Published online: December 21, 2020
Eick S (ed): Oral Biofilms. Monogr Oral Sci. Basel, Karger, 2021, vol 29, pp 195–200 (DOI: 10.1159/000510192)

Halitosis

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Abstract

Halitosis is a widespread condition presenting several social and psychological implications, leading to a reduction in the quality of life of an individual. Halitosis, per definition, defines an unpleasant smell of the exhaled air, independent of its etiology. It can have a long-term prevalence or be transient, making it difficult to establish this symptom's epidemiology. Oral malodor can be attributed to a high local concentration of intraoral microbial populations, particularly those of the tongue's biofilm, as well as the biofilms associated with teeth and periodontal tissue. Frequently, the treatment options rely on improving oral health via tongue cleaning, detecting periodontal diseases, insufficient dental restorations, alternating diets, and/or alleviating local factors. Different methods targeting specific bacteria species have been designed to improve this condition. The aim here is to underline the correlation between oral biofilms and halitosis, describing prime bacteria species influencing oral malodor and addressing new concepts to ameliorate this condition.

Halitosis is generally defined as a symptom which presents a noticeably unpleasant breath odor, derived from the Latin word "halitus," meaning "breath" [1]. It is often interchangeably used when describing real halitosis, pseudo-halitosis, and halitophobia [2], and inadequately described when not distinguishing between intraoral or extraoral [2] malodor, as is recommended by the International Consensus Group, as displayed in Table 1 [2].

Pseudo-halitosis describes a subjective perception of obtaining this symptom without objectively presenting any signs, yet improving the condition when undergoing psychological therapy und simple oral hygiene measures [2]. In contrast, halitophobia describes a state where the patient is in denial to accept that he or she does not present any of these symptoms [2]. Real halitosis is multifactorial in its nature and pertains to both systemic and local factors inhibiting a patient's social acceptance and hence affecting their interpersonal relationships. Frequently, patients who have developed an awareness for this condition

Table 1. Classification of different types of halitosis (according to Yaegaki and Coil [2])

Type of halitosis	Definition
Real halitosis	Obvious malodor with intensity beyond socially acceptable level and/or affecting personal relationships
Temporary halitosis	Malodor caused by food and dietary factors such as garlic or morning bad breath
Intraoral halitosis	The source lies within the mouth The origin is often a coating on the dorsoposterior region of the tongue and/or a pathologic condition or malfunction of oral tissues (e.g., medication, smoking, stress)
Extraoral halitosis: blood borne	The source lies outside the mouth The malodor is emitted via the lungs and originates from disorders anywhere in the body (e.g., hepatic cirrhosis)
Extraoral halitosis: non-blood borne	The malodor originates from nasal, paranasal, or laryngeal regions, or the pulmonary or upper digestive tract
Psychogenic halitosis	Obvious malodor is not perceived by others but the patient complains of its existence. No physical or social evidence exists for the presence of halitosis
Pseudo-halitosis	Condition is improved by counselling and simple oral hygiene measures
Halitophobia	The patient persists in believing they suffer from halitosis even after treatment of halitosis or pseudo-halitosis

will visit a dentist. Therefore, in order to exclude any psychogenic factors, it is crucial for a practitioner to have an accurate understanding about this symptom's origins and treatment options.

Halitosis is a problem affecting a vast majority of today's population, occurring in both genders, and affecting patients of all ages with varying prevalence rates [3]. There are a few epidemiological studies underlining this condition. A study carried out in Japan by Miyazaki et al. [4] found that 25% of the subjects tested were aware of pertaining transient oral malodor in comparison to 6% who acknowledge this condition to be persistent throughout the entire day. In China, 27.5% were diagnosed via an organoleptic assessment, correlating with an increase of the biofilm on the tongue's surface [5], while in Kuwait 23.3% declared to have halitosis at a certain time of the day [6].

Overall, 80–90% of the underlying cause of halitosis is attributed to an intraoral microbial cause [7]. A correlation between the intensity of malodor and age was identified, highlighting an association with an increase in periodontal diseases, reduced saliva flow, and tongue coating amongst the older population [8]. Some of the main causes of intraoral halitosis include periodontal diseases, tongue coating, caries lesions, reduced salivary flow, and/or poor oral hygiene. Due to its enlarged surface-area through its papillary structure, the tongue's dorsum enables a niche for anaerobic bacteria to embed itself within these crypts, fissures, and papillae, providing an adequate surface for the oral biofilm to develop.

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Diagnostics

The clinical examination focuses on intraoral halitosis factors such as periodontal screening and the patient's oral hygiene, including the detection of carious lesions, insufficient dental restorations, tongue coating, and the amount of dental plaque present. An international consensus conference established two primary methods to obtain information about this condition:

1. An organoleptic measurement – a subjective sensory test score based on the examiner's perception of a patient's breath odor
2. An instrumental test – an objective way to measure the volatile sulfur compounds (VSCs) known to be the principal components of halitosis [9–11]

The organoleptic measurement is a subjective score based on the examiner's perception of the patient's breath odor [9, 12]. Through an objective, quantitative set of data, via the use of an instrumental device such as HaliSens (ScioDent, St. Sebastian, Germany), a Halimeter (Interscan, Chatsworth, CA, USA), and/or an OralChroma (Abimedical, Kawasaki, Japan), information about the quantity of VSCs can be collected. The HaliSens and Halimeter are portable sulfide monitors [13, 14] that measure the concentration of the sum of volatile sulfides, while the OralChroma is a gas chromatographic assessment able to display the three most important VSCs [8].

Further investigations enable patients to increase their awareness of the tongue coating via the use of an autofluorescence device (VELscope, Apteryx, Akron, OH, USA) demonstrating the bacterial colonized area of the tongue's dorsum [15]. In addition, there are methods such as the Winkel Tongue Coating Index (WTCI) to evaluate the tongue's coating.

Biofilm

A biofilm comprises any syntrophic consortium of microorganisms in which cells stick to each other and adhere to a surface [16, 17]. Oral biofilms found on teeth, periodontal tissue, or on the tongue form an extracellular matrix made up of extracellular polymeric substances assembling a polymeric conglomeration of extracellular polysaccharides, food debris, desquamated epithelial cells, and bacteria. These generate odiferous volatile organic compounds and VSCs [1] when metabolizing these organic components. Through hyposalivation, the biofilm's duration on the tongue is lengthened, allowing a longer enzyme-substrate interaction time, proceeding to a completion of the microbial transformation of glycoproteins. This is then followed by a de-glycosylation of these glycoproteins, the main source of organic nutrients, allowing microbes to digest these substrates (primarily carbohydrates, amino acids, proteins, and peptides), hence generating VSCs as one of its corresponding products [1]. In summary, the decomposition of organic substances by oral anaerobic bacteria leads to the production of VSCs, contributing simultaneously to the presence of halitosis [1, 18].

Microbiological Aspects

Halitosis has been acknowledged as a consequence of microbial putrefaction within the oral cavity [5]. These odors arise from the microbial degradation of proteins (especially those containing cysteine and methionine), peptides, and amino acids present in saliva and gingival crevicular fluid [19]. According to the concentration of the VSCs measured via a gas chromatograph, one is able to address its origin more accurately as it is stated that H_2S is a main component of physiological halitosis, whereas CH_3SH is the main component of pathological oral halitosis caused by periodontitis [20].

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The proteolytic activity is associated mainly with anaerobic, Gram-negative bacteria that reside on the tongue and tooth surface or in periodontal pockets [21]. Each wave of microbial overgrowth is a response to nutrient availability leading to an increase in the production of VSCs, such as hydrogen sulfide and methyl mercaptan, and to volatile fatty acids, such as butyrate, propionate, and valerate [22], which we in turn perceive as foul smelling.

Most of the intraoral bacterial species are either saccharolytic (metabolizing carbohydrates) or asaccharolytic (digesting amino acids, peptides, or proteins as their source of energy), or a combination of both, such as *Prevotella intermedia* or *Fusobacterium nucleatum* [23]. In vivo studies have demonstrated that halitosis is due to microbes producing VSCs from proteins and peptides containing cysteine and methionine [24]. Persson et al. [25] were able to define a group of intraoral bacteria (in vitro) primarily leading to the production of intraoral VSCs, including *Porphyromonas gingivalis* and *P. endodontalis*, *P. intermedia*, *Actinobacillus actinomycetemcomitans*, *F. nucleatum*, *Bacteroides forsythus*, *Peptostreptococus micros*, and *Eubacterium* species and spirochetes.

Furthermore, a study using a culture-independent method examined the tongue microflora of 11 patients and compared the microbial population between those of healthy patients to those with halitosis [26]. This resulted in *Streptococcus salivarius* only being diagnosed amongst those who did not suffer from this condition, while *Atopobium parvulum*, *E. sulci*, *F. periodonticum*, and *Solobacterium moorei* were found to be strongly associated with halitosis.

Intraoral factors affecting the microflora, such as the pH, pO_2, and its oxidation potential play a major role in the formation of malodor [27]. The acid base metabolism of the bacterial flora is mainly controlled by the plaque microbial composition as well as two main substrates: carbohydrates and nitrogenous compounds. When being digested, carbohydrates (monosaccharides and polysaccharides) lead to a decrease in the pH, creating sugar amines and other moieties that assemble with salivary glycoproteins. Nitrogenous compounds, on the other hand, have a ureolytic capability and lead to an increase in the pH, favoring halitosis.

An overload of a highly fermentative non-arginolytic Gram-positive microorganism, such as *S. sanguis* (associated with a cariogenic microbiota development) can be expected to reduce malodor, as this would lead to a decrease in pH, inhibiting its formation through its acidity [28].

Treatment

The treatment of choice is determined according to the cause of halitosis. The primary treatment relies on informing the patient about local factors that can be reduced to improve the symptoms, such as dietary factors. As previously mentioned, the tongue coating is a significant factor contributing to the development of halitosis; therefore, it is important to address and include mechanical tongue cleaning as part of daily oral hygiene. Different studies have demonstrated that tongue cleaning leads to a reduction of VSCs and, hence, has effectively reduced halitosis [29–31].

As a result of the tongue's morphology (crypts, papillae, and fissures) a tongue scraper, in comparison to a toothbrush, only removes the superficial biofilm on the surface of the tongue, having little effect. A tongue brush is therefore an adequate tool to efficiently remove the coating of the tongue with an adequate tongue paste (including zinc) [31].

If a mechanical tongue cleaning does not suffice, then an additional mouthwash containing antibacterial properties (e.g., chlorhexidine, cetylpyridinium chloride) or neutralizing components (e.g., zinc) may be used. These are able to absorb VSCs or their precursors [32], forming insoluble sulfides and inhibiting thiol proteinase

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activity related to VSC production [33, 34], leading to a synergistic effect.

Preventing the re-growth of odor-causing organisms through pre-emptive colonization of the oral cavity with non-odorous, commensal microorganisms may be an alternative to chemical or physical antibacterial regimens [4]. A study has demonstrated that *S. salivarius* K12 inhibited the Gram-positive bacteria *S. anginosus* T29, *E. saburreum*, and *Micromonas micros*, which are involved in halitosis, therefore underlining its potential use as a probiotic targeting halitosis-causing bacteria [35].

Conclusion

Halitosis is a common problem affecting approximately 25–30% of the general population [31]. A positive correlation between the bacterial load and halitosis has been confirmed, demonstrating that the tongue's biofilm is one of the root causes of oral malodor. It is clear that degradation of certain amino acids is caused by Gram-negative anaerobic bacteria and is key to the production of odiferous substances. Hence, it is important to emphasize the causes leading to this symptom, enabling the development of a cause-oriented treatment.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Funding Sources

No funding sources were involved in this work.

Author Contributions

Virginia Ortiz drafted, designed, collected, and interpreted the data presented. Andreas Filippi provided guidance and revised the draft. All authors read and approved the final manuscript.

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Eick S (ed): Oral Biofilms. Monogr Oral Sci. Basel, Karger, 2021, vol 29, pp 195–200 (DOI: 10.1159/000510192)