ISSN Print: 2394-7489
ISSN Online: 2394-7497
IJADS 2019; 5(4): 33-37

www.oraljournal.com
Received: 19-08-2019
Accepted: 21-09-2019

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Recent advances in management of halitosis

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Abstract
Halitosis is an unpleasant offensive odor that originates from oral cavity. It is a common social problem, one in every four people suffers from halitosis and is reported as the third most common reason that people seek dental care. The origin can be either intra-oral or extra-oral, with 90% of etiology being intraoral, which is caused by microbial degradation of organic substrates in food debris. Major constituent for malodor is volatile sulphur containing compounds. Research in this area has lead to the development of advanced diagnostic instruments for detection and measurement of halitosis. This review focuses on current strategies for the management of halitosis. Their effectiveness and significance are discussed and presented here. Mechanical reduction of bacterial load by maintaining oral hygiene is found to be more efficient. Short term good results were reported by using oral rinses with chemical agents such as chlorohexidine and others. Non surgical periodontal therapy as well as photodynamic therapy and laser treatment results in significant reduction of organoleptic score.

Keywords: Halitosis, bad breath, organoleptic score, photodynamic therapy, laser therapy

1. Introduction
Halitosis is a Latin word which means halitus (breathed air) and osis (pathologic alteration) [1]. It is the term used to define an unpleasant or offensive odor in expired air, regardless of whether it originates from oral or non oral sources [2]. Halitosis is a widespread problem; about 50% of the world population suffers from oral malodor. It can be of intra-oral or extra-oral origin. In 90% of cases malodor emanates from oral cavity and the main sources are tongue coating, periodontal disease, extensive carious lesions with exposed tooth pulps, pericoronitis, mucosal ulcerations and diseases, impacted food and debris, unclean dentures, and a decreased salivary flow rate [3, 4] Although the oral cavity is the main source of halitosis, the following conditions can also contribute to malodor ; chronic sinusitis with postnasal drip, bronchitis, pneumonia, esophageal reflux, pyloric stenosis, hiatal hernia, diabetic ketoacidosis, hepatic failure, kidney dialysis, and leukemia [5]. In this review article current strategy for the management of halitosis, their efficacy and significance are elaborated.

2. Role of Bacteria & Sources of Halitosis
Halitosis is mainly due to the dominance of gram negative anaerobic organisms in oral cavity. Normal Salivary PH is slightly acidic (6.5) which suppresses the growth and proliferation of these microbes while periodontal infections causes the saliva to be alkaline, this favours the growth of gram negative anaerobic bacteria such as Treponema denticola, Porphyromonas gingivalis, Porphyromonas endodontalis, Prevotella intermedia, Bacteroides loescheii, Enterobacteriaceae, Tannerella forsythensis, Centipeda periodontii, Eikenella corrodens, Fusobacterium nucleatum [8] Murata *et al* in 2002 proposed the classification of halitosis for its management which includes treatment need (given in table 1) [10]. The principal component of oral malodor is Volaile Sulphur Compounds (VSC) especially methyl mercarpatan (CH_3SH), hydrogen sulphide (H_2S) and di-methyl sulphide ($(CH_3)_2S$) [6] These VSC's are mainly produced due to the microbial degradation of organic products in oral cavity.

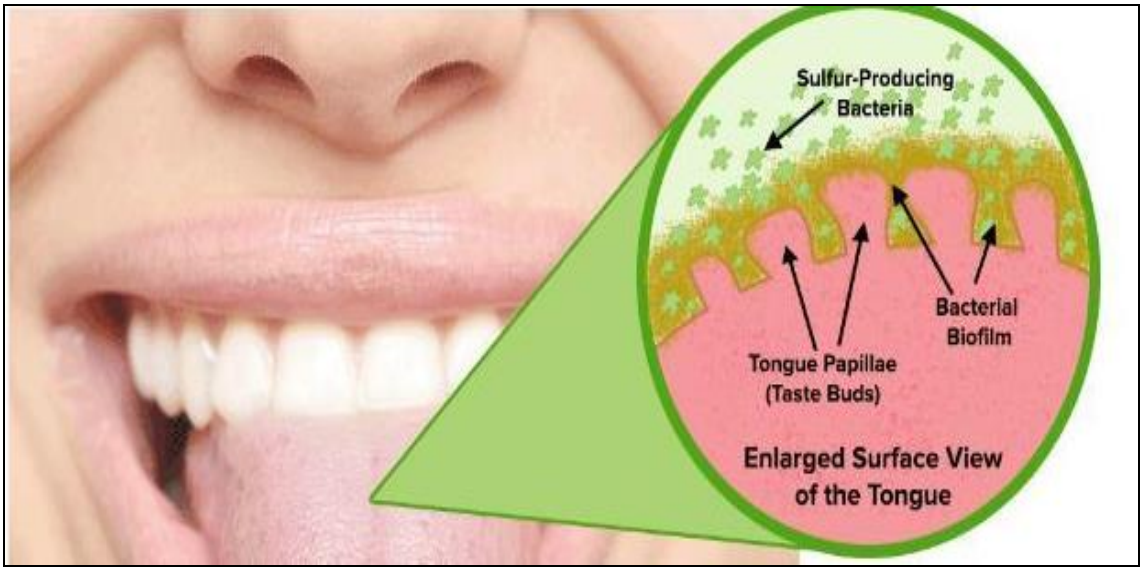

Fig 1: Tongue as source of Halitosis

Other compounds produced during anaerobic bacterial degradation are diamines (indole & skatole), polyamines (putrescine & cadaverine) and short chain fatty acids such as butyric acid, propionic acid and valeric acid [7]. Apart from VSC, the exhaled air contains volatile organic compounds (VOC) which is due to non pathophysiologies including systemic diseases such as diabetes or respiratory or gastrointestinal illness or renal failure etc. So the diagnosis of VOC can be considered as biomarker of certain systemic diseases. Elevation of VSC in women is reported during menstrual period. Tobacco and alcohol consumption also increase the risk of halitosis.

3. Different Diagnostic Methods

The proper diagnostic approach to a malodor patient starts with thorough questioning about medical history. Extra oral factors has to be identified and treated. Extra oral halitosis can be subdivided into: halitosis from the Ear, Nose and Throat region (ENT), pulmonary pathology, gastrointestinal tract and blood-borne halitosis. Patients with extra-oral halitosis and halitophobia must be referred to appropriate specialists such as an otorhinolaryngologist, internist, endochrinologist, gastroenterologist, pulmonologist, psychologist, or psychiatrist. Organoleptic measurement is the gold standard for assessment of halitosis, in which a well trained clinician will analyze the exhaled breath, giving score according to intensity.[9] The score varies from 1 to 5 depending upon intensity of odor (0: no odor, 1: barely noticeable, 2: slight but clearly noticeable, 3: moderate, 4: strong, and, 5: extremely strong). There are different diagnostic methods to detect and measure halitosis which are given in table no:1

Table 1: Diagnostic Methods

Diagnostic Method	Description
Gas Chromatography	Measure two major VSC-H_2S & (CH_3) SH with accuracy. Cannot detect $(CH3)_2S$. High sensitivity and reliability
Halimeter	Chair side equipment to assess oral malodor. Measures H_2S Cannot discriminate sulphide components. False results in presence of ethanol & essential oils.
BANA Test (Benzoyl-DL-arginine-a-naphthylamide)	Detects short chain fatty acids & proteolytic obligate gram negative anaerobes. Detects T. denticola, P. gingivalis & T. forsythesis Can be used for periodontal risk assessment
Quantifying β galactosidase activity	Enzyme responsible for removing O- and N- linked carbohydrate chains. Detected by using chromogenic substances absorbed on to chromatography paper.
Saliva Incubation Test	Saliva is collected in glass tube, sealed and incubated at 37 °C in anaerobic condition. Measure halitosis indirectly Less influenced by external parameters.
Ammonia Monitoring	Detects ammonia quantity which is producing by oral bacteria.
Ninhydrin Method	Used for examination of amino acids and low-molecular-weight amines. Simple, rapid and inexpensive.
Electronic Nose	Chemical sensors are used to assess oral malodor. Instrument consists of sensor array, pattern reorganization modules, and headspace sampling, to generate signal pattern that are used for characterizing smells.
Biomimetic Oflactory Sensors	The most fundamental elements are ORs in the cilia of olfactory sensory neurons (OSNs). Uses artificial Intelligence.

Clinically Miyazaki *et al.* [10] classified halitosis on the basis of treatment needs. After physical examination halitosis can be classified into categories of genuine halitosis, pseudo halitosis and halitophobia. (shown below in table no 2 and 3).

Pseudohalitosis is not perceived by others, although the patient often complains of its existence. Haltiphobia is the condition even after treatment of genuine halitosis patient believes that he/she has halitosis.

Table 2: Classiication of Halitosis based on Treatment needs [10]

Classification	Treatment Need	Description
I Genuine Halitosis		Obvious malodor, with intensity beyond socially acceptable level is perceived
a. Physiologic halitosis	TN-1	Malodor arises through putrefactive processes within the oral cavity. Neither a specific disease nor a pathologic condition that could cause halitosis is found. Origin is mainly the dorsoposterior region of the tongue. Temporary halitosis due to dietary factors should be excluded.
b. Pathologic halitosis		
Oral	TN-1 and TN-2	Halitosis caused by disease, pathologic condition or malfunction of oral tissues. Halitosis derived from tongue coating, modified by pathologic condition (e.g., periodontal disease, xerostomia), is included in this subdivision
Extraoral	TN-1 and TN-3	Malodor originates from nasal, paranasal and/or laryngeal regions. Malodor originates from pulmonary tract or upper digestive tract. Malodor originates from disorders anywhere in the body whereby the odor is blood–borne and emitted via the lungs (e.g. diabetes mellitus, hepatic cirrhosis, uremia, internal bleeding).
II. Pseudo- Halitoss	TN-1 and TN-4	Obvious malodor is not perceived by others, although the patient stubbornly complains of its existence. Condition is improved by counseling (using literature support, education and explanation of examination results) and simple oral hygiene measures.
III. Halitophobia	TN-1 and TN-5	After treatment for genuine halitosis or pseudo–halitosis, the patient persists in believing that he/she has halitosis. No physical or social evidence exists to suggest that halitosis is present.

Table 3: Treatment Needs for oral malodor [10]

Category	Description
TN-1	Explanation of halitosis and instructions for oral hygiene
TN-2	Oral prophylaxis, professional cleaning and treatment for oral diseases, especially periodontal diseases
TN-3	Referral to a physician or a medical specialist
TN-4	Explanation of examination data, further professional instruction, education and reassurance
TN-5	Referral to a clinical psychologist, a psychiatrist or other psychology specialist

4. Methods to Reduce Halitosis

The treatment of halitosis can be cause related. Since oral causes are related to microbial degradation of organic compounds inside oral cavity, the following treatment modalities can be adopted i) Mechanical reduction of microbial load, ii) Chemical reduction of oral microbial load,iii) Masking of oral malodor or iv) Probiotic treatment.

4.1 Mechanical Reduction

Several studies have implicated the dorsum of the tongue as the primary source of VSC (shown in figure 1), both in periodontally diseased and healthy individuals [11]. Researchers have been able to find positive correlations between tongue coating status (amount and or presence) and the different parameters directly related with oral malodor. The development of a predominant anaerobic microbiota associated with tongue coating has been considered an ideal microenvironment to produce malodorous compounds, and therefore different authors have tried to assess the relationship between the morphology of the tongue and the severity of oral halitosis [12, 13]

4.1.1 Tongue Cleaning & Tooth Brushing: Several studies proved that tongue brushing and mouth rinsing are basic treatment measures for halitosis. Kuo YW *et al*. compared the effectiveness of two types of oral care, tooth brushing alone and tooth brushing plus tongue cleaning, on halitosis and tongue coating (TC). The use of tooth brushing plus tongue cleaning compared with tooth brushing alone significantly reduced the indicators of halitosis and TC. [14] S Saad *et al* (2016) in his study showed that combined treatment of a sonic tongue brush with the antibacterial tongue spray is able to deliver more than 6 h of fresh breath following a single use.[15] Wang *et al* through their studies concluded that mechanical self-cleaning of tongue coating did not influence plaque index while it had tendency to reduce tongue coating area and thickness [16]

4.1.2 Non Surgical Periodontal Therapy: Sao-ShenLiu *et al* evaluated the impact of nonsurgical periodontal therapy alone on the oral malodor in chronic periodontitis patients by comparing the intraoral concentrations of volatile sulfur compounds (VSCs) before and after nonsurgical therapy. All patients received oral hygiene instructions and full mouth scaling and root planning with specific instructions not to use tongue scraping or chlorhexidine mouth rinse. On the basis of findings, they suggest that nonsurgical periodontal therapy has a mild impact on oral malodor [17] Significant reductions for Organoleptic score, total sum of volatile sulphur compounds (T- VSC) and methyl mercaptan (MM) values were found after non surgical periodontal treatment in studies conducted by Seida Erovic Ademovski *et al*. [18]

4.1.3 Photodynamic Therapy: PDT involves the use of a non-toxic light-sensitive photosensitizer combined with visible light at the appropriate wavelength to coincide with the absorption spectrum of the photosensitizer, which reaches a state of excitation after absorbing the photons, reacting with the oxygen in the medium to form reactive oxygen species (ROS). This phototoxic reaction induces the destruction of bacterial cells, but the antimicrobial effect is confined to areas covered by the light-activated photosensitizer, quickly acting on the target organisms when the appropriate energy dose and output power are used. After treatment, a statistically significant reduction in halitosis was found in a study conducted by Rubia Garcia Lopes *et al* to evaluate the effect of photodynamic therapy for the treatment of halitosis in [19].

4.1.4 Laser Therapy: Finkelstein Y *et al* evaluated the tonsils as a source of halitosis and to assess the efficacy of laser CO(2) cryptolysis for the treatment of oral bad breath caused by chronic fetid tonsillitis [20]. The laser treatment resulted in

significant reduction of halitosis. The study conducted by Kellesarian SV *et al* assessed the efficacy of laser therapy (LT) and antimicrobial photodynamic therapy (aPDT) as adjunct to mechanical debridement (MD) on the management of halitosis study reported a significant reduction in bacterial colony forming units on the dorsum of the tongue among patients with coated tongue receiving MD with aPDT compared with MD alone [21].

4.2 Chemical Reduction

Mouthrinses with antimicrobial properties can reduce oral malodor by reducing the number of microorganisms chemically. Often used active ingredients in these products are chlorhexidine (CHX), essential oils (EOs), triclosan and cetylpyridinium chloride (CPC). It can also reduce halitosis by chemically neutralizing odor compounds, including VSCs. Often used active ingredients of these products are metal ions and oxidizing agents [11]. Chlorhexidine (CHX is the most efficient molecule against plaque. Also, the reduction in odor-producing bacteria is limited. Chlordioxide is a strong oxidizing product that can reduce oral malodor by the oxidation of H2S, CH3SH, cysteine and methionine.

4.2.1 Combination of Chemical Agents: Zinc ions, chlorhexidine (CHX) and cetylpyridinium chloride (CPC) are all known to inhibit production of volatile sulfur compounds (VSCs). Young *et al*. conducted a study to examine the anti- VSC dose–response effects of each of the above agents. Zinc had a marked dose- and time- dependent anti- VSC effect. Chlorhexidine maintained a moderate anti- VSC effect over time. Cetylpyridinium at a concentration of 0.2% was onlymarginally more effective than 0.025% CHX over the 3 h, while 0.025% CPC had no better anti- VSC effect than water at both 2 h and 3 h. It was concluded that the three test agents demonstrated different anti- VSC kinetics. Although Zn had the best anti- VSC effect at 1 h,
0.2% CHX was at least as effective as 1% Zn at 3 h, most likely as a result of its unique substantivity [22].

4.2.2 Herbal Remedies: Green Tea, Tulsi, Clove, Ela triphala has antimicrobial and anti halitosis activity which helps to reduce oral malodor to an extent. Several studies have been conducted to analyse the effect of these herbs on reduction of VSC which is major component of Halitosis. The study conducted by Nir Sterer *et al* tested the effect of a palatal mucoadhesive tablet containing an herbal formulation on oral malodor production and volatile sulfide compound (VSC) levels, and to evaluate its antimicrobial activity. The active ingredient was an herbal formulation composed of equal shares of four herbal medicinals: Echinacea (Echinacea augustifolia), Mastic gum (Pestacia lentiscus), Lavender (Lavandula augustifolia) and Sage (Salvia officinalis), supplied as dried powders. Sage, Lavender and Mastic gum showed antimicrobial activity against all three oral pathogens. Results suggested that the palatal adhesive tablets containing herbal formulation may serve as an effective means of treatment for patients complaining of oral malodor [23].

4.3 Masking the Odor

Treatments with rinses, mouth sprays and lozenges containing volatiles with a pleasant odor have only a short-term effect. Another pathway is to increase the solubility of malodorous compounds in the saliva by lowering the pH of saliva or simply increase the secretion of saliva; a larger volume allows retention of larger volumes of soluble VSCs. In order to lower the pH, an orange juice may be sufficient. The latter can also be achieved by ensuring a proper liquid intake or by using a chewing gum [24]. The study by Muniz FW *et al* analyzed the impact of chewing gum on halitosis parameters. Chewing gums containing zinc acetate and magnolia bark extract as well as allylisothiocyanate (AITC) with zinc lactate significantly reduced the levels of VSC in comparison to a placebo chewing gum. Furthermore, a sodium bicarbonate-containing chewing gum and eucalyptus-extract chewing gum significantly reduces the VSC levels. Chewing gum containing sucrose was able to reduce the VSC levels, in comparison to xylitol and zinc citrate chewing gum, but only for 5 min. The findings in another study indicated that chewing gum containing Phyllanthus emblica (PE) fruit extract stimulated salivary flow and significantly reduced clinical test indexes in the short term. Chewing PE gum might be a safe means of improving oral hygiene [25].

4.4 Probiotics

Probiotics can be defined as living microbes, or as food ingredients containing living microbes, that beneficially influence the health of the host when used in adequate numbers. The general mechanisms of probiotics can be divided into three main categories: normalization of the intestinal microbiota, modulation of the immune response, and metabolic effects [26]. The study conducted by J.P. Burton *et al* found that administration of bacteriocin- producing S. salivarius after an oral antimicrobial mouthwash reduces oral VSC levels considerably [27].

5. Conclusion

Halitosis is an extremely unappealing characteristic of sociocultural interactions and may have long-term detrimental after effects on psychosocial relationships since it is a recognizable common complaint among the general population. Only with proper diagnosis, identification of the etiology, and timely referrals a successful individualized therapeutic approach can be given for each patient seeking assistance. Research has shown that patients recognize an improvement in social life and satisfaction after completion of treatment for halitosis

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