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A plenary review of halitosis

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Abstract
Halitosis is any noxious smell arising from the oral cavity when breathing or speaking. Breath malodor is a condition that have health and social implications. The origin of oral malodor are caused by both systemic and oral conditions. Oral malodour leads to social embarrassment and can adversely affect individual's social interactions. Though many oral and non-oral sources could give rise to halitosis, the volatile sulfur compounds –produced by microbial activity- were the main elements of oral malodor. In addition, there are very few instances where patients suffer from pseudohalitosis or halitophobia. Diagnosis play an important role in oral malodour and there are many direct and indirect measurements techniques and chairside diagnostic kits are available.

Keywords: Oral malodor, breath malodor, Halitosis, pseudohalitosis, halitophobia

1. Introduction
Halitosis is any disagreeable odor, regardless of whether the odorous substances originate from oral or non-oral sources in expired air. The most common spaces where halitosis originates are bacterial niches, such as the posteriortongue dorsum, periodontal tissue sites (including the gingival sulcus, pathological pockets and interdental spaces), defective dental restorations, deep carious lesions and poorly maintained dentures [1-3]. Other pathological conditions from oral sources that can influence or provoke bad breath include xerostomia, dental abscesses, candidiasis, oral tumors, necrotizing periodontal diseases and pericoronitis [4]. Major compounds that contribute to oral malodor are volatile sulfur compounds (VSCs) such as hydrogen sulfide (H2S), methyl mercaptan (CH3SH) and dimethyl sulfide (CH3SCH3). Additionally, propionic acid and butyric acid, cadaverine, indole, and scatole, have been reported to cause oral malodor which results from the proteolytic degradation by predominantly anaerobic Gram negative microorganisms associated with gingivitis and/or periodontitis (*Porphyromonas gingivalis*, *Prevotella Intermedia* / *nigrescens*, *Campylobacter* rectus, *Aggregatibacter actinomycetemcomitans*, *Fusobacterium nucleatum*, *Peptostreptococcus* micros, Tanerella forsythia, Eubacterium species, and spirochetes) are known to produce large amounts of volatile sulfur compounds, which are malodorous. It is likely that the majority of adults suffer from bad breath at least occasionally. In some situations it is the individual's perception of malodor which is not detectable by others. The impact of halitophobia can be minute or very deleterious because some people avoid social events, and even talk sideways when engaged in conversation.

1. Classification of halitosis (Yaegaki K & Coli M 2000) [5]
1. Pseudo halitosis.
2. Genuine halitosis.
- Physiologic
- Pathologic
3. Halitophobia.

2. Halitosis of pathological origin due to local factors.
3. Halitosis of nonpathological origindue to local factors.
4. Halitosis of pathologic origin due to systemic factors.
5. Halitosis of nonpathologic origin due to systemic factors.

6. Halitosis due to systemic administration ofdrugs.
7. Halitosis due to xerostomia.

Aetiology of malodor: (Delanghe *et al* 1999) [6]

- Intra oralcauses
- Periodontal infections
- Odontogenic infections
- Xerostomia
- Mucosal lesion

Extra oral causes

- Maxillary sinusitis
- Upper respiratory tract infection
- Pharyngitis
- Bronchiectasis
- Cystic fibrosis
- Diabetes Mellitus
- Leukemia
- Pyloric stenosis
- Hepatic failure
- Renal failure
- Peptic ulcer (H. pylori infection)
- Menstruation (menstrual breath)
- GERD
- Trimethylaminuria
- Hypermethioninemia
- Agranulocytosis

85-90% of cases are intraoral origin.10-15% of cases are of an extraoral origin [7-10].

Factors involved in the etiology of halitosis

Halitosis is due to the odorous gases in the air expelled from the oral cavity. The odorous compounds are mainly divided into;

1. Sulphur containing gases (VSCs).

a. Hydrogen sulphide
b. Methyl mercaptan
c. Methyl sulphide
d. Dimethyl disulfide

2. Non-Sulphur containing gases.

Volatile aromatic compounds

a. Organic acids (acetic and propionic acids)
b. Amines (putrescine, cadeverine-20)

Diagnosis

An accurate diagnosis of halitosis depends on analysis of data collected from patient history and physical examination. The patient history should contain chief complaint, medical, dental and halitosis history. Parts of the physical examination are extraoral examination, intraoral examination with special attention paid to the tongue and the periodontal tissues, and upper respiratory tract examination. It is important to understand the psychological component in perceptions of oral malodor. This prompts a need for psychological evaluation when treating patients for this disorder. Expectation and perceptions of results are multifactorial for these patients, and thus very subjective. This complexity is an obstacle both in diagnosis and treatment, yet it may also serve as an avenue of treatment that should be addressed by the medical community, in particular the psychological specialties.

I. Direct measurement techniques

1. Organoleptic Method (Sniff Test)

The sensory organoleptic test by a trained clinician is the gold standard for diagnosis of intraoral halitosis. In this method, direct smelling of the exhaled air from patient's mouth and nose is used for evaluation of the oral malodor [15-22]. Has a degree of subjectivity. No need for special equipment [23-25]. Objectivity and reproducibility are poor. It gives a reflection of the everyday situation. Assessment should be performed at several appointments on different days. The sensory organoleptic test is scored on a scale from 0 to 5 based on the perception of a trained clinician as 0: no odor, 1: barely noticeable, 2: slight but clearly noticeable, 3: moderate, 4: strong, and 5: extremely strong [11-13] or more widely point scale from 0 to10 point [14].

The organoleptic evaluation of oral malodor also includes other simple tests such as tongue odor test, dental floss odor test and saliva odor test.

(i) Spoon test: The spoon test is used to assess halitosis originating from the posterior part of the dorsum of the tongue. Using a sterile plastic spoon sample is taken from the dorsum of the tongue. After about 5 seconds, the odor from the contents of the spoon is assessed, holding the spoon about 5cms away from the nose.

(ii) Dental floss odour test: This test is used to assess the odour originating from the interdental regions. The examiner passes a sufficient length of unwaxed floss through the interdental regions of posterior teeth. The odour is assessed by holding the floss about 3cms from the nose.

(iii) Saliva odour test: About 1-2ml of saliva is collected into a glass tube. The tube is covered immediately and incubated at 37^0C for five minutes. Assessment of odour is done by placing the glass tube at 4cms away from the nose.

2. Gas chromatography

It is the method of instrumental analysis of halitosis using gas Chromatography coupled with flame photometric detection [23, 26] 12. In this method before taking measurement, patients should close the mouth and refrain from talking for 5 min prior to measurement, then a disposable tube of the sulfide monitor is inserted into patient's mouth to collect mouth air. Meanwhile, the patient is breathing through the nose and the disposable tube is connected to the monitor. Sulfur-containing compounds in the breath can generation electro-chemical reaction. This reaction related directly with levels of volatile sulfur-containing compounds. The quantitative analyses of VSCs causing the odor (Dimethyl sulfide, methyl mercaptan, and hydrogen sulfide gases) are performed by this method [27]. With this method, even low concentration of gases can be measured separately and their quantities can be determined [28]. It is expensive, requires skilled personnel, cumbersome and lack of portability

2.1. Gas chromatography mass spectrometry: It is useful in the rapid detection of trace levels of mycobacterial secondary alcohols, results can be obtained within two days, it has high sensitivity and specificity. Expensive and skillful personnel are required [24, 29].

3. Dark field/phase contrast microscopy

Higher incidence of motile organisms and spirochetes are associated with Gingivitis and periodontitis, so shifts in these

proportions allow monitoring of therapeutic progress and also the patient becomes aware of bacteria present in plaque, tongue coating, and saliva. High proportion of spirochetes in plaque has been associated with a specific acidic malodor (Quirynen & van Steemberghe 2006).

2. Indirect measurement techniques

1. BANA (Benzoyl-DL-arginine- α-Naphthylamide) test

Many of the anaerobic bacteria in the dorsum of the tongue and subgingival plaques can produce VSCs and malodorous volatile fatty acids. BANA test is us\ed to identify 3 major bacteria such as *Treponema denticola*, *Porphyromonas gingivalis*, and Tannerella forsythia [30]. When these proteolytic bacteria are treated with a synthetic trypsin substrate BANA, the arginine hydrolase enzyme which is a colored compound is released. Thus, the presence of bacteria is proved and the test can be done within a 5-10 minutes.

2. Chemical sensors

Special probes are used to measure the amount of VSCs in the periodontal pocket and tongue surface. In the presence of sulfide ions, an electrochemical voltage is generated that is proportional to the sulfide-sensing element concentrations and is indicated by the digital score after the electronic unit is measured [31]. The electronic nose is another device developed for measuring halitosis and the information received by means of chemical sensors is transferred to the computer environment. It has 6 sensors with different selectivity and sensitivity [32]. Using the new chemical sensors, ammonia and methyl mercaptan compounds can be measured from breath air and some new types of sensors measure each volatile sulfur-containing compounds separately

3. Quantifying beta-galactosidase activity

Deglycosylation of glycoproteins are essential in oral malodor production. β-Galactosidase activity can be easily determined by the use of chromogenic substrates absorbed onto a chromatography paper disc [33-35]. In order to measure β-galactosidase activity, saliva was taken in a paper disc and discoloring of the paper disc changes based on β-galactosidase activity and these changes are recorded; no color: 0, faint blue color:1, moderate to dark blue color: 2 Sterer *et al*. found a positive correlation between organoleptic scores and β-galactosidase [36].

4. Salivary incubation test

First time, Marc *Quirynen et al* carried out a study to evaluate salivary incubation and halitosis. Non-invasive test for the patient and helps to identify various compounds that contribute to oral malodor [29]. To measure halitosis, saliva was collected in a glass tube and incubated at 37 °C in an anaerobic chamber under an atmosphere of 80% nitrogen, 10% carbon dioxide, and 10% hydrogen for 3-6 hrs. After incubation, an examiner evaluates the odor. The salivary incubation test has much less influenced by external parameters such as smoking, drinking coffee, eating garlic, onion, spicy food, and scented cosmetics. If the hardness of the incubation process does not be counted, the salivary incubation test could be one of the valuable tests for halitosis measurements.

5. Ammonia monitoring

Breath contains high levels of ammonia; it is 1 ppmv in the breath of a healthy individual or may be higher in individuals with renal failure [37]. Ammonia Monitoring is a method based on the detection of ammonia released by oral bacteria which cause halitosis. The patients should refrain from eating and drinking activity, at least 2 h before measurements. The device consists of a pump it draws the expiratory air into the ammonia gas detector and a disposable tube that is inserted into the patient's mouth. The amount of ammonia is read by the gas detectors after rinsing their mouth with urea and then blow into the tube. The ammonia concentration produced by the bacteria can be read directly from the scale [38].

6. Ninhydrin method

Gases were produced from the breakdown of peptides and glycopeptides by bacterial putrefaction in the oral cavity. During this process, peptides are hydrolyzed to amino acids which further are metabolized to amines or polyamines. These molecules cannot be measured by sulfide monitoring. Hence, the ninhydrin method was used for examination of amino acids and low-molecular-weight amines. The ninhydrin method is simple, rapid, and inexpensive. This method is a kind of colorimetric reaction. With this method, isopropanol is mixed with the sample taken from the patient and centrifuged. It is then read according to its light permeability using a spectrometer [39].

7. Polymerase chain reaction (PCR)

Quantitative analysis of the microorganisms causing VSCs from oral specimens such as saliva, tongue coating, and subgingival plaque can be performed by PCR. PCR isa rapid, sensitive and specific diagnostic technique. Qualitative analysis are unsuitable for the accurate evaluation of bacteria causing oral malodor.

3. Chairside diagnostic aids

1. Oral chroma (Portable gas chromatography)

Oral Chroma TM is a portable gas chromatographic device. The device can be used without any software [40]. It is small-available for periodontal clinics, useful in quantitative measurements. *highly sensitive*. and low cost. It cannot detect other than sulphur compounds, needs calibration, the sensor and column need to be replaced every two years.

2. Halimeter (Portable sulfide monitor)

The sulfide monitor is a portable device that allows easy measurement of the VSCs found in the expiration air outside the laboratory environment. ('Halimeter',Interscan Corp., Chatsworth, CA, USA).The patient keeps his mouth closed for 5 minutes. Then, a single-use tube connected to the sulfide monitor was inserted into the patients mouth while breathing from the nose. The electrochemical reaction that takes place in the sulfur containing compounds in the breath brings the electric current in proportion to the levels of the compounds. [41, 42]. It analyses the concentration of Hydrogen Sulphide and Methyl mercaptan without discrimination between the two. It is a portable-chair side test, non-invasive, relatively inexpensive, no need for skilled personnel, low likelihood of cross infections, Inability to distinguish between individual sulphide measurement in the presence of high levels of ethanol or essential oils, cannot be used other than intraoral causes, necessitates periodic recalibration, insensitive to dimethyl sulphide and detects only sulphur compound.

3. Breathron

It is semiconductor type sulfide monitor, which is composed of an airintake, sensor detector, control panel, digital display and printer. The semiconductor sensor is based on a thick

Zinc Oxide (ZnO) membrane that has a high specificity for VSC's [43]. The disposable mouthpiece, which has a build-in filter to eliminate other volatile compounds (like ketone and alcohol in toothpaste and mouth wash), is inserted into an end of the Teflon tube connected to the monitor inlet. Measurements are performed by directly inserting the disposable mouthpiece into the patient's oral cavity. The patients are instructed to close their mouth tightly and breathe through their nose during the measurement. The Breathtron® values are presented in units of parts per billion (ppb). Because of the monitor's problem with differentiating sulfide compounds and because methyl mercaptan is three times more unpleasant than hydrogen sulfide at the same concentration, Breathtron® underestimates the malodor in people with high methyl mercaptan concentrations in their mouths [44]. Among the portable monitors, the Halimeter® and Breathtron ® are the most appropriate devices for general dental practitioners because they are easy to handle and provide results similar to GC.

4. Breath checker

1. Tanita breath alert

Tanita's breath checker as a motivational tool for encouraging the patients towards the better oral hygiene has been used, by co-relating the oral hygiene status of the patients with breath checker scores and comparing the breath checker scores before and after the complete oral prophylaxis, thus motivating the patient towards the better oral hygiene [45].

2. Fitscan breath checker

It detects and measures the presence of breath odors (VSCs). It measures odor in seconds and results are displayed similarto organoleptic method.

5. Tongue sulfide probe

The sulfide level on the tongue dorsum (Ps level) was determined using the tongue sulfide probe. A sulphide-sensing element in the probe generates an electrochemical voltage proportional to the concentration of sulphide ions present [46]. The electrochemical voltages generated by sulphide ions are measured by an electronic unit and displayed in a digital score.

6. Diamond probe/perio 2000

These probes are designed to detect sulphide concentration of various forms in gingival sulci. The system combines a conventional Michigan 'O' Probe style dental probe with a sulphide sensor, which measures probing depth, bleeding on probing and sulphide levels. The micro-sulphide sensor responds to sulphide ions and measures metabolic products of many anaerobic bacteria and, indirectly bacterial activity. The reaction of the sulphide ions with the sensor
generates a measurable voltage that is proportional to the sulphide concentration. Therefore, the presence of high sulphide levelsindicates a higher level of anaerobic bacterial activity. The probe tip was gently inserted into the base of the gingival sulcus and moved along with light pressure. As the probe moved along the sulcus, the three parameters were recorded. If the presence of sulphide was indicated above threshold (>0.5), the light on the front of the display panel would change colours depending on sulphide concentrations and an audible tone would sound [47].

7. Halitox reagent kit (Ammonia monitoring)

A chair side test kit (Halitox reagent kit) measures the halitosis linked toxins. It is quick, simple colorimetric test that detects both volatile sulphur compounds such as hydrogen sulphide and methyl mercaptan as well as polyamines like putrescine and cadaverine. The colour chart contains 3 colour scale- low toxin, moderate toxin and high toxin.

Treatment of halitosis

The treatment of oral malodor is based on a cause-related strategy. Treatment strategies can include: (i) masking the malodor; (Mouth sprays, lozenges and chewing gums containing volatiles with pleasing odor). (ii) mechanical reduction of intraoral nutrients, substrates and microorganisms; (tongue cleaning. tooth brushing, interdental cleaning and professional periodontal therapy). (iii) chemical reduction of the oral microbial load; (CHX mouthwash 0.2%, essential oil mouth wash, chlorine dioxide, two phase oil-water rinse, triclosan, fluorides, hydrogen peroxide and oxidizing lozenges etc.) (iv) rendering malodorous gases nonvolatile; (metal salt solutions like ZnCl2, SnCl2, HgCl2, SnF2; Backing soda dentifrices etc). If, after conscientious succession of these approaches, breath malodor rpersists and intraoral sources can be excluded, other (extraoral) sources of malodor, such as ear, nose and throat pathologies, lung diseases, gastrointestinal diseases and metabolic abnormalities (e.g. diabetes) should be investigated.

5. Conclusion

Halitosis is a complex phenomenon and is mainly a problem of oral origin. Patients should be referred for psychological evaluation if a psychological component is suspected. Various methods of self assessment are available for the patients and several methods for the practitioners. The development of small, easy to handle, chair side advanced diagnostic aids has overcome the disadvantage of the conventional diagnostic aids to a great extent but still additional or alternative chair side methods, such as breath checker, chemical sensor, tongue sulfide probe, diamond probe, halitox reagent kit and ammonia monitoring are infrequently employed.

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