

Oral malodor

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Oral malodor, also known as bad breath, is a common complaint among the general population. Recently, this area has witnessed growing technology and communications, particularly an enormous increase in advertisements for bad-breath remedies on the Internet, on television and in magazines. This, in turn, has raised the levels of information and misinformation about bad breath among the patient population.

Ninety percent of bad breath is of intraoral origin.

Early scientific research¹⁻⁵ assessed the effects of oral microorganisms and conditions within the mouth, nose and sinuses on the production of

breath odor. Thirty-one years ago, a study by McNamara and colleagues⁶ revealed sufficient information to determine that the major cause of bad breath is the oral microflora that produces volatile odoriferous molecules (including sulfur compounds and organic acids among others). Subsequent studies noted that this malodor can be controlled by cleaning the teeth and tongue.^{7,8} Recent research on oral malodor has revived the dental profession's interest in this area.⁹⁻¹¹ On one hand, concerns have been raised about commercial "breath clinics" and products that lack scientific credentials.¹¹ On the other hand, there is a need for the dental profession to identify and consolidate the current knowledge in this area, to give balanced scientific information to patients and to increase the education of dentists and dental students in this area. Oral malodor is a

recognizable condition that deserves professional attention.¹¹

PREVALENCE OF ORAL MALODOR

The overall prevalence of oral malodor in the adult population is uncertain.^{12,13} According to Tonzetich and Ng,⁸ bad breath is a common condition found (at least on occasion) in approximately 50 percent of the adult population. Some authors have indicated that, at least occasionally, the majority of adults have bad breath, usually immediately after waking or after consuming particular kinds of food.¹⁴⁻¹⁶ Others stated that at least 50 percent of the sampled people suffered from persistent oral malodor, and that for approximately one-half of these people (that is, 25 percent of the population) bad breath was a severe chronic problem.¹⁷ It is believed that the prevalence of bad breath in the United States is high, and that the condition may rank only behind dental caries and periodontal diseases as the chief complaint of patients.^{12,13}

CAUSES OF ORAL MALODOR

Oral malodor has a complex etiology with extrinsic and intrinsic pathways. Extrinsic causes include tobacco, alcohol and certain foods such as onions, garlic and certain spices.^{15,18} Substances absorbed into the circulatory system may be released in pulmonary air or saliva as volatile odoriferous compounds derived from foods. Extrinsic causes of oral malodor are best controlled by eliminating the intake of offensive substances and will not be considered further in this review.

Intrinsic causes of bad breath are oral and systemic in origin. In general, roughly 10 percent of these cases are of systemic origin; approximately 90 percent of the cases are of intraoral origin.²⁰⁻²²

Using mass spectrometric and gas chromatographic, or GC, methods, Tonzetich⁷ identified several volatile sulfur compounds, or VSCs, including hydrogen sulfide, or H₂S; methylmercaptan, or

CH_3SH ; and dimethyl sulfide, or $(\text{CH}_3)_2\text{S}$. He suggested that they are the principal malodorous products of oral bacterial putrefaction found in exhaled air. The intensity of bad breath is associated with increased intraoral levels of these VSCs in exhaled air.⁷

VSCs are produced primarily by the action of gram-negative, anaerobic oral bacteria on sulfur-containing amino acids derived from peptides and protein in gingival crevicular fluid, blood, desquamated epithelial cells, saliva and food.^{7,23,24} In addition to VSCs, other components also may be involved in the development of oral malodor. Potentially odoriferous molecules are indole, skatole, short-chain carboxylic acids such as butyric and valeric acids, ammonia and polyamines such as putrescine and cadaverine.²⁵ The substrates may include peptides and proteins that contain lysine²⁶ or arginine.²⁷

Multiple sites within the oral cavity have been implicated in the formation of oral malodor, including the teeth, the tongue and periodontal pockets.^{7,16,18} It now, however, is clear that the most important source of oral malodor is the microbial deposits on the tongue. Several investigators have identified the dorsal posterior surface of the tongue as the primary contributor to bad breath in healthy people.¹³ Using organoleptic analysis (critical evaluation of a detectable sensory stimulus such as odor or taste) and GC measurements, Tonzetich and Ng⁸ found that tongue brushing yielded a 70 percent reduction in bad breath measurements, whereas tooth-brushing produced a 30 percent reduction. Yae-gaki and Sanada,²⁸ using GC methods, found that the tongue coating is an important factor for oral malodor origin, and that VSC production is reduced by one-half when the tongue coating is removed with a small spoon.

The filiform, circumvalate and foliate papillae and crevices associated with mucous glands and lingual tonsils increase the accumulation of bacteria and exfoliated epithelial cells by entrapping debris and retaining substrate, both of which favor the growth of anaerobic bacteria.^{28,29}

Deposits on teeth can contribute to oral malodor. This possibility has been demonstrated under exaggerated conditions in the experimental gingivitis model,³⁰ where discontinuation of tooth-brushing resulted in bad breath before the development of clinical gingivitis. The role of periodontal disease as a major source for oral odor is equivocal.¹³ Though one study demonstrated that

periodontal disease is correlated with oral malodor,³¹ other studies have shown that no correlation exists.^{10,29} Differences in the contribution of tongue deposits and supragingival plaque in these populations may account for the differences found in these studies.

In vitro studies on gram-negative, anaerobic organisms have shown that many species can produce objectionable malodor,^{6,24} but it is not clear which organisms play a role in vivo. The most extensively studied organisms that produce malodor are those commonly associated with periodontal disease and the subgingival flora.¹² However, it still is believed that the tongue plays the most important role in harboring organisms that contribute to oral malodor. Recent studies of microorganisms on the tongue have revealed a unique flora comprising heretofore unrecognized species.¹³ Future studies may reveal and characterize new organisms in the tongue flora that are important in the production of oral malodor.

Respiratory tract conditions, tonsillitis, post-nasal drip (caused by nasal infections, sinusitis or nasal polyps),^{1,11} craniofacial anomalies and various kinds of lung infection—such as anaerobic lung abscesses, necrotizing pneumonia and carcinomas of the respiratory tract—also can be responsible for malodor. Odors emitted from patients with respiratory conditions vary according to the disease. Respiratory conditions cause a breakdown of tissue that leads to the production of VSCs, not unlike those produced in malodor of the oral cavity.

Carcinomas of the upper respiratory tract, including the oropharynx, produce normal or branched organic acids, while lung carcinomas can produce acetone, methylethylketone, n-propanol, aniline and *o*-toluidine.³³ Liver disease can produce a variety of aromatic compounds, such as H_2S , aliphatic acids, CH_3SH , ethanethiol and $(\text{CH}_3)_2\text{S}$. Trimethylaminuria is a rare, odor-producing metabolic disease with symptoms of dysgeusia (perversion of the sense of taste)/dysosmia (defect or impairment of the sense of smell), which are due to excess production of trimethylamine, or $(\text{CH}_3)_3\text{N}$.³² Uremia that is caused by kidney failure also produces $(\text{CH}_3)_3\text{N}$ along with dimethylamine.³² In addition, patients with uncontrolled diabetes mellitus can emit ketonic breath, which is caused by a metabolic disturbance leading to the production of acetones and other ketones.

DIAGNOSIS AND ASSESSMENT OF ORAL MALODOR

The initial contact with a patient commonly stems from a complaint of bad breath, as identified by another person or suspected by the patient himself or herself. A patient may, however, be a very poor judge of his or her personal level of bad breath. Many patients who complain of bad breath do not have malodor as determined organoleptically.^{10,11} Furthermore, there are people who do not have bad breath but are convinced that they have oral malodor.³³ The term "halitophobia" has been applied to patients who insist that they have oral malodor without it being detected by established testing procedures.¹³ Some of these patients have a variety of psychopathological symptoms that often complicate the diagnosis and management of oral malodor.¹⁵ Conversely, some people have oral malodor and are entirely unaware of it.

A thorough medical, dental and oral malodor history is necessary to determine whether the patient's complaint of bad breath is due to intraoral causes. Several systemic conditions can be the exclusive or partial cause of the problem. Particular emphasis in the patient's medical history must be placed on medication history and history of disease or injury to the upper face or sinus. An intraoral examination is necessary to reveal any disease of oral origin that may contribute to bad breath, as well as the status of oral tissues and the extent of mouth breathing. The patient's ability to perform oral hygiene procedures also can be evaluated during the intraoral examination.³⁴

As studies and clinicians have noted, eating, drinking and oral hygiene procedures increase salivary flow and can decrease oral malodor at least temporarily.^{4,18} Therefore, patients should be instructed to refrain from drinking, eating, chewing, rinsing, gargling and smoking for at least two hours before the appointment to evaluate oral malodor.¹¹

There is no ideal test that can objectively assess the extent of oral malodor. The tests that are used can be divided into direct and indirect tests. Direct tests include sniffing of the bad breath and determination of odoriferous sulfur-containing substances by halimetry or GC. Indirect methods assess the products produced by microorganisms *in vitro* or identify odor-producing microorganisms.

The primary reference standard for the detection of oral malodor is the human nose. Direct sniffing of the expired air ("organoleptic" and "hedonic" assessment) is the simplest, most common method to evaluate oral malodor.⁹ Although the method presents several problems and may be objectionable to the dentist, it is the one that most closely resembles daily situations in which malodor is detected. Rosenberg and colleagues³⁶⁻³⁷ introduced an organoleptic scale ranging from 0 to 5 (0 = no odor, 1 = barely noticeable odor, 2 = slight but clearly noticeable odor, 3 = moderate odor, 4 = strong odor, 5 = extremely foul odor) that has been used in malodor studies.

The organoleptic evaluation of oral malodor depends on the person who makes the evaluation and the technique used (whole mouth or nose assessment, tongue odor test, dental floss odor test and saliva odor test). For whole-mouth breath assessment, regarded as the consensus method of choice at the November 2001 ADA Conference on the Diagnosis and Management of Oral Malodor, the subject is instructed to breathe out through the mouth at a distance of approximately 10 centimeters from the nose of the judge, who is blinded.^{37,38}

The spoon test assesses the odor emanating from the dorsum of the posterior tongue; a plastic spoon is used to scrape and scoop material from the back region of the tongue dorsum.¹¹ Five seconds later, the spoon odor is evaluated at a distance of approximately 5 cm from the examiner's nose. The dental floss odor test is used to determine the presence of interdental plaque odor. Unwaxed floss is passed through interproximal contacts of the posterior teeth, and the examiner assesses the odor by smelling the floss at a distance of approximately 3 cm.

The saliva odor test routinely involves having the subject expectorate approximately 1 to 2 milliliters of saliva into a petri dish. The dish is covered immediately, incubated at 37 C for five minutes and then presented for odor evaluation at a distance of 4 cm from the examiner's nose.²² In most cases, saliva obtained directly from the mouth possesses little or no foul odor, but after some time of incubation, malodor is easily detected.²⁸ The saliva odor test, however, has not been standardized by the research community, and investigators commonly use different protocols and techniques to conduct this test.

A highly sensitive and specific GC method coupled with flame photometry detection has been

adapted for the direct measurement of the three VSCs: CH_3SH , H_2S , and $(\text{CH}_3)_2\text{S}$. These compose approximately 90 percent of VSC content in the mouth.^{7,8,20} Other odoriferous gases such as cadaverine, putrescine and skatole also can be detected by gas or liquid chromatography.^{26,26,39}

GC allows for the identification and quantification of individual components within the air sample, even when extremely low gas concentrations are present and when there are masking effects by flavored products. The main disadvantages of GC measurement are its relatively high cost, the requirement for highly trained personnel, the lack of portability and its extensive procedures for detection and measurement.⁹

More recently, a relatively inexpensive, portable industrial sulfide monitor, sold commercially as the Halimeter (Interscan, Chatsworth, Calif.), has been adapted to measure gases associated with oral malodor.^{37,38} This sulfide monitor measures VSCs with an electrochemical sensor using a suction pump to bring mouth air into the instrument.^{37,38} The advantages of this sulfide monitor compared with GC include lower cost, operation by nonskilled personnel, portability and rapid measurement of the VSCs at chairside. Some studies that used this monitor found significant correlations between the measures of sulfide concentration obtained with the monitor and the organoleptic assessment of oral malodor.^{35,37}

One major disadvantage of this sulfide monitor is its inability to differentiate between various sulfides.⁴⁰ Because of this monitor's problem with differentiating sulfide compounds and because CH_3SH is three times more unpleasant than H_2S at the same concentration, it is possible that the Halimeter underestimates the malodor in people with high CH_3SH concentrations in their mouths.³¹ Other disadvantages include interference of the results by high levels of ethanol or essential oils and decreased instrument sensitivity over time that necessitates periodic recalibration.⁹ Even though some investigators have questioned the correlation between organoleptic and Halimeter readings,⁴¹ the monitor does supply useful data for clinical studies of oral malodor.⁴⁰

Indirect methods assess bad breath potential either by identifying putative organisms that are believed to produce VSCs *in vivo* or the byproducts produced by these microorganisms *in vitro*. These include bacterial culture, direct bacterial smears and enzyme assay.

There also is a chairside test that is used to determine the proteolytic activity of certain oral anaerobes that contribute to oral malodor.^{28,42,43} This test consists of incubating samples from plaque or the tongue with N-benzoyl-DL-arginine-naphthylamide, or BANA, which is a synthetic trypsin substrate. If the organisms have enzymes that degrade BANA, a colored compound is produced within roughly five to 15 minutes that indicates a positive BANA test. Using a step-wise multiple regression analysis technique that combines a positive BANA test with Halimeter readings vastly improves the correlation of the combined readings with organoleptic scores.⁴³ When patients are treated successfully to reduce and/or eliminate oral malodor, the tongue BANA test converts from positive to negative.^{10,29}

Two types of patients pose problems in terms of oral malodor management. One is the patient who does not have bad breath at the time of examination. This type of patient requires a re-examination and reassurance of the lack of bad breath. The second type of patient is one who has malodor due to nonoral causes. Some of the indications that malodor is of systemic origin are that the patient demonstrates oral malodor with tongue scrapings or a floss test or continues to have malodor after treatment has been instituted, though the patient has meticulously followed the oral hygiene instructions. Nasal etiology can be determined by assessing the odor of exhaled air. Also, odor from the tonsils can be determined by assessing the tonsils' enlargement and the presence of tonsillar crypts in concretion.^{11,18} Patients with malodor of a nasal or tonsillar origin can be referred to an otolaryngologist for further evaluation.

TREATMENT OF ORAL MALODOR

The first step in treating oral malodor is to assess all oral diseases and conditions that may contribute to oral malodor, including large carious lesions.

For disease-free people, current oral malodor treatment is based on the assumption that the malodor is the result of an overgrowth of oral microorganisms, which produce volatile compounds that are offensive. The aim of the treatment is to reduce these microorganisms in the oral cavity, with concomitant reduction in the formation of volatile compounds. This may be accomplished by mechanical or chemical methods.

Mechanical reduction of microorganisms

through improved oral hygiene procedures has been associated with reductions in oral malodor. Particular emphasis has been placed on mechanical cleaning of the tongue. Tonzetich⁷ showed that brushing the tongue decreased VSCs by approximately 75 percent. Tongue cleaning is critical for reducing oral malodor, and a number of tongue brushes and tongue cleaners now are commercially available.^{11,14,29} There is ample evidence in the literature that brushing and flossing of teeth reduces the number of microorganisms in the oral cavity, thereby reducing oral malodor.^{19,30,44} Both professional and personal oral hygiene procedures play a key role in controlling oral malodor.

Chemical control of oral malodor may be accomplished by a number of oral actives, including antibacterial agents (essential oils, cetylpyridium chloride, chlorine dioxide, hydrogen peroxide, domiphen bromide and others) and antimicrobial metabolites (zinc salts and others). Mouthwashes have been advertised for the control of bad breath, and this appears to be the primary reason people use them.⁴⁵ Over-the-counter, or OTC, mouthwashes are considered cosmetic products and by definition are not subject to the same level of regulatory scrutiny before being introduced into the marketplace.¹² To date, manufacturers have published few data on the safety and efficacy of OTC mouthwashes to assist practicing clinicians. Such OTC products may be genuinely effective as a result of actually reducing the number of bacteria, while others may mask the odors, though their masking effect may only last for a brief period.^{13,45,46} Another mechanism that has been proposed for the action of mouthrinses is the inactivation of VSCs and their conversion into nonmalodorous compounds by zinc salts.¹³ Further investigation of lozenges, toothpastes, mints and breath strips is needed to determine their efficacy in controlling oral malodor.

Few studies have examined the long-term effectiveness of a particular mouthwash on the reduction of oral malodor. Some studies have been conducted without appropriate controls, so it cannot be determined if the malodor reductions observed are due to the mouthwash or to the oral hygiene procedures used by the study subjects. Furthermore, the mechanisms of odor reduction have not been adequately studied. Nonetheless, Loesche³² and Loesche and colleagues¹³ have evaluated the studies on oral malodor that have reasonable scientific design. Specifically, mouth-

rinses containing either zinc chloride, essential oils or an oil-water-cetylpyridium chloride mixture³⁵ reduced the organoleptic levels of malodor in the absence of tongue brushing.¹² These agents all have antibacterial activity and act by reducing the number of microorganisms in the oral cavity.

For the treatment of oral malodor, the public increasingly has turned to commercially available mouth-freshening products. The market for these products has been growing continuously. In 1999 alone, nearly \$1 billion was spent in the United States on deodorant-type mouthrinses.^{12,13}

Other causes that have been implicated in the etiology of oral malodor include systemic diseases and the use of some drugs.¹⁸⁻²⁰ If it is determined that the source of malodor is not in the oral cavity, the patient should be referred to a physician for further treatment. In the meantime, the research challenge is to discover agents that can be effective at neutralizing odors that are of systemic origin, so that patients can enjoy the peace of mind that comes from using such agents while being treated for the systemic disease.

The increase in research and interest in oral malodor among dental professionals should result in a better understanding of the etiology of oral malodor and the development of more effective diagnostic and treatment methods. The need for methods to evaluate available products for safety and efficacy is an area of concern that must be addressed. Once this body of knowledge is organized, it should become a component of the curricula of dental schools and continuing education for dentists.

SUMMARY AND RECOMMENDATIONS

Further studies are needed to determine the actual prevalence of oral malodor and the clinical variability of oral malodor. Nevertheless, it appears that up to 25 percent of the population suffers from chronic bad breath.

Evidence is available demonstrating that approximately 90 percent of bad breath is of intraoral origin. VSCs and other organic compounds produced by oral bacteria residing on the tongue are chiefly responsible for bad breath. The role of periodontal disease in bad breath is uncertain, and more studies are needed on the various conditions that affect oral malodor.

A thorough medical and dental history is necessary to evaluate oral malodor complaints. The primary reference standard for detection of oral malodor is the human nose (organoleptic assess-

ment) because it provides an overall evaluation of the existing malodor condition. This could be supplemented with an instrumental method, such as VSC evaluation by sulfide monitor or GC, for an objective malodor assessment.

For the treatment of bad breath, improved oral hygiene, especially tongue cleaning, has been shown to reduce VSCs significantly. The value of some oral care products in reducing bad breath, however, is less certain. Though numerous industry-sponsored studies have evaluated the safety and effectiveness of oral malodor products, most of these studies are unpublished and their results are equivocal and proprietary. Recommendations of specific products to control oral malodor can be made with greater confidence when clinical results demonstrating safety and efficacy have been published. ■

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