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A Pandect of Oral Malodor

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Abstract: *Oral malodor is one of the major concern of patients today as it brings marked psychological discomfort and may interfere with social interactions. Although it usually originates from oral cavity, there are multiple other systemic causes that have to be addressed for its diagnosis. Correct diagnosis of the cause of the malodor and its precise treatment can render the patient satisfaction. There are newer development in faster and more efficient detection of levels of malodor, and wide array of treatment options are available in the market. It is utmost requirement for the dentist to have a sound understanding of this prevalent oral condition and provide effective intervention program. This article reviews the various causes and diagnosis option which will help in treatment of this multifactorial condition.*

Key words : *Halitosis, periodontal disease, Oral Malodor, volatile sulphur compounds*

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I. Introduction

Oral Malodor has been recognized in the literature since ancient times, but in the last five to six years it has increasingly come to forefront of public and dental professional awareness.[1] Oral malodor has a significant impact on social life for those who suffer from it.[2] Oral malodor (also known as bad breath, halitosis, fetor ex ore) usually originates when it emitted through mouth combine with malodorous compounds in oral cavity.[3] At least 50% of the population suffers from a chronic oral malodor condition by which individuals experience personal discomfort and social embarrassment leading to emotional distress. The consequences of oral malodor may be more than social; it may reflect serious local or systemic conditions. [4]
The present review summarizes the diagnosis, prevalence, etiology and current treatments of oral malodor.

Epidemiology:

The prevalence of halitosis has been reported to be high as 50%.[5] Oral malodor can affect persons of any ages. The prevalence of persisitent oral malodor in a Brazalian study was reported to be 15% was nearly three times higher in men than in women. The risk is three times higher in people over 20 years of age compared with those under of 20 years.[6]

Classification:

According to its etiology, oral malodor can be classified [7-9] as [Figure 1]:

- **Genuine halitosis**: Obvious malodor with intensity which is beyond socially acceptable level.
- **Physiologic:** Malodor that originates in the oral cavity and not caused by any specifi c disease or pathologic condition. The main source of origin is likely to be dorsum of the tongue.
- **Pathologic, oral**: Halitosis caused by disease or pathologic processes related to the oral cavity.
- **Pathologic, extra-oral**: Malodor caused by disease or pathologic processes related to nasal, paranasal and/or laryngeal regions.
- **Pseudohalitosis**: There is no obvious malodor perceived by others, but the patient believes that he or she has oral malodor.
- **Halitophobia:** Patient complains of malodor which is not perceived by others. Halitophobia is characterized by a patient's persistent belief that he or she has halitosis despite reassurance, treatment and counseling.

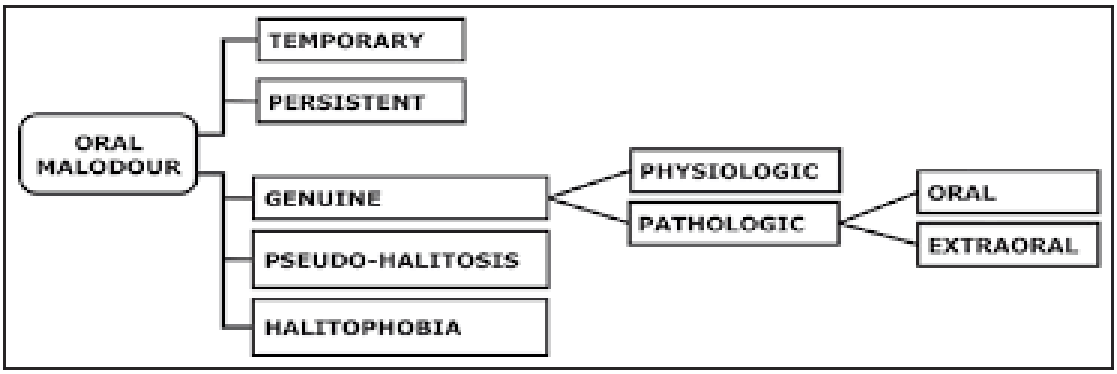

Fig 1: classification of oral malodor

Etiology :

The most likely cause of oral malodor is the accumulation of food debris and dental bacterial plaque on the teeth and tongue, resulting from poor oral hygiene and resultant gingival (gingivitis) and periodontal (gingivitis/ periodontitis) inflammation.[10]

Table 1: Presents the list of possible etiological factors responsible for oral malodor.[11]

Genuine
Physiologic
Diet — vegetables such as onions, garlic, radishes, turnips and leeks
Beverages such as tea and coffee
Alcohol-based wine, brandy, whisky, liqueurs and beer
Dairy products that contain protein
Dehydration, starvation, constipation, diarrhea
Pathologic
Local oral
Tongue coating (poor oral hygiene)
Gingivitis-ANUG, acute herpetic gingivostomatitis
Periodontitis
Xerostomia (e.g. from drugs, Sjögren's syndrome, radiotherapy, chemotherapy)
Pericoronitis
Candidiasis
Oral sepsis
Oral cancer
Bone diseases — dry socket, osteomyelitis, osteonecrosis
Debris under dental appliances (e.g., dentures, removable orthodontic appliances, bridges)
Extraoral (nonoral systemic conditions)
ENT
Postnasal drip
Tonsillitis, tonsilloliths
Rhinitis, rhinoliths
Sinusitis, antral malignancy
Nasal polyps, carbuncle, carcinoma
Nasal obstruction/foreign bodies
Other systemic factors
Lung — chronic bronchitis, bronchiectasis, pulmonary abscess, tuberculosis, pneumonia, emphysema, secondary infection, bronchial carcinoma, pulmonary infarcts and its sequelae
Renal — renal failure, uremia
Hepatic — cirrhosis, gall bladder dysfunction, hepatic failure
Renal failure
Carcinomas (various types) — bronchial carcinoma
Diabetic ketoacidosis — acetone breath of uncontrolled diabetes
Trimethylaminuria — fish odor syndrome
Gastro-intestinal — esophageal reflux, pyloric stenosis, hiatal hernia, malabsorption syndrome, enteric infection
Other systemic conditions - dehydration, starvation, Sjögren's syndrome, leukemias and other blood dyscrasias
Medications — antihistamines/decongestants, antidepressants, anxiolytics, anticholinergics, antipsychotics etc
Halitophobia
Pseudo-halitosis
Idiopathic

ANUG = Acute necrotizing ulcerative gingivitis

Chemistry of Malodor

It is generally accepted that oral malodor is the result of a mixture of gases and foul-smelling substances into the breath which include volatile sulfur compounds(VSCs), especially H_2S,CH_3SH and $(CH_3)^2$ S, organic acids (butyric acid), aromatic compounds (indole, skatole) and amines (putrescine, cadaverine).

Table 2: Lists various volatile organic compounds (VOCs) that may be present oral malodor.[12]
Table 3 : Provides the etiology of halitosis and the related compounds.[13]
Table 4 : Correlates the oral malodor smell with the related compounds. Volatile sulfur compounds are likely to result from bacterial metabolism of amino acids in food debris, the concentration of VSCs in mouth air.[14]

Category	Chemical
Sulfur compounds	Hydrogen sulfide-H_2S
	Methylmercaptan-CH_3SH
	Methanthiol
	Allyl mercaptan
	Dimethyl sulfide-$(CH_3)_2S$
	Dimethyl disulfide
	Dimethyl trisulfide
Short chain fatty acids	Propionic acid
	Butyric acid
	Valeric acid
	Isocaproic acid
	Capric acid
	2-and 3-ethyl butyric acid
	Lauric acid
	Myristic acid
Polyamines	Cadaverine
	Putrescine
Alcohols	1-propoxy-2-propanol
Phenyl compounds	Indole
	Skatole
	Pyridine
Alkanines	2-methyl-propane
Ketones	
Nitrogen-containing compounds	Urea, ammonia

VOCs = Volatile organic compounds

Table 2: list of various volatile organic sulfur compounds

Cause	Specific compounds
Oral malodor	Hydrogen sulfide, methyl mercaptan, dimethyl sulfide and dimethyl disulfide
Diabetes mellitus — weight reduction	Acetone, other ketones
Uremia — kidney failure	Dimethylamine, trimethylamine, ammonia
Liver diseases	Dimethyl sulfide, ethanethiol, C2-C5 aliphatic acids (acetic acid, proprionic acid), butyric acid, isobutyric acid, and isovaleric acid
Lung carcinoma	Acetone, 2-butanone, *n*-propanol, aniline, and *o*-toluidine
Upper respiratory/ oropharyngeal carcinoma	C2-C8 normal and branched organic acids Trimethylaminuria Trimethylamine
Food: garlic/onions	Allyl methyl sulfide
Other potential compounds	Indole, skatole, cadaverine, putrescine, carbon disulfide, and dimethyl selenide

Table 3: list of various etiological compounds of halitosis

Compound	Smell
Hydrogen sulfide (H_2S)	Rotten eggs
Methyl mercaptan (CH_3SH)	Feces
Skatole	Feces
Cadaverine	Corpses (cadaver)
Dimethyl sulfide $(CH_3)_2S$	Rotten cabbage
Putrescine	Decaying meat
Indole	Small quantity in perfumes, smelly in large amounts
Isovaleric acid	Sweaty feet

Table 4: Oral malodor smell and related compounds

Microbiology Of Halitosis:

Halitosis reflects putrefaction by anaerobic, Gram-negative bacteria . These microorganisms digest proteins from food residues, cells and other saliva debris into amino acids. This is followed by further cleavage of certain amino acids to bad-smelling by-products of bacterial metabolism, predominantly VSCs (H_2S, CH_3SH and dimethyl sulfide $[CH_3]^2$ S), organic acids (butyric acid), aromatic compounds (indole, skatole) and amines (putrescine, cadaverine).[16]

Table 5.[16] Lists the various bacterial species associated with oral malodor

Actinomyces species	*Aggregatibacter*
Atopobium parvulum	*actinomycetemcomitans*
Bacteroides forysthus	(formerly *Actinobacillus*
Campylobacter rectus	*actinomycetemcomitans*)
Dialister species	*Bacteroides* (*Bacteroides*)
Eikenella corrodens	*loescheii*
Enterobacteriaceae	*Centipedia periodontii*
Eubacterium limosum	*Desulfovibrio species*
Fusobacterium nucleatum	*Eubacterium sulci*
Granulicatella elegens	*Firmicutes species*
Peptosteptococcus anaerobius	*Fusobacterium periodonticum*
Porphyromonas endodontalis	*Micros prevotti*
Prevotella intermedia	*Peptostreptococcus micros*
Prevotella loescheii	*Porphyromonas gingivalis*
Solobacterium moorei	*Prevotella* (*Bacteroides*)
Staphylococcus warneri	*melaninogenica*
Veillonella species	*Selenomonas artermidis*
Vibrio species	*Tannerella forsythia* (formerly
	Bacteriodes forsythus)
	Treponema denticola
	Unidentified oral bacterium

Pathophysiology of oral malodor

The odoriferous substances that produce malodor arise from the interaction of microorganisms in the oral cavity and their specific substrates. Proteolytic degradation of substrates containing sulfur in the saliva, blood, food debris, and epithelial cells by these anaerobic gram negavtive bacteria result in the formation of agents that can give rise to oral malodor.[17]

Amino acids such as cysteine, methionine, arginine, tryptophan, and lysine are biotransformed by the anaerobic bacteria into VSCs(odiferous hydrogen sulfide, methylmercaptan, indole, putrescine, and cadaverine) and sugars are biotransformed by the anaerobic bacteria into short-chain organic compounds[Figure 2].[17,18]

The gram-negative bacterial species commonly associated with oral malodor are Treponema denticola, Porphyromonas gingivalis, Prevotella intermedia, Prevotella endodontalis, Bacteriodes loescheii, Tannerella forsythensis, Enterobacteriacea, Eikenella corrodens, and Fusobacterium nucleatum.[17]

Prevotella intermedia have been reported to generate produce CH_3SH and H_2S from L-methionine and L-cysteine, respectively.[19]

Gram-positive microorganisms such as Streptococcus salivarius also have been found to contribute to malodor production. They can deglycosylate the salivary glycoproteins, therefore helping in exposing the protein core for further denaturation by gram-negative bacteria.[20]

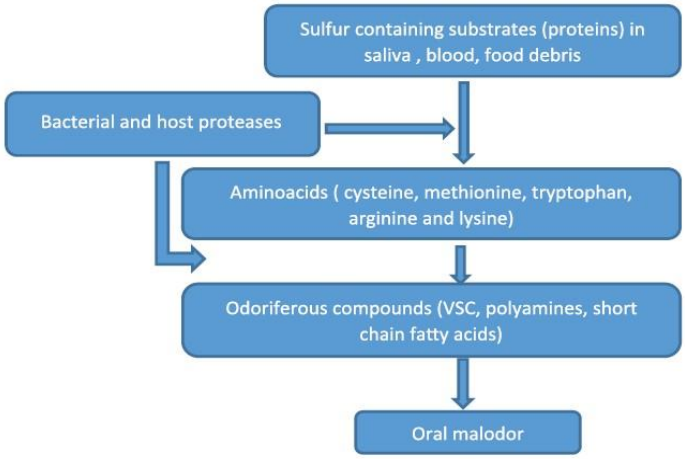

Fig 2: Pathophysiology of VSCs

Association between periodontitis and Oral Malodor:

Up to date evidence has confirmed an obvious relation between halitosis and compromised periodontal conditions. Microorganisms colonizing the tongue and periodontal sulcus aids in the formation of volatile sulphur compounds in both periodontally healthy individuals and periodontally diseased individual.

Tonzetich demonstrated the elevated VSC levels in periodontally involved pockets.[21]Solis and Gaffer measured hydrogen sulfide production in 240 gingival crevicular fluid (GCF) samples. A positive correlation was observed between gingival index, GCF volume and hydrogen sulfide production.[22] Yaegaki K indicated that oral malodor often accompanies periodontal diseases. Higher VSC levels have been found in subjects with probing depths > 4 mm than in subjects with healthy periodontium and the intensity of the odor increases with the severity of the disease.[23]

Diagnosis of Oral Malodor:

Diagnosis of the halitosis, and assessment of its severity conditions that patients have,is it genuine halitosis or pseudohalitosis or halitophobia are very important. Therefore, the diagnostic ways and tools are developed.[24]

Self Examination

When an intraoral cause has been identified, involve the patient in monitoring the results of therapy by self examination. The following self-testing can be used:

Smelling a metallic or nonodoros plastic spoon after scraping the back of the tongue.

Smelling a toothpick after introducing it in an interdental area.

Licking the wrist and allowing it to dry.[25]

Organoleptic measurement:

Measurement of unpleasant odors by smelling the exhaled air of the mouth and nose is called organoleptic measurement.

Severity of odor is classified into various scales,such as 0 to 5 point scale

0: no odor,

1: barely noticeale

2: slight but clearly noticeable,

3: moderate,

4: strong

5: extremely strong or widely point scale from 0 to 10 point

This measurement is considered to be the gold standard for measuring and assessing bad breath because of no cost and being practical and simple.[26]

Diamond probe/perio 2000: it is dental device designed to detect sulfide concentration of various forms in gingival sulci. The reaction of sulfide ions with the sensor generates a measurable voltage that is proportional to the sulfide concentration.[27]

Gas chromatograpy: gas chromatography can measure VSCs it separates and analyses compounds that can be vaporized without decomposition. The concentration of each VSC(ng/10ml mouth air) was determined based on standard of hydrogen sulfide and methyl mercaptan gas prepared with a permeater.[28]

Chemical Sensor:

Chemical sensors have an integrated probe to measure sulfur compounds from periodontal pockets and on the tongue surface. The working principle of chemical sensors is similar to sulfide monitors where sulfide compounds generate an electrochemical voltage and this voltage is measured by an electronic unit.[29]

Sulfide Monitoring:

The portable sulfide meter (Halimeter^{R}) has been widely used over the last few years in oral malodor testing. The portable sulfide meter uses an electrochemical,voltametric sensor which generates a signal when it exposed to sulfur gases(to be specific, hydrogen sulfide) and measure the concentration of hydrogen sulfide gas in parts per billion.[30]

Bana test:

The BANA test is practical for chair side usage. It is a test strip which composd of benzoyl –DL-arginine – a – naphthylamide and detects short chain fatty acids and proteolytic obligate gram negative anaerobes, which hydrolyze the synthetic trypsin substrate and cause halitosis.[26]

Quantifying β-galactosidase activity Proteolysis of glycoprotein depends on the initial removal of the carbohydrate side-chains which are O- and N-linked carbohydrates. β-Galactosidase is one of the important enzymes which are responsible for the removal of both O- and N-linked carbohydrate side-chains.[26]
β-galactosidase activity can be determined by the use of chromogenic substrates absorbed onto a chromatography paper disc and changes are recorded as

0 no color
1 faint blue color
2 moderate to dark blue color

Salivary incubation test

This test has advantages like, it has less influenced by external parameters such as smoking, drinking coffee, eating garlic, onion ,spicy food etc. the result of the salivary incubation test are shown a strong correlation with organoleptic measurement.[31]

Other tests:
Ammonia monitoring
Ninhydrin method
Saliva incubation test
Dark field or phase contrast microscopy

Treatment of Oral Malodor

After positive diagnosis for oral malodor has been made, the treatment plan is implemented, which comprises the elimination of the causative agent and the improvement of oral health.[32]

General measures

1. Patients should be advised to drink plenty of water and rinse mouth thoroughly after every meal.
2. Patients should be encouraged to clean the dorsum of the tongue gently with a soft bristled tooth brush.
3. Patients should be encouraged to undergo periodic scaling procedure.
4. Proper brushing and fl ossing technique should be advised.
5. Patient can be encouraged to include fibrous vegetables in the diet.[33]

Specific measures

Self care products - oral hygiene products used by patients for preventing unpleasant odor,
However, by these products direct treatment of halitosis is not possible. Self care products like chlorhexidine mouthwash and zinc salts have a substantial effect on masking halitosis. These approaches should be used as a temporary solution to relieve and improve the satisfaction of the patient. Professional treatment of real halitosis has crucial severity.[34]

Professional treatment – initial periodontal treatment includes scaling and root planning which may alleviate the depth of the periodontal pockets and severity of gingival inflammation and it eliminates halitosis causing bacteria. Oral malodor can be ameliorated through:
Reduction of bacterial load.
Reduction of nutrient availability.
Conversion of VSC to nonvolatiles.[32]

Chemical approach – oftenly used active ingredients in these products are chlorhexidine, essential oils, triclosan and cetylpyridinium chloride, chlorine dioxide. Often used active ingredients of these products are metal ions and oxidizing agents.[35]

Effective combination of agents
Chlorhexidine and zinc- these agents have a strong effect on volatile sulfur containing compounds and effective for atleast for 9 hours

Cetylpyridinium and zinc ions – these combination has a good synergistic effect on VSCs levels after 1 hour, but minimally above the effect of zinc alone.[35]

Chlorhexidine, cetylpyridinium chloride and zinc lactate – chlorhexidine is gold standard mouthrinse but it does have some side effects, for this reason new formulations have been developed. Studies have indicated a synergistic action between CHX and cetylpyridine and the formulations achieved the best results, both in term of antimicrobial activity and antihalitosis efficacy.[35]
In recalcitrant cases, the specialist empirically may use a 1 week course of metronidazole (200 mg tds) in an effort to eliminate unidentified anaerobic infections; metronidazole may reduce tongue microbiota and odor levels(Hartley et al,1999)

II. Conclusion

This review gives a complete insight into the various aspects of malodor, as it is the common problem of the patients and is a cause of distress. A thorough knowledge and its clinical application becomes mandatory. With increasing demand for dental care, and with continuing advances in dental education and research, there may be a greater potential for the dentist to play a role in the prevention and control of Oral Malodor.

Conflicts of interest : None

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