation-associated progression in periodontal disease [16,17] and those observing no relationship between saliva secretion levels and periodontal status [18,19], which suggest that saliva secretion is less likely to be directly related to the onset of periodontal disease. A recent study on the relationship between dry mouth and periodontal status in 2077 Japanese university students (18–24 years old) showed that 188 subjects (8.8%) had dry mouth, and reported positive associations between dry mouth and the rate of bleeding of probing (BOP) and plaque index in these patients [20]. This study concluded that dry mouth may be used as an index of high-risk gingivitis in young adults.

3. Culture analysis of microbiota in individuals with hyposalivation

The majority of studies on the effects of saliva secretion on alterations in bacterial communities have supported the above-mentioned association between dry mouth and oral disease. Almståhl et al. compared the number of bacteria (total number of anaerobes, α-hemolytic streptococcus, mutans streptococci, lactobacilli, *Fusobacterium nucleatum*, *Prevotella intermedia*, *Prevotella nigrescens*, *Staphylococcus aureus*, *Candida albicans*, and enteric bacteria) in rinsing samples of individuals, by dividing the subjects into a hyposalivation group ($n=14$) and a control group ($n=14$) [21]. The results showed that the number of lactobacilli was significantly greater, and the number of mutans streptococci also tended to be greater in the hyposalivation group. Another study in subjects who underwent head and neck radiotherapy, and exhibited hyposalivation indicated that the numbers of *C. albicans* and *Enterococci* were significantly greater on the lingual mucosa, that the numbers of *C. albicans* and *Lactobacillus* were significantly greater, and that the number of mutans streptococci tended to be greater in the supragingival plaque [22]. Leung et al. cultivated bacteria found in supragingival plaque collected from 11 primary Sjogren's syndrome patients, 11 secondary Sjogren's syndrome patients, and 11 control subjects, and found that the number of *Lactobacillus acidophilus* was

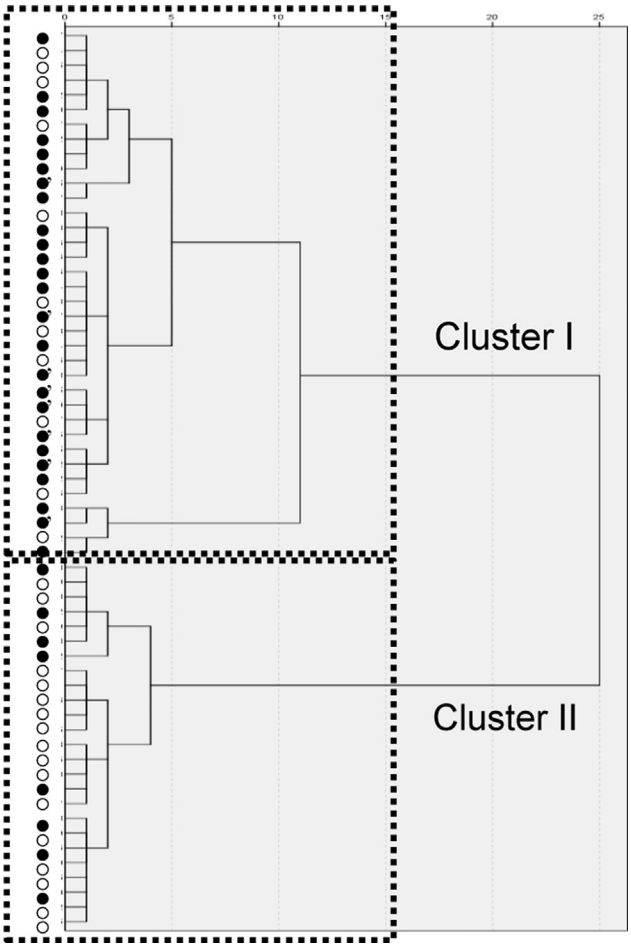

Fig. 1. Cluster analysis of the bacterial communities present in tongue coating samples. A dendrogram was constructed by combination of three T-RFLP patterns, with three different restriction enzymes (*Hae*III, *Hha*I or *Msp*I) using Ward's algorithm. The bacterial compositions were classified into two clusters, Cluster I ($n=36$) and Cluster II ($n=25$). •: Hyposalivation group (•′: Sjögren's syndrome), and ○: Normo-salivation group.